COORDINATED INTELLIGENT TRANSPORTATION SYSTEMS DEPLOYMENT IN NEW YORK CITY (CIDNY)

FINAL REPORT

TASK 6

STRATEGIC ITS DEPLOYMENT PLAN FOR NEW YORK CITY

Performed by: The City College of New York,
The City University of New York

U.S. Department of Transportation
Federal Highway Administration

NEW YORK STATE OF OPPORTUNITY. Department of Transportation

NEW YORK CITY DOT

University Transportation Research Center - Region 2

ABOUT THE PROGRAM

The FHWA, through its New York Division/New York City Metropolitan office is promoting programs pertaining to urban Intelligent Transportation Systems (ITS) in the region. The NYCDOT and NYSDOT-Region 11 Planning have taken the initiative in working with FHWA to take advantage of this FHWA program. NYCDOT and NYSDOT have developed the Training Courses and Research and Development Programs for the NYCDOT and NYSDOT Coordinated Intelligent Transportation Systems Deployment in New York City (CIDNY) which is a set of multi studies (task assignments) toward the fulfillment of the objectives of these programs.

The 2013 studies are being performed by institutions of the Region 2 University Transportation Research Center (UTRC). The studies focused on the following program areas: Construction Management, Traffic Demand Management, Dynamic Data Collection, Traffic Incident Management, Traffic Signal Timing and Detection Technologies, Strategic ITS Deployment Plan, Pedestrians and Cyclists Safety, Data Storage and Access Platform for MTA Bus Time Data.

The following tasks have been completed under this program.

- *Task 2 – Develop a multi-agency/multi modal construction management tool to enhance coordination of construction projects citywide during planning and operation phases to improve highway mobility and drivers experience*
- *Task 5 –Develop a comprehensive guide to traffic signal timing, new detection technologies and advanced signal timing concepts applicable in New York City*
- ***Task 6 – Strategic ITS Deployment Plan For New York City***
- *Task 7 – Research on Pedestrians and Cyclists Safety Using ITS Technology in NYC*
- *Task 8 – Develop Data Storage and Access Platform for MTA Bus Time Data.*

TASK 6 FINAL REPORT

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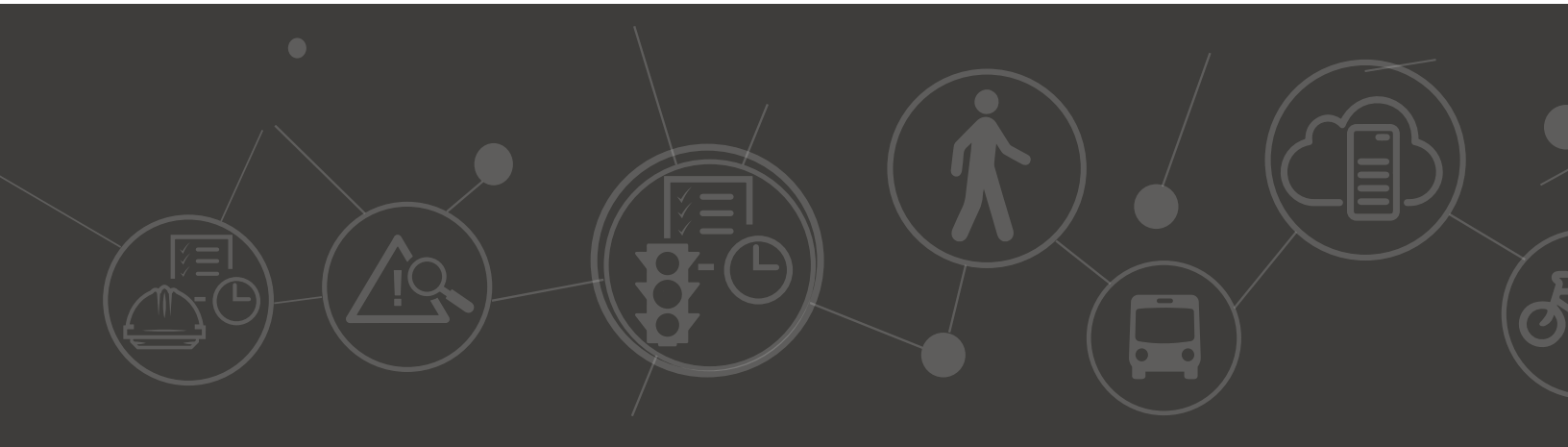

New York City Department of Transportation

2016 ITS Strategic Plan

Final Document v1.0

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16. Abstract

The *Strategic Intelligent Transportation Systems (ITS) Deployment Plan for New York City* was last updated in 2005 by Polytechnic University of New York. The New York City region has invested significant resources on ITS deployment in the past decades. It has involved the deployment of an advanced controller (the ASTC), a wireless communication infrastructure (NYCWiN), detectors, and the overall data management system to process information and to communicate the control settings. Over the past several years, NYC has designed and implemented a master plan for a total modernization of the entire ITS infrastructure, with the design concept driven by (a) cost-effective procurement and operation, (b) attention to using and advancing national ITS standards, helping to define the state of the practice when needed, (c) development of a system capable of addressing a multi-modal environment that includes Bus Rapid Transit (BRT), Transit Signal Priority (TSP), adaptive control (ACDSS) in select locations, delivering vehicular capacity while improving the pedestrian and urban environment.

This ITS Strategic Plan describes the strategic development areas and specific strategies and objectives needed to realize the Department's ITS goals and priorities, through the acquisition, design, deployment, and operation of ITS technologies and platforms. These strategies and objectives will enable actionable decision making on ITS investments for the next 10-15 years. This document was developed to be consistent with the New York City Sub-Regional ITS Architecture (NYCSRA). The document is also consistent with the Federal Highway Administration (FHWA) Rule issued in 23 Code of Federal Regulations (23 CFR 940) and the comparable Federal Transit Administration (FTA) Policy. Going forward, this document will serve to support and guide the City's ITS program as it responds to ongoing transportation challenges and ever-evolving transportation technologies.

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Executive Summary

New York City's transportation system is in a period of strong growth in travel demand, forecasted to increase over the coming decades. Because infrastructure options are constrained, NYC faces some serious supply-and-demand challenges and decisions, some of which are uniquely New York in nature. The reach of these challenges goes beyond the transportation system itself, where the impacts to local economy and regional competitiveness can be felt.

NYCDOT has successfully implemented a suite of strategies to tackle these issues over time; these are described in depth through their Agency-wide Strategic Plan. One focus, mainstreaming Intelligent Transportation Systems (ITS – technology services that support traffic operations and maintenance) – has been a highly successful part of that suite of strategies for the past 15 years.

However, the accelerating change in the capabilities of technology, business models, and public expectations requires a shift towards longer-term strategic planning to better manage ITS programs and projects for the future.

NYCDOT therefore needs to prepare for and guide decisions and changes in its ITS vision. Transformative ITS changes on the horizon include Connected Vehicles, expansion of Advanced Travel Demand Management deployments, Integrated Corridor Management, Data Mining – all of which require decision making and prioritization with limited experience in the NYC context; transitional changes such as greater sensor coverage and CCTV upgrades will also be required. Enabling business changes such as greater emphasis and need for regional coordination or new Quality and Asset Management programs may also generate further needs for NYCDOT's ITS capability. The strategic approach is therefore essential to a successful ITS program.

Key elements in the strategic approach include the vision, goals, and strategies that NYCDOT will use.

ITS Vision

Aligned to NYCDOT's agency-wide Strategic Plan, this ITS vision statement encapsulates the over-arching theme of ITS advacement that NYCDOT seeks. It is:

Serving the city and region's transportation needs through the coordinated deployment of leading-edge ITS technologies, making NYCDOT a global example of effective, sustainable ITS management and use in a major metro center.

ITS Goals

Aligned to NYCDOT's overall strategic objectives, these goals are measurable criteria for advancing the vision. They are:

Enabling NYCDOT to achieve its strategic goals through the deployment of tailored ITS technologies that:

a. achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback
b. enhance planning and policy development through improved data quality and data analysis
c. enhance the quality of communications with the traveling public
d. keep pace with evolving local and national ITS capabilities and standards

e.	**enhance the ability of the organization to deliver and manage services given limited organizational resources**

ITS Strategic Areas

To realize the ITS vision and goals of the organization, ITS strategies are developed in six categories, which when managed and acted on as a complete suite of strategies will advance the organization towards its longer term, agency-wide vision and goals.

1. **Enhancing Operational Capabilities;** ITS strategies to support operational activities.
2. **Advancing Operational Planning;** ITS strategies to support and integrate planning and analysis activities.
3. **Emerging Technology Readiness; ITS strategies to** prepare technologically and organizationally for future functionality.
4. **Lifecycle Management;** strategies for the management of ITS through the systems lifecycle.
5. **Professional Capacity Building;** ITS strategies as they relate to NYCDOT's ITS competency model

6. **Outreach and Communication;** strategies for the engagement of NYCDOT's ITS program with other parties, including suppliers and vendors, other agencies, and the traveling public.

Implementation of these strategic areas will occur in accordance with City procurement policies and federal funding requirements, as necessary, consistent with FHWA Rule/FTA Policy (23 CFR 940).

Topics Covered In-Depth

This document focuses on nine major areas with two appendices. Section descriptions are as follows:

#	Section Title	Section Description
1	Importance of ITS Strategic Planning for NYCDOT	Description of the role and value of ITS and ITS strategic planning to NYCDOT
2	New York City's Priorities in Transportation and Infrastructure	NYCDOT needs and priorities for better transportation system investment.
3	Role of ITS at NYCDOT	How ITS is utilized, and will be utilized at NYCDOT
4	Recent Advances in the State of ITS	Evolutionary and revolutionary changes in transportation technologies from across the world
5	Regional ITS Stakeholders	The state of ITS in the region and NYCDOT's role
6	Recent NYCDOT ITS Projects and Initiatives	Significant existing and completed ITS projects
7	Strategic Vision, Goals, and Mission for ITS at NYCDOT	Providing the ITS vision, goals and mission for the agency

8	NYCDOT ITS Strategy Areas	Explanation of strategic areas and objectives therein
9	Achieving the Vision and Goals	Next steps to realize the strategic plan

List of Acronyms

ACDSS	Adaptive Control Decision Support System
ASD	Aftermarket Safety Devices
ASTC	Advanced Solid-State Traffic Controllers
ATC	Adaptive Traffic Control
ATDM	Advanced Traffic Demand Management
ATIS	Advanced Traveler Information System
ATM	Active Traffic Management
CCTV	Closed-circuit television cameras
CV	Connected Vehicles
DRE	Disaster Recovery and Evacuation
HAR	Highway Advisory Radio
ICM	Integrated Corridor Management
ITIF	Information Technology & Innovation Foundation
ITMS	Integrated Transportation Management System
ITS	Intelligent Transportation Systems
JPO	Joint Program Office
JTMC	Joint Transportation Management Center
EU	European Union
FHWA	Federal Highway Administration
GDP	Gross Domestic Product
MIM	Midtown In Motion
MPO	Metropolitan Planning Organization
MTA	Metropolitan Transit Authority
NJDOT	New Jersey Department of Transportation
NTCIP	National Transportation Communications for ITS Protocol
NYC	New York City
NYCDOT	New York City Department of Transportation
NYCSRA	New York City Sub-Regional Architecture
NYCWiN	New York City Wireless Network
NYMTC	New York Metropolitan Transportation Council
NYSDOT	New York State Department of Transportation
OCCC	Operations Central Command Center
PANYNJ	Port Authority of New York and New Jersey
QMT	Queens Midtown Tunnel
RFID	Radio Frequency Identification

RSE	Roadside Equipment
TMC	Traffic Management Center
TRANSCOM	Transportation Operations Coordinating Committee
TSP	Transit Signal Priority
USDOT	United States Department of Transportation
V2I	Vehicle-to-Intersection
V2V	Vehicle-to-vehicle
VMS	Variable Message Signs
VSLS	Variable Speed Limit Signs

1. Importance of ITS Strategic Planning for NYCDOT

The mission of the New York City Department of Transportation (NYCDOT) is to provide for the safe, efficient, and environmentally responsible movement of people and goods in the City of New York and to maintain and enhance the transportation infrastructure crucial to the economic vitality and quality of life of the City residents as their primary customers. In accomplishing this mission, NYCDOT continues to face ever growing safety and mobility challenges within its already constrained financial environment. To address these challenges the Department routinely updates its strategic plan, consisting of an entire suite of strategies designed to advance the organization toward specific operational and performance targets.

For some time now, one of NYCDOT's strategic interests has been the deployment and use of Intelligent Transportation Systems (ITS) to support the needs of the traveling public, operations and maintenance personnel, regional partner agencies, and emergency management agencies. The Federal Highway Administration (FHWA) defines *Intelligent Transportation System (ITS)* to mean electronics, communications, or information processing used singly or in combination to improve the efficiency or safety of a surface transportation system. With increasing mobility demand in New York City, a regional partnership focus, and accelerating options in ITS functionality, a structured approach to ITS technology management is essential.

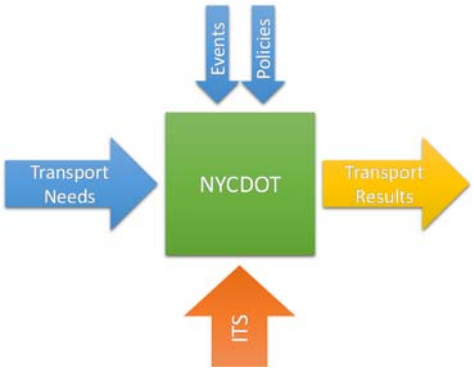

Figure 1. Role of ITS at NYCDOT

Improved traffic operations and plans and improved communication to the traveling public are major benefits that ITS services and functionalities bring to NYCDOT and all stakeholders involved. Figure 1 illustrates the role that ITS plays at NYCDOT.

ITS and its platforms serve NYCDOT as means to operational ends; ITS are not an ends unto themselves. The Department's ITS priorities, investment decisions, and approach are driven by two complementing purposes:

a. **NYCDOT's Operational Needs –** what NYCDOT needs to achieve operationally in the short, medium, and long term (as defined in its Agency-wide Strategic Plan) drives what ITS capabilities it will require, where and when it will require them, and how they will be delivered and used.

b. **New ITS Capabilities** – new ITS capabilities enter the marketplace on a daily basis. These ITS may offer a path to attractive new operational capabilities not previously considered or realized in the Agency-wide Strategic Plan. ITS capabilities may be transitional (*e.g.:* newer generation CCTV cameras) or transformative (*e.g.:* connected vehicle), and while they offer new opportunities, also create new requirements for the organization to meet.

Because of the size and scope of traffic operations in New York City, over the past decades NYCDOT has deployed a significant number of ITS technologies (*e.g.:* CCTV cameras) and platforms (*e.g.:* Advanced Traffic Demand Management (ATDM)). Though a large scale deployment demands a coordinated, strategic approach toward investment, recent advancements in ITS capabilities (*e.g.:* connected vehicle technology) reinforces the continuing need for a cohesive, single-point approach to ITS capabilities and platform investment and management at NYCDOT.

Through a stand-alone plan, the ITS Strategic Plan is aligned with and reinforces the NYCDOT's Agency-wide strategic plan (Figure 2). The purpose of this plan is to articulate and document the vision and strategic approach for the Department with regard to Intelligent Transportation Systems in order to facilitate clear decision making.

Figure 2. Strategic plans related to one another

This ITS Strategic Plan describes the strategic development areas and specific strategies and objectives needed to realize the Department's ITS goals and priorities over the short, medium, and long term, through the acquisition, design, deployment, and operation of ITS technologies and platforms. These strategies and objectives will enable actionable decision making on ITS investments for the next 10-15 years.

Certain questions that this plan helps to address include:

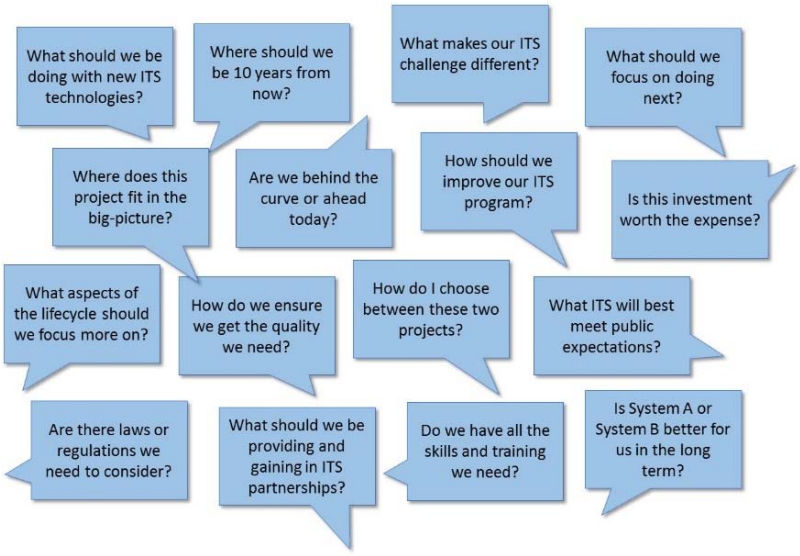

Figure 3. Selected concerns motivating this ITS plan

The ITS Strategic Plan can work in concert with other strategic plans the Department adds in the future. It is important to note that this plan is to be considered a "living document" – the plan documents a vision, goals, strategies and priorities at a given moment in time, and will need to be revisited and updated as transportation needs and context evolve and change over time.

The 2016 ITS Strategic Plan thus describes the path that the Department is taking with regards to ITS. The ITS Strategic Plan should always be consistent in aligning its vision, goals, and strategies to support larger Agency-wide strategies and efforts. As a complementing strategic plan, the ITS Strategic plan lays

out a specific vision, goals, as well as six strategic areas for NYCDOT to pursue in order to best deploy ITS in support of larger departmental goals and objectives.

2. New York City's Priorities in Transportation and Infrastructure

Transportation in the NYC metropolitan area is complex. It involves multiple jurisdictions, each performing significant data collection and possibly using competing ITS technologies. The jurisdictions fall under several agencies including: NYCDOT, NYSDOT Region 10 and 11, Metropolitan Transportation Authority (MTA), Transportation Operations Coordinating Committee (TRANSCOM), Port Authority of New York and New Jersey (PANYNJ), and NJDOT.

In order to understand the relevance of the ITS Strategic Plan and where it derives from, it is necessary to understand its connection to the region, and more specifically to New York City's strategic plan.

In 2007 Mayor Bloomberg's administration put in place a strategic plan for NYC branded PlaNYC[1]. Its last version was published in 2011 and was used as a platform by NYCDOT to produce its own strategic plan, Sustainable Streets[2], in 2013. Most recently in 2014, under Mayor Bill De Blasio, the city adopted a new strategic plan called OneNYC[3], which primarily focuses in four major areas: growth, equity, sustainability and resiliency.

Figure 4. Alignment between NYC's Strategic Plan and the NYCDOT ITS Strategic Plan

Among the primary goals highlighted in OneNYC is improving the transportation and infrastructure in NYC. The goals for transportation and infrastructure include:

1. Having a reliable, safe, sustainable, and accessible transportation network that meets the needs of all New Yorkers and supports the city's growing economy
2. Continuing to embrace Vision Zero[4] and accept no traffic fatalities on New York City streets
3. Becoming an example of global economic, environmental, and social leadership infrastructure and built environment
4. Adapting infrastructure systems across the region to maintain continued services

The specific objectives set to be achieved under transportation and infrastructure are as follows:

Transportation:

1. Increase overall rail transit capacity into the Manhattan Central Business District between 8-9 am by 20 percent, by 2040
2. Double the number of cyclists, tracked by the NYC In-Season Cycling Indicator, by 2020
3. Increase the share of cargo moved within the region via rail and water
4. Reduce the number of traffic fatalities to zero
5. Reduce the number of serious injuries due to traffic collisions to zero

Infrastructure:

1. Reduce customer-hours of weather-related utility and transit service outages

[1] The City of New York: Mayor Michael Bloomberg, PlaNYC: A Greener, Greater New York, 2007.
[2] New York City DOT, Sustainable Streets: DOT's Strategic Plan, 2013.
[3] The City of New York Mayor Bill De Blasio, One New York-The Plan for a Strong and Just City, April 2015. The City of New York Mayor Bill De Blasio, One New York-The Plan for a Strong and Just City, April 2015.
[4] Vision Zero is a multi-national initiative to achieve a highway system with no fatalities or serious injuries in road traffic.

2. Increase the percentage of patient beds at hospitals and long-term care facilities in the 100-year floodplain benefiting from retrofits for resiliency

In 2009, the New York Metropolitan Transportation Council (NYMTC) developed an ITS Integration Strategy. The ITS Integration Strategy represents a shared vision of how each of the NYMTC planning area's ITS Architectures should work to share information and resources. The strategy has three major goals:

1. Identify opportunities where ITS investments can work together toward regional interoperability and provide the desired regional ITS services;
2. Enhance interagency cooperation in the management and development of ITS; and
3. Identify and target ITS projects and initiatives early in the planning process which will facilitate integration.

In 2013, transportation stakeholders in New York City also completed an update to the New York City Sub-regional ITS Architecture[5] (NYCSRA). Consistent with FHWA Rule/FTA Policy (23 CFR 940), this sub-regional ITS architecture serves to document and describe existing and planned ITS services deployed in the New York City sub-region. The NYCSRA also documents intended linkages and information flows among ITS elements and ITS stakeholders to help individual agencies provide coordinated and seamless provision of ITS services to the general public. NYCDOT participated in this update to the sub-regional ITS architecture.

NYCDOT is in the process of updating its Agency-wide Strategic Plan. The 2016 update of the NYCDOT Strategic Plan, Strategic Plan 2016, will consider the strategies needed to achieve these transportation and infrastructure objectives. This 2016 ITS Strategic Plan is intended to be consistent with and in support of the 2016 update of the NYCDOT Strategic Plan.

[5] New York City Sub-Regional Intelligent Transportation Systems (ITS) Architecture website. http://www.consystec.com/nycsraupdate/web/. Accessed May 2016.

3. Role of ITS at NYCDOT

To develop an appropriate vision for ITS and associated goals and strategies, it is necessary to put ITS at NYCDOT in its proper context. This section describes the supporting, enabling role that ITS plays at the Department, supporting it in the facets of its operational mission through tailored services and business processes. A high-level description of *what ITS does* is also provided in order to crystalize the full extent of how these technologies impact operational missions.

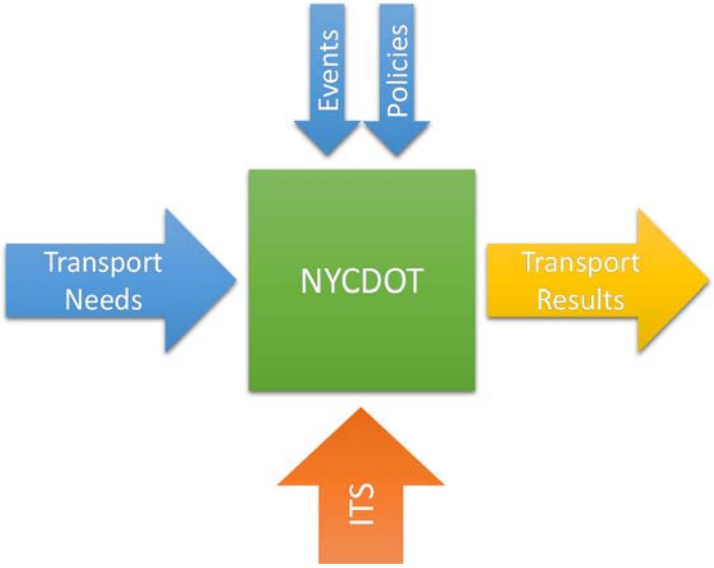

Figure 5. ITS as an enabler at NYCDOT

ITS at NYCDOT – An Enabler

NYCDOT is an operating agency and its operational mission is to transform traffic needs and demands into safe and efficient vehicle throughput within New York City's limits. ITS is merely one tool among many to assist and enable the Department in accomplishing this mission.

Figure 6 illustrates the traffic management functions and resources at NYCDOT. NYCDOT performs certain management functions (green) either executively or in partnership with others ("NYCDOT Role"). These activities are performed today, and will be performed in the future for a variety of vehicle types (conventional, connected, and autonomous) through either managed territories or areas or integrated corridors.

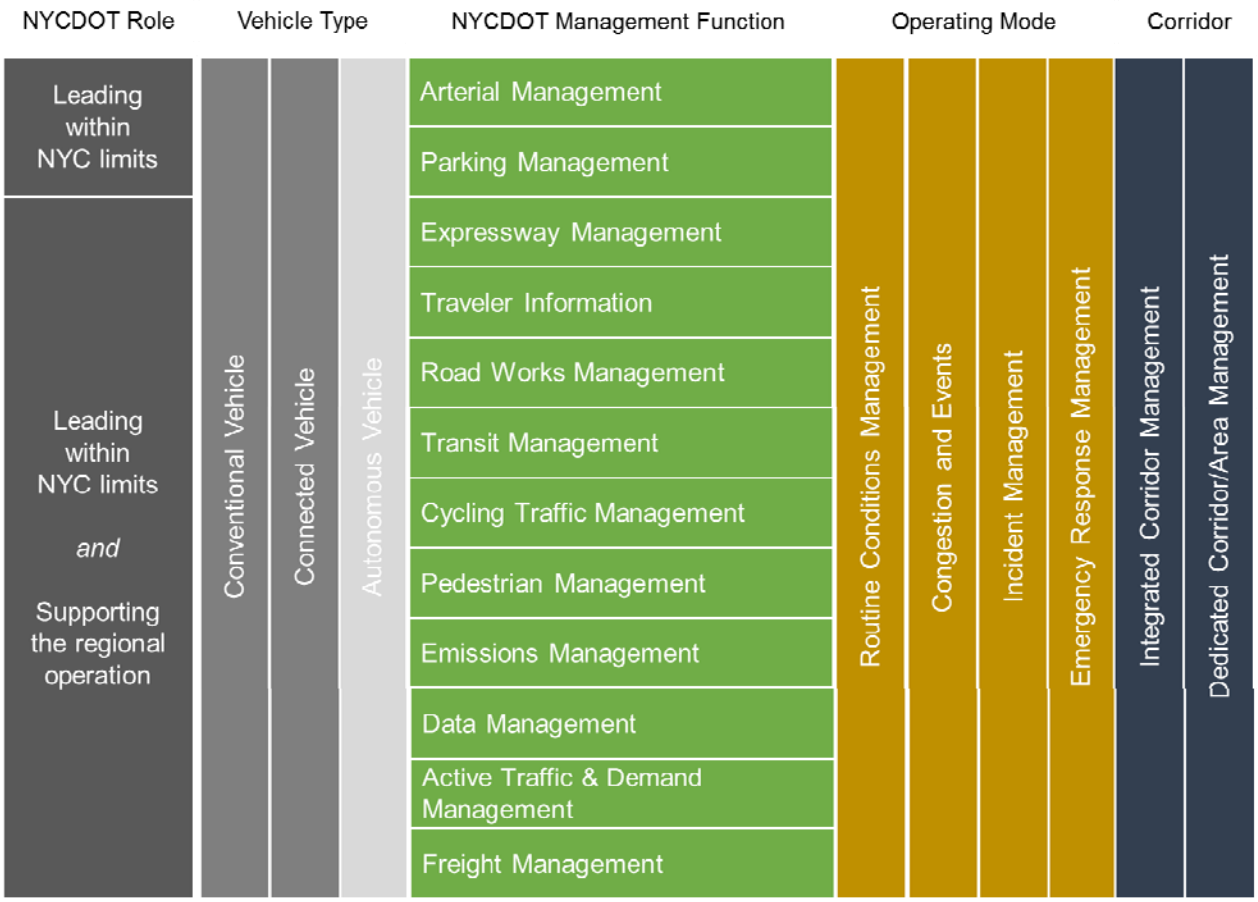

Figure 6. Primary elements of traffic operations at NYCDOT

High-Level ITS Functionalities

ITS supports NYCDOT operations through the provisioning of three key functions, either as a standalone, or in combination. They are:

Evaluation – ITS can provide continuous situational awareness of traffic conditions to NYCDOT, provided via field sensors, CCTV imagery, communications, or logged reports. The quality and usefulness of this situational awareness data depends on several factors. In addition to awareness, ITS can support assessment of situations in the form of alerts, performance measures or thresholds, Key Performance Indicators (KPIs), or other assessment or decision support tools and recommendations.

Control – ITS can provide the ability to influence the traveling public's behavior, for example via signalized intersection control, Variable Message Sign (VMS) messaging for lane closures, direction reversals, public advisories (*e.g.:* road works advisory, gray alerts, alternate/detour route) text messaging, 511 messaging, or in-vehicle messages.

Feedback – ITS can also return certain information back to Situation Awareness and Assessment functions via ITS communications systems, for example fiber optics, Wi-Fi, LTE, owned or leased by NYCDOT. This feedback may help assess the efficacy of NYCDOT actions and suggest future refinements to decision-making. Feedback also includes a component of delay (see timer insert). This means that latency in receiving feedback may influence its effectiveness.

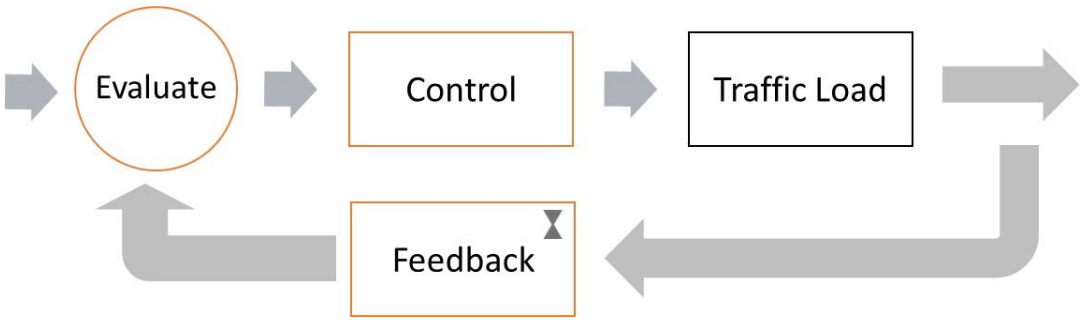

Figure 7. Major functions that ITS delivers

The model (Figure 7) applies either in part, or whole, to any class of ITS component – an Advanced Traffic Management System (ATMS), Advanced Traveler Information System (ATIS), CCTV, Point Vehicle Detection, or Variable Message Signs (VMS), to name a few examples. Thus, improving NYCDOT's capabilities in each of those functional areas is *the purpose of those systems*.

Transport Results

The result of traffic management action takes place in one or more operating modes:

1. **Routine Conditions –** routine management action that is taking place within normal parameters
2. **Congestion and Events –** adapted management through planned and unplanned (non-vital) disruption conditions such as recurring congestion, special events with planned closures
3. **Incident Management –** adapted management in response to unanticipated, degraded conditions, such as a collision or an unexpected event causing problems, *e.g.:* a protest
4. **Emergency Management –** adapted, multi-agent coordinated management in response to a time-sensitive condition that can have safety and security ramifications, and that may involve implementing a widespread plan.

4. Recent Advances in the State of ITS

Intelligent Transportation Systems (ITS) is an ever-evolving field due to constant improvements in related services, technologies, and implementations. A survey of emerging technologies and ITS vision in both international and national context is crucial to set the wider ITS scene and shed light onto the development of the strategic plan for NYCDOT. In this respect, this chapter focuses on existing and envisioned ITS functionalities and deployments over the globe, in the U.S., and in the NYC metropolitan region. This will allow understanding and comparing definition and approaches to adoption and deployment of ITS strategies by governments and agencies in different geographical locations.

International Overview

Although ITS projects are based on similar emerging technologies and deployed for similar purposes throughout the world, there are subtle variances in overall approaches, adoption and deployment. In fact, the subtleties start with the definition of ITS. The USDOT defines ITS as "the application of advanced information and communications technology to surface transportation in order to achieve enhanced safety

and mobility while reducing the environmental impact of transportation."[6] A United Nations report[7] compiles the worldwide definitions of ITS which are presented in the table below.

Table 1: Definitions of ITS by Different Institutions/Countries

Organization	Definition
European-Union	Applications of information and communication technology to transport
European Road Transport Telematics Implementation Coordination Organization	A system that integrate information and communication technology with transport infrastructure, vehicles and the user
ITS United Kingdom	A combination of information and telecommunications technology that enables provision of online information in all areas of public and private administration
European Telecommunications Standards Institute	Telematics and all types of communications in vehicles, between vehicles, and between vehicles and fixed locations; not restricted to road transport
ITS Japan	A system that capitalizes on leading-edge information technology to support the comfortable and efficient transportation of people and goods, anticipating a "quantum leap" in safety, efficiency and comfort
ITS Canada	Applications of advanced and emerging technologies (computers, sensors, controls, communications and electronic devices) in transportation systems to save lives, time, money, energy and the environment
Republic of Korea	A transportation system that (a) improves efficiency and safety through automated systems management; (b) provides transportation data through services that integrate such state-of-the-art technologies as electric control and communication with vehicles and other transport facilities.
Malaysia	Applications of advanced and emerging technologies (computers, sensors, controls, communications and electronic devices) in transportation systems to save lives, time, money, energy and the environment; and the integration of information and communication technology with transportation infrastructure, vehicles and users
Philippines	Applications of computing, electronics, information technology and communications to solve problems in all transport sectors
China	A new generation of transportation system for improving safety, efficiency, accessibility and sustainability in transportation through application of advanced information technology

Source: Intelligent Transport System for sustainable mobility, UNECE, unless otherwise specified.

Some of the definitions in the table above spell out the expected ITS outcomes (e.g. safety) whereas some countries provide a broader definition without specifics, (e.g. EU's definition "integration of information and communication technology to transport"). Irrespective of the definition, the ITS plans around the world draw on strategic transportation goals of respective transportation agencies. In the case of Japan, ITS is contextualized under the broader national goal of "Declaration on the Creation of the World's Most Advanced IT Nation"[8]. Given this ambitious national priority, Japan invests almost $700 million a year in ITS and leads the world in ITS with respect to the number of citizens benefitting from operationally deployed intelligent transportation systems[9]. South Korea, on the other hand, follows a city-by-city approach, establishes "ITS Model Cities", which implement adaptive traffic signal control, real-time traffic information, public transportation management, and speed violation enforcement[10].

[6] US Department of Transportation, USDOT Intelligent Transportation System (ITS) ITS Strategic Plan 2015-2019, May 2014.
[7] United Nations Economic and Social Commission for Asia and the Pacific, Intelligent Transportation Systems for Sustainable Development in Asia and the Pacific, Prepared by the Information and Communications Technology and Disaster Risk Reduction Division, 2015.
[8] Ministry of Land, Infrastructure, Transport and Tourism, Up-date of Intelligent Transport Systems in Japan, http://fot-net.eu/download/international_workshops/tokyo/fot_welcome_japan.pdf, October 2013.
[9] The Information Technology & Innovation Foundation, Explaining International IT Application Leadership: Intelligent Transportation Systems, http://www.itif.org/files/2010-1-27-ITS_Leadership.pdf, January 2010.
[10] *ibid*

The following table provides a summary of ITS strategic goals/priorities/focus for major countries in the world. As shown in the table some countries list ITS goals in a broader context of transportation goals without going into specific technologies (e.g.: New Zealand), whereas some list specific technologies (e.g.: Australia). Safety is one of the common themes because of the high toll of human lives and economic loss due to roadway accidents. The other common topic is vehicle to vehicle (V2V) and vehicle to infrastructure (V2I), which is also a very natural consequence of recent developments in connected vehicle technologies. McKinsey Global Institute report[11] also acknowledges the importance of autonomous and near-autonomous vehicles, and ranks this advancement as one of the 12 selected technologies that are expected to transform life, business, and the global economy.

Table 2: ITS Strategic Goals from Around the World

COUNTRY	STRATEGIC ITS GOALS/PRIORITIES/FOCUS
European Union (EU)	• optimal use of road, traffic and travel data • continuity of traffic and freight management ITS services • ITS road safety and security applications • linking the vehicle with the transport infrastructure[12]
Australia	• Advanced Transport Management Systems (e.g. lane control and ramp metering, public transport priority management • Vehicle detection and enforcement solutions (e.g. tolling system support) • Passive Driver Information (e.g. intelligent speed assistance, lane departure warnings) • Active Driver Assistance Solutions (e.g. predictive terrain adaptive • cruise control, pedestrian avoidance, automatic parking) • Cooperative ITS (e.g. vehicle to vehicle – V2V – and vehicle to infrastructure – V2I –communication) • Traveler Information Systems • Vehicle performance tracking and monitoring, • Vehicle Environmental (e.g. managed charging of electric vehicles)[13]
Japan	• Advances in navigation systems • Electronic toll collection systems • Assistance for safe driving • Optimization of traffic management • Increasing efficiency in road management • Support for public transport • Increasing efficiency of commercial vehicle operations • Support for pedestrians • Support for emergency vehicle operations[14]
South Korea	• Traffic Management • Electronic Payment Systems • Traffic Information • Traveler Information • Public Transportation • Efficient Cargo Systems

[11] McKinsey Global Institute, Disruptive technologies: Advances that will transform life, business, and the global economy, http://www.mckinsey.com/business-functions/business-technology/our-insights/disruptive-technologies, May 2013
[12] Conroy, P. and Ygnace, J.L., Institutional and Organizational Factors for the Successful Deployment of Intelligent Transportation Systems (ITS): International Comparisons, http://www.uctc.net/research/papers/627.pdf, June 2002
[13] ITS Australia Intelligent Transport Systems, National Intelligent Transport Systems Industry Strategy 2012-2017, http://www.seeits.eu/docs/Related/national_action_plans/Australian_ITS_industry_strategy%20(en).PDF, March 2012
[14] Ministry of Land, Infrastructure, Transport and Tourism, Up-date of Intelligent Transport Systems in Japan, http://fot-net.eu/download/international_workshops/tokyo/fot_welcome_japan.pdf, October 2013

	• Vehicle/Road Modernization[15]
New Zealand	• ITS solutions towards effective, efficient, safe, secure, accessible and resilient transport system The three key areas of government focus: 1. Economic growth and productivity 2. Value for money 3. Road safety[16]
Hong Kong	• create greater efficiency in traffic management • provide better and more informed choices to road users with access to real-time information • facilitate better interaction among people, roads and vehicles • enhance utilization of existing transport infrastructure[17]

The Information Technology & Innovation Foundation (ITIF) report[18] synthesizes the ITS success stories in words and argues that policy factors are much more important than non-transportation policy factors. It is also argued that rising countries such as China and India are making substantial investments in ITS and the United States will risk falling further behind in ITS if it does not significantly fund ITS in future. As a conclusion, the report lists the following qualities of the countries that lead the world in ITS deployment:

> *"1) Demonstrate national level commitment and vision,*
>
> *2) make substantial investments in ITS deployment, and*
>
> *3) feature strong government leadership in crafting a clearly articulated ITS vision, setting a national agenda, convening relevant stakeholders, and spearheading implementation."* [19]

Where the United States Stands in ITS from an International Perspective

The Information Technology & Innovation Foundation (ITIF) 2010 report[20] provides a critical analysis of the ITS deployment in the U.S. The report highlights the U.S. strengths at particular regions and applications (i.e. electronic toll collection, variable toll pricing, ramp metering), but also argues that the United States lags in ITS deployment in other areas, such as real-time traffic information, vehicle-to-infrastructure and vehicle-to-vehicle integration, adoption of computerized traffic signals, and maximizing the effectiveness of its already fielded ITS systems. It is further discussed that the ITS deployments in the U.S varies considerably by state and region, and the deployments are not necessarily integrated. Related to the conclusions presented in the previous section, the high degree of centralization in ITS decision-making is mentioned as a positive aspect for countries that are advancing in ITS deployment, such as Japan where the federal government has direct control over roadways. The report stipulates that the two main challenges in the U.S. are 1) *"every state has his own approach"* rather than a federally led approach, 2) lack of adequate funding. Both South Korea's and Japan's investments in ITS as a share of

[15] Transport Department - The Government of the Hong Kong Special Administrative Region, Speech by Deputy Commissioner for Transport on ITS, http://www.td.gov.hk/en/publications_and_press_releases/press_releases/transport_department/index_t_id_690.html, December 2001.
[16] Government of New Zealand, Intelligent Transport Systems Technology Action Plan 2014-18, http://www.transport.govt.nz/assets/Uploads/Our-Work/Documents/Intelligent-Transport-Systems-Technology-Action-plan-June-2014.pdf, May 2014.
[17] Transport Department - The Government of the Hong Kong Special Administrative Region, Speech by Deputy Commissioner for Transport on ITS, http://www.td.gov.hk/en/publications_and_press_releases/press_releases/transport_department/index_t_id_690.html, December 2001.
[18] The Information Technology & Innovation Foundation, Explaining International IT Application Leadership: Intelligent Transportation Systems, http://www.itif.org/files/2010-1-27-ITS_Leadership.pdf, January 2010
[19] *ibid*
[20] *ibid*

GDP, are more than double of the United States. Overall, the lack of coordination between ITS deployments is underlined as an obstacle to achieve efficiency.

Future of Transportation and International Trends

New ITS deployments are closely related to technological improvements as well as the society's transportation needs. For instance, the autonomous vehicles were not getting the same emphasis a decade ago, but recent advancements in the related technologies made autonomous vehicles one of the core priorities of any ITS strategic plan. The example of autonomous vehicles alone shows the dynamic nature of the ITS field and the need for envisioning the future of transportation for ITS deployment strategies. A Deloitte report[21] envisions the future of transportation as:

- ***"Massively networked**, with ubiquitous connectivity throughout the system*
- ***Dynamically priced**, so as to balance supply and demand*
- ***User centered**, taking into account users' needs, priorities, data flows, and dynamic responses to conditions*
- ***Integrated**, so that users can move easily from point A to point B, regardless of mode, service provider, or time of day*
- ***Reliant on new models of private-public collaboration**, which take advantage of the increasingly diverse ecosystem of public, private, and nonprofit entities that are working to meet the mobility challenges of the 21st century"*[22]

Such future predictions are key for planning ITS operations accordingly not to stay behind the curve of change. An ITS study from Australia[23] provides a similar worldwide perspective for the future and with also considering institutional changes. For instance, *the report emphasizes the changing role of road authorities from building and maintaining roads to* facilitating transport use of the network, e.g., *"how the community and the economy benefit from the use of the transport system and the service it provides". Intelligent infrastructure* is also emphasized regarding the need for improving existing ramp metering, signaling, and operations with centrally controlled communication network with infrastructure sensors. *Smarter vehicles* complement the intelligent infrastructure by communicating with other vehicles and the infrastructure to enable efficient traffic operations. *The Growth of Big Data* and the challenge of extracting valuable information from large chunks of data are also posited as one of the future transportation challenges. USDOT ITS Joint Program Office report[24] on big data implications on transportation also argues that big data will have the potential to radically improve transportation operations from multiple perspectives. The Australian report touches on "improved asset management" where the demand and capacity match is performed dynamically. Last, the increasing share of private sector traveler information is discussed since tools such as Google Maps have abundant of travel data, which can potentially be integrated, with other existing services for more comprehensive transportation data.

National Overview

In order to put NYCDOT's ITS needs into the national perspective, the project team surveyed multiple ITS plans which are available online. The available documents exhibit a wide range of geographical (statewide to citywide), time period (from the 90s to current) and information (from list of ITS projects to strategic planning) coverage. A full list of plans reviewed is included in Appendix B.

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[21] Fishman, T., Digital-Age Transportation The Future of Urban Mobility, http://dupress.com/articles/digital-age-transportation/, December 2012
[22] *ibid*
[23] Main Roads Western Australia, Intelligent Transport Systems Master Plan, https://www.mainroads.wa.gov.au/Documents/International%20Trends%20in%20ITS%20v1.RCN-D14%5E23294218.PDF, February 2014
[24] USDOT, Big Data Implications for Transportation Operations, http://ntl.bts.gov/lib/55000/55000/55002/Big_Data_Implications_FHWA-JPO-14-157.pdf, December 2014

The emphasis on “strategic plan” with a broader vision on emerging technologies is found on more recent documents whereas older documents tend to list the undertaken and planned ITS projects for the region of interest. ITS strategic plans at different regions also have subtle differences in priorities. For instance, the ITS strategic plan for Colorado (dated 2011) lists “Add Static/Transit Route Information to Google” as one of the main strategies to “*increase transit ridership and demand by integration and coordination with alternative travel modes”*. Since such static transit information had been already utilized for NYC area, NYCDOT strategic plan (dated 2005, 6 years earlier than Colorado study) was looking for ways to better manage bus fleets by providing real-time/en-route transit information. Similarly, the regions with severe weather conditions (e.g. Idaho, Kentucky) put more emphasis on systems like Road Weather Information Systems (RWIS) whereas NYCDOT strategic plan extensively discussed ITS for comprehensive emergency response in disaster context. Those nuances aside, there are also common themes. For instance, “safety” is not only echoed in every ITS plan in the U.S. but also worldwide. This is not surprising as transportation safety is repeatedly listed on top of the list in Transportation Research Board’s periodic reports regarding “Critical Issues in Transportation”. Besides the geography, the time frame of a strategic plan is also very important due to constantly evolving technological developments and their impacts on ITS. For example, the term “connected vehicle” appears in almost all *recent* ITS plans. This is mainly because the connected vehicle technologies gained significant traction during the last decade, putting these technologies to the top of any transportation policy considerations list. In fact, older studies discuss concepts related to connected vehicles but USDOT’s strategic ITS plan for 2010-2014 (which is titled “Transforming Transportation through Connectivity”) plays an important role to direct the focus of ITS to connected technologies and lay out a consistent terminology.

Briefly, the ITS priorities may change based on the geography and urbanization patterns, as well as the time period. For the purposes of this study, the identified documents are categorized with respect to the urban setup and proximity to NYC as “Cities”, “NYC Region” and “Other States and Regions”. On the one hand, “NYC-compatible” cities and metropolitan areas were given special emphasis to assess where NYC ITS plan stands among similar urban cities. On the other hand, some ITS plans are “regional” in the title, but heavily dominated by a metropolitan city, e.g. Los Angeles County – LA, Northern Illinois – Chicago. Meanwhile, some city ITS plans were not investigated in detail as the urbanization scale is very different from NYC, i.e. Tempe, AZ, Bellevue, WA, De Moines, IA, Dubuque, IA. Nevertheless, any ITS plan around NYC were also documented to understand the connections between NYCDOT ITS infrastructure with the surrounding ITS systems. Refer to Appendix B for additional detail and description of these reviewed plans.

One of the most important documents that describe the vision and future deployment of ITS in the U.S. is the strategic plan prepared by USDOT Intelligent Transportation Systems (ITS) Joint program Office (JPO). The latest release covers the vision for 2015-2019[25]. Figure 8 provides a schematic representation of the strategic plan. The plan is built on five strategic priorities to guide and direct the ITS community attention to the intended outcomes of the new technologies and systems. Serving these priorities, a total of six programs are defined. Two of these programs (“Realizing connected vehicle (CV) implementation” and “Advancing Automation”) are highlighted as the major thrusts of the strategic plan.

[25] US Department of Transportation, USDOT Intelligent Transportation System (ITS) ITS Strategic Plan 2015-2019, May 2014

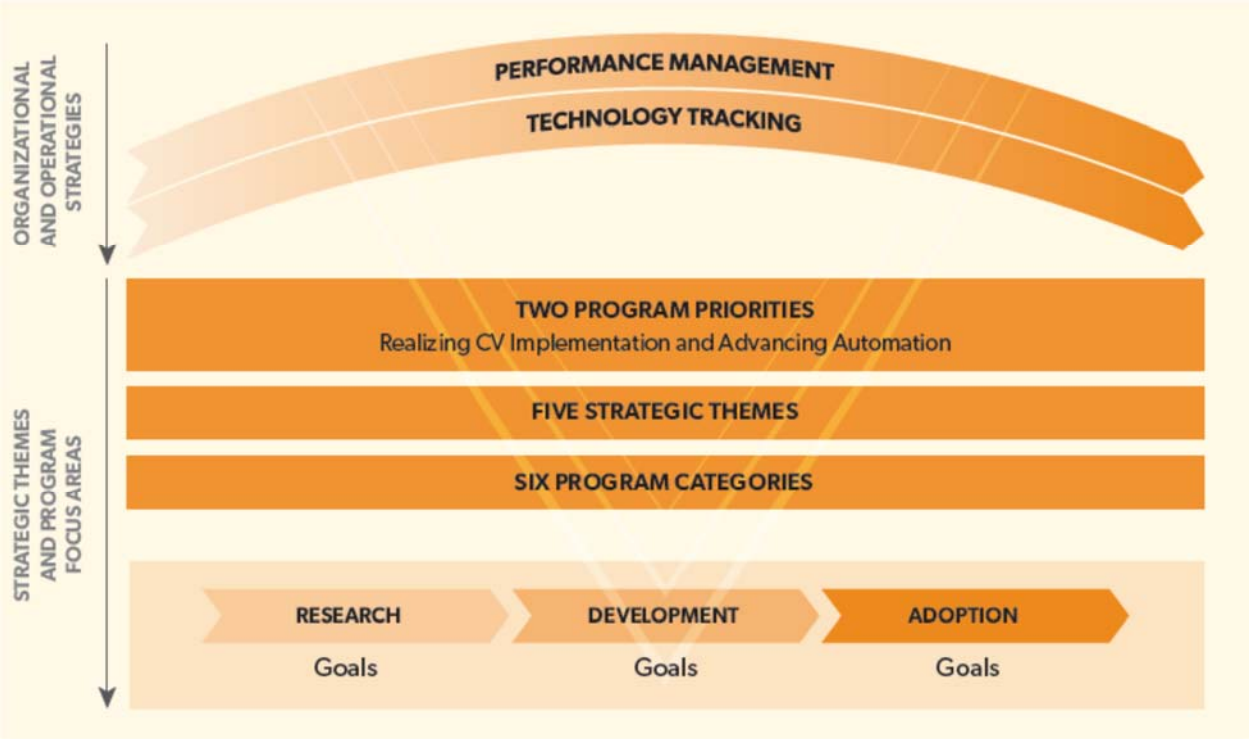

Figure 8: Overall View of USDOT ITS Strategic Plan with respect to Strategic Themes and Program Categories[26]

Overall, the five USDOT strategic priorities are:

1. Enable Safer Vehicles and Roadways
2. Enhance Mobility
3. Limit Environmental Impacts
4. Promote Innovation
5. Support Transportation System Information Sharing

Accordingly, the identified six program categories are:

1. ***Connected Vehicles*** (i.e. V2V and V2I technologies, protocols and standards)
2. ***Automation*** (i.e. automated road-vehicle systems that transfer vehicle control from the driver to the vehicle)
3. ***Emerging Capabilities*** (i.e. technological, market and demographic trends which have potential to transform transportation)
4. ***Enterprise Data*** (i.e. management and handling of increasingly generated transportation data)
5. ***Interoperability*** (i.e. effective communication of different ITS components)
6. ***Accelerating Deployment*** (i.e. addressing issues and questions with adoption and deployment of new ITS products)

[26] *ibid*

For each of the programs above, the strategic plan lists questions under "research", "development" and "adoption" categories to guide the deployment process. "Realizing connected vehicle (CV) implementation" and "Advancing Automation" are particularly emphasized as the main thrusts. This is not surprising given that the USDOT's previous strategic ITS plan for 2010-2014[27] is titled "Transforming Transportation through Connectivity" and extensively discusses transportation connectivity and related technologies. In other words, USDOT draws significant attention to these ITS areas as national priorities. Going forward, it would be advantageous for NYCDOT's ITS efforts to be aligned with these USDOT programs and national priorities. By aligning these ITS efforts and goals, NYCDOT can continue to position itself to allocate and justify federal funding for future ITS projects.

NYCDOT's ITS Position

Nationwide, NYCDOT is in a good position with existing sophisticated ITS deployments covering both roadway transportation and transit. There are ongoing initiatives and planning considerations that align well with USDOT's priorities, specifically with regards to NYCDOT's Connected Vehicle initiatives. Overall, NYCDOT has significant expertise and existing in ITS area, which makes NYC as one of the cities in the U.S. with a well-developed and 'used' ITS Regional Architecture in the ITS project development process.

NYCDOT is in a good position nationally, with existing sophisticated ITS deployments covering both roadway transportation and transit, significant ITS expertise, and ongoing involvement in Connected Vehicle initiatives.

Besides the regional integration, the worldwide review shows the trend of exploring the role of "big data" in ITS, which is not currently discussed in nationwide ITS strategic plans. Big data has been shown to have the potential to radically improve transportation operations[28]. This is not surprising as observed through the last several decades; Intelligent Transportation Systems (ITS) have been supplying necessary data for policy analysis and operations. The sources of transportation data can be 1) infrastructure-based sensors, 2) vehicle-based sensors, and 3) personal mobile devices[29]. Current ITS implementations are mainly based on infrastructure-based sensors, which will continue to be an important source for the foreseeable future[30]. Meanwhile, cloud computing and crowdsourcing technologies are considered to be well-developed in computer science, yet their applications in transportation are at early stages[31]. Considering the widespread adoption of smart devices, "crowdsourcing" as user-centered way of collecting information is also an emerging big data source. Based on Merriam-Webster Online Dictionary, crowdsourcing is defined as *"the practice of obtaining needed services, ideas, or content by soliciting contributions from a large group of people and especially from the online community, rather than obtaining them from traditional employees or suppliers"*. Crowdsourcing has been recently adopted in transportation through mobile phone applications such as "Waze" where users can actively report traffic information (e.g., accidents, congestion) and "StreetBump" where the users can provide information regarding road surface roughness by allowing the application to use the built-in accelerometer in their mobile devices. Given the increasing market penetration and use of mobile phones, the value and the uses of crowdsourced data are anticipated to increase in the future. In these respects, NYCDOT can

In addition to Connected Vehicles, NYCDOT can preserve its advanced role in ITS by incorporating *Big Data* and *Crowdsourcing* considerations into its strategic planning.

[27] USDOT, Transforming Transportation through Connectivity, http://www.its.dot.gov/strategicplan/pdf/ITS%20Strategic%20Plan%20Update%202012.pdf, October 2012
[28] Burt, M., Cuddy, M., & Razo, M. (2014). Big Data's Implications for Transportation Operations: An Exploration (No. FHWA-JPO-14-157). http://ntl.bts.gov/lib/55000/55000/55002/Big_Data_Implications_FHWA-JPO-14-157.pdf.
[29] USDOT ,Big Data and ITS., www.its.dot.gov/index.htm, October 2013
[30] Burt, M., Cuddy, M., & Razo, M. (2014). Big Data's Implications for Transportation Operations: An Exploration (No. FHWA-JPO-14-157). http://ntl.bts.gov/lib/55000/55000/55002/Big_Data_Implications_FHWA-JPO-14-157.pdf.
[31] Burt, M., Cuddy, M., & Razo, M. (2014). Big Data's Implications for Transportation Operations: An Exploration (No. FHWA-JPO-14-157). http://ntl.bts.gov/lib/55000/55000/55002/Big_Data_Implications_FHWA-JPO-14-157.pdf.
Jin, P. J., Fagnant, D., Hall, A., Walton, C. M., Hockenyos, J., & Krusee, M. (2013). Developing Emerging Transportation Technologies in Texas (No. FHWA/TX-13/0-6803-1), http://library.ctr.utexas.edu/ctr-publications/0-6803-1.pdf

follow the worldwide trend, and preserve its advanced role in ITS by incorporating big data and crowdsourcing considerations into its strategic planning.

Changes that Next-Generation ITS Brings

The capabilities that technology can deliver in transportation continue to go through a significant transformation. The technologies provide evaluation, control, and feedback capability step-changes across a number of high-profile technology platforms that result in major changes in how NYCDOT must operate, including but not limited to:

1. **Connected Vehicle Management –** the management of connected vehicles and any new roles, responsibilities and capabilities that brings, along with ITS needs for the Department.
2. **Autonomous Vehicle Management –** the management of autonomous (*i.e.:* ostensibly driverless) vehicles and any new roles, responsibilities and capabilities that brings, along with ITS needs for the Department.
3. **Integrated Corridor Management –** the management of integrated traffic corridors other and any new roles, responsibilities and capabilities that brings, along with ITS needs for the Department. Significant in this area are concerns over the operational and technological interfaces between NYCDOT and other agencies or agents.
4. **Data Mining –** the management and processing of volumes of new data sourced from ITS. This may include further consideration of Big Data initiatives and new data sources (e.g.: crowdsourced data)
5. **Adaptive Traffic Management –** the adaptive management of traffic through continuous real-time feedback that updates evaluation and control functions, either fully or partly autonomously

Through the adoption of strategies, objectives, and projects, these changes can be brought about operationally and technologically by three general time horizons:

1. **Rapid Change**
2. **Evolutionary Change**
3. **Removal**

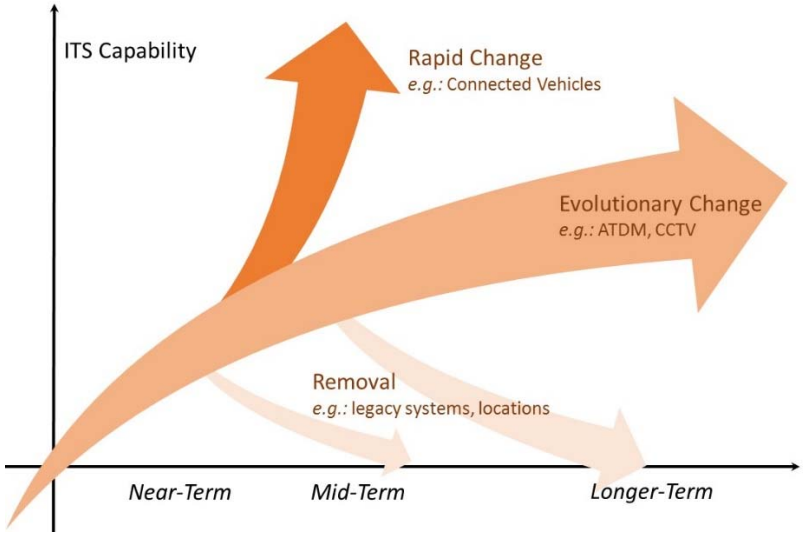

Figure 9. Types of ITS change at NYCDOT in the short, medium and long term.

NYCDOT should be seeking to predict and respond to transformational changes in transportation industry, identifying strategies that reflect these changing conditions, and provide flexibility to adapt as transportation conditions evolve over time.

5. Regional ITS Stakeholders

Transportation in the NYC metropolitan area involves multiple jurisdictions each performing significant data collection and possibly employing competing technologies. In addition to NYCDOT, the jurisdictions fall under the agencies such as: NYSDOT Region 10 and 11, Metropolitan Transit Authority (MTA), Transportation Operations Coordinating Committee (TRANSCOM), Port Authority of New York and New Jersey (PANYNJ), and the New Jersey Department of Transportation (NJDOT). To address the transportation complexity of the region, NYCDOT and other stakeholders participated in the development of the NYC Sub-Regional Architecture (NYCSRA). The NYCSRA aims to achieve the following ITS objectives:

- Improvements in operational efficiency.
- Ability to communicate and coordinate operations both at the local and regional level.
- Ability to exchange information within the agency and with other partners in the region.
- An Integrated Transportation Management System (ITMS)
- Ability to enhance transportation security and emergency management (i.e., The Disaster Recovery and Evacuation (DRE) market package in version 5.1 of the National ITS Architecture for emergency management). This version has yet to be included in the NYCSRA at this time.

In such a complex transportation environment, it is recognized that different strategies implemented by one agency or stakeholder impacts the others. Some of the ITS strategies implemented by other agencies are described in the sections below.

TRANSCOM ITS Strategic Plan

TRANSCOM is a coalition of 16 transportation and public safety agencies in the New York – New Jersey – Connecticut metropolitan region. It was created in 1986 to provide a cooperative, coordinated approach to regional transportation management. The 16 transportation and public safety agencies include New Jersey Turnpike Authority, New Jersey Department of Transportation, New York City Department of Transportation, New Jersey State Police, New York State Police, Port Authority of New York and New Jersey, Connecticut Department of Transportation, New York City Police Department, New York State Thruway Authority, Metropolitan Transportation Authority, New York State Department Transportation, MTA New York City Transit, New York State Bridge Authority, New Jersey Transit Corporation, Port Authority Trans-Hudson Corporation, and MTA Bridges and Tunnels.

TRANSCOM plays an important role to improve 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. TRANSCOM's role includes the integration of transportation and incident information and the management of regional ITS programs. TRANSCOM completed its own Strategic Plan for 2016-2018[32]. Various strategies employed by TRANSCOM are mentioned below:

1. *Improve transportation demand management across the regional transportation network*. TRANSCOM coordinates and develops a common operation during emergency transportation events such as severe weather and major planned events. In addition, TRANSCOM utilizes and enhances its central database and transit construction in order to mitigate disruption and conflicts.
2. *Maximize the availability of each member agency's data.* TRANSCOM enhances the primary and central source of regional transportation information including network travel times and incidents and construction information. In addition, it will enhance the

[32] TRANSCOM, 2016-2018 Strategic Plan, June 2016

efficiency of regional transportation communications and reduce lag time. TRANSCOM also increases accessibility of transportation information to public safety agencies and will standardize event language to more easily represent. Finally, TRANSCOM supports member agencies' social media efforts with a focus on commercial trucking associations and large companies.

3. *Increase member ability to access, sort, and analyze ITS data*. In order to increase member ability, TRANSCOM developed the Open Reach system to access, sort and analyze the data. Then TRANSCOM developed functional enhancements to the real-time data fusion/ data comparison module. Importantly, the TRANSCOM Open Reach system provides coordination, integration, validation, and verification of advanced transportation management and traveler information data which are being implemented by the 16 member agencies.
4. *Increase quantity and comprehensiveness of information.* TRANSCOM expanded the existing systems' capacity by including applications to freight, transit, parking, evacuation plans, and weather information. In addition, TRANSCOM developed a framework for pursuing regional level Integrated Corridor Management (ICM)/Active Transportation Demand Management (ATDM).
5. *Increase coordination during special events and severe weather condition*. In detail, TRANSCOM will maintain a database of the locations, dates, times for special events in the region. They will provide the most up-to-date regional construction information and coordinates construction planning. Finally, TRANSCOM will maintain a long-term data base of all construction planned for the region.

These strategies implemented by TRANSCOM will impact NYCDOT's efforts in providing real-time traveler information and coordinating real-time transportation incidents and events in the broader regional context.

NYSDOT ITS Strategies

Apart from TRANSCOM's research, NYSDOT is developing an ITS plan, "A Framework for Active Transportation and Demand Management in New York State" which has a bearing on the operations of NYCDOT infrastructure.

In order to implement ATDM statewide, four critical components from NYSDOT[33] are proposed to form the backbone of the State's approach. These four components are illustrated in the figure below. These four components are: a) new models of active collaboration, b) a focus on actionable multimodal information, c) dynamic management, and d) application in various travel market and contexts.

[33] NYSDOT, Working Together for Reliable Travel from Door to Door, December 9, 2015

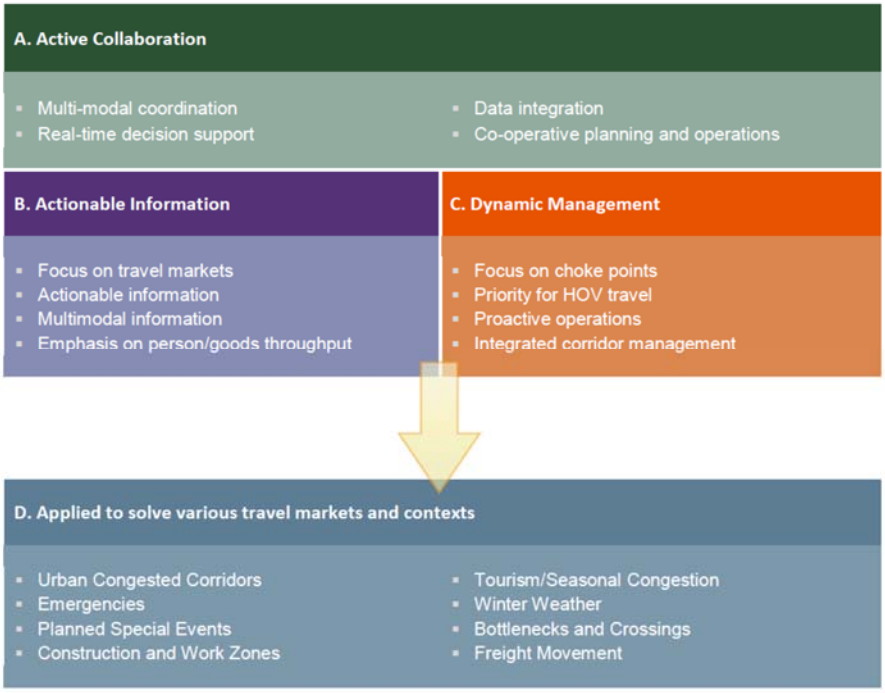

Figure 20: NYSDOT Statewide ATDM framework

Active Collaboration: this system will enhance models and partnerships for day-to-day operations. ICM focuses on managing a transportation corridor as a system considering freeways, arterials, transit services, and other transportation services. ICM also relays on a foundation of co-operation across multiple agencies and different management systems to achieve corridor-wide outcomes.

Actionable information: it will provide high-quality, tailored, and multimodal information to support diverse travel decisions and will be able to enable with rapidly expanding steams of real-time data through connected vehicles, public and private systems, and user-generated content. ATDM also supports a transformation in how users obtain information about every detail of their trip.

Dynamic Management: ATDM will create safe, reliable, and optimized facilities and corridors. Meanwhile, it will build on a robust intelligent transportation system (ITS), approaches in this research area can dramatically support regions and the State in preparing for and responding to changing travel conditions.

Applying ATDM in Different Contexts and Markets: ATDM provide a flexible set of tools to address different needs within New York and respond to events in the complex NYC metropolitan area. This area involves a wider array of modal options, partners, and strategies compared with a rural area with more limited road and transit options.

6. Recent NYCDOT ITS Projects and Initiatives

NYCDOT has implemented many ITS projects in the NYC area. In general, these ITS projects collectively aim to:

1. Increase mobility and travel safety in New York City
2. Increase the efficiency and effectiveness of the city's multi-modal transportation system
3. Increase the quality of life of its residents.

These aims are consistent with the transportation and infrastructure goals of the City's OneNYC plan. More specifically, these projects have included: installation of red light cameras, bus lane cameras, and sensors on bridges; development of systems and smartphone applications for parking payment, mapping of empty parking spots, and variable parking pricing; transit signal priority, and active traffic management. These projects build upon and enhance the operational capabilities and functionalities of the existing Joint Transportation Management Center (JTMC) (jointly operated by NYCDOT, NYSDOT, and NYPD) and the NYCDOT Traffic Management Center (TMC). A list of these projects dating back to 2005 is available in Appendix A. A summary of the most recent projects is provided below.

Procurement of Advanced Solid-State Traffic Controllers (ASTC)
NYCDOT has been undergoing a Traffic Controller Replacement Program since 2001. Most of the traffic controllers used in NYC are electromechanical controllers which design dates to the early 1900's. While these controllers are computer controlled and support variable timing by central commands, they cannot support complex intersections, phase skipping, or real-time traffic responsive operation. This program involves the development of a microprocessor-based electronic controller for the city. Since the new microprocessor-based advanced traffic controller is capable of implementing various traffic patterns for different traffic situations, it is an effective and reliable controller that will improve the efficiency of the roadways with less stop and delay time and therefore, reduce air pollution and improve public health.

Early Action for Implementation of an ITS system along the Belt Parkway
The purpose of this project is to implement an ITS system consisting of 20 traffic surveillance cameras, 20 vehicle detection equipment, 6 variable message signs, 9 travel time sign, 20 RFID transponder/reader systems, 2 HARs and communication equipment along the Belt Parkway corridor's service roads and ramps from 65th Street in Brooklyn to the Southern State Parkway in Queens. The entire length of the proposed project area is approximately 25 miles. This will serve as a foundation to establish a system that will provide real time information from CCTV, VMS's, vehicle's sensors, and HARs (Highway Advisory Radios). This project is proposed for ITS deployment using wireless communication as an early action to support the future NYSDOT fiber project installation.

Brooklyn Bridge ITS
This project involves the implementation of an ITS system consisting of 1.14 miles of fiber optics cable along the Brooklyn Bridge and its proximities, 4 VMSs, 10 traffic surveillance cameras, 10 vehicular detection equipment, and 12 Automatic Vehicle Identification Detectors. The communications with the field equipment and the Joint Traffic Management Center in Long Island City will be through fiber optics. In order to minimize capital costs, the fiber optics link that will be installed on the bridge will be interconnected to the existing control point on FDR Drive/BQE fiber. The installation process for both the traffic surveillance cameras and the vehicle detection equipment will replicate the successful deployment the NYCDOT currently uses to monitor traffic conditions on other East River bridges such as the Queensboro Bridge, Manhattan Bridge, and Williamsburg Bridge.

Flushing Active Traffic Management
To improve efficiency of surface transportation systems in Flushing area, NYCDOT is developing an integrated traffic control system conforming to the Advanced Traffic Demand Management (ATDM) framework. In addition, an integrated traffic control system is proposed to combine the essential functions of two main subsystems: a central-based Adaptive Traffic Control (ATC) subsystem and a central-based Transit Signal Priority (TSP) subsystem. Both subsystems would utilize the New York City Wireless Network (NYCWiN) to communicate with field data collection devices. The ATC subsystem is proposed to

cover the core downtown Flushing area between Northern Boulevard and Sanford Avenue, with extended real-time detection along Main Street and Kissena Boulevard south to the Long Island Expressway service road (Horace Harding Expressway). It is anticipated that the proposed ATC within the downtown core would permit development of intersection-level adaptive signal timings at congested locations based on flows and occupancies, in addition to monitoring segment travel times.

Implementation of ITS system along the Jackie Robinson Parkway
The purpose of this project is to implement an ITS system consisting of 12 traffic surveillance cameras, 12 vehicle detection equipment, 3 variable message signs, 4 travel time signs, 7 Automatic Vehicle Identification Detectors, and communication equipment along the Jackie Robinson Parkway from GCP/Whitestone Expressway in Queens to Bushwick Avenue in Brooklyn including ramps and service roads. The entire length of the proposed project area is approximately 5 miles. Communications with the field equipment and the Joint Traffic Management Center in Long Island City, Queens will be through the NYCWiN. The NYCWiN project has been already deployed in the project area using NYC City funds, as a result wireless coverage for ITS deployment is available throughout the Jackie Robinson Parkway corridor within the project area. The central system expansion (software and hardware for video and data) will be required to integrate the new ITS devices to the existing TMC systems. This task will include the installation of additional digital video switching equipment and routers, video management software, travel time software and flow map updates.

Implementation of ITS system along the Korean War Veterans Pkwy
This project aims to implement an ITS system consisting of 12 traffic surveillance cameras and 12 vehicle detection equipment 2 variable message signs, 4 Travel time sign, 4 RFID transponder/reader, 1 HAR, communication equipment, and central software equipment utilizing NYCWiN coverage along the Korean War Veterans Pkwy from Richmond Avenue/S.I. Expressway Interchange Area to Outer Bridge crossing. The NYCWiN project has been already deployed in the project area using NYC City funds, as a result wireless coverage for ITS deployment is available throughout the Korean War Veterans Parkway corridor within the project area. NYCWiN in the project area and the city when it will be fully deployed will provide a significant communication backbone for this ITS planned project. The accelerated deployment of NYCWiN has enabled the project to start upon obligation of FHWA funding. The entire length of the proposed project area is approximately 4 miles. This project is proposed for ITS deployment using Wireless Communication as an early action to support the future New York State DOT fiber project installation.

Midtown In Motion – Active Traffic Management
In July 2011, NYCDOT commissioned the Midtown in Motion (MIM) project, which included Active Traffic Management (ATM), some operational improvements (e.g. changes in lane usage), and enforcement. This was focused on improving mobility in the core of Manhattan, using an ATM system that adjusted traffic signals in real time based on field data. The ATM component of MIM is a hierarchical system with a two levels of system control for strategic and tactical objectives. Level 1 Control includes implementing three different sets of plans that changes traffic approaching the zone. This is avenue specific and is implemented at the traffic management center (TMC) with an operator override. Level 2 Control is intersection specific and is part of automated control that changes signal splits in real time.

Retiming of 1503 traffic signals for 33 major routes in the four outer-boroughs and 300 intersections in Manhattan
By retiming and coordinating signals in relation to each other, groups of vehicles can travel through a corridor with minimal or no stopping and this can significantly reduce delays experienced by motorists, which can improve safety and reduce fuel consumption and air pollution emissions. The current signal timing was implemented many years ago, and since then there has been significant growth and development in these areas that has affected these roadways' traffic and signal intersection design. As a result, the existing signal timing is not efficient with the new traffic patterns. The signal retiming according to the new traffic patterns will improve the signal coordination, thereby ensuring that vehicles can travel through a series of intersections with minimum delays and stops, reducing emissions and fuel consumption. The project will enable the city to retime the traffic signals of major arteries in the outer

boroughs. This would increase mobility by providing better movement for the driving public and improving the level of service for all vehicles.

Smart Lights – Adaptive Control
The Smart Lights system builds upon DOT's existing investments in ITS infrastructure - new advanced traffic controllers, NYCWiN, a NYC centralized Traffic Control System and the adaptive control system (ACDSS). ACDSS is a multi-regime, variable objective, adaptive signal control system. As with any adaptive system, the goal is to have a signal system that dynamically adjusts to traffic demand in order to maximize the efficiency of operations. The system includes a number of checks to screen the detector data to ensure that it is feasible and also to check that all components of the system are communicating, prior to making a timing adjustment. If any of the fail-safes are triggered, the background (base) plan is deployed. The system has been deployed and is currently operational.

Integrated Corridor Management
Given the complex nature of the NYC metropolitan region with multiple jurisdictions, competing technologies, improved data collection and ITS capabilities, the NYCDOT capitalized the work performed by other agencies to promote strategies over larger areas and among multiple agencies. With support from FHWA, a group of agencies started to work towards strategies sharing information, best practices and working together to maximize the output and benefit to users. Subsequently, ICM was undertaken preceded by active traffic demand management (ATDM) strategies. The I-495 corridor was chosen for the ICM shown in Figure 11.

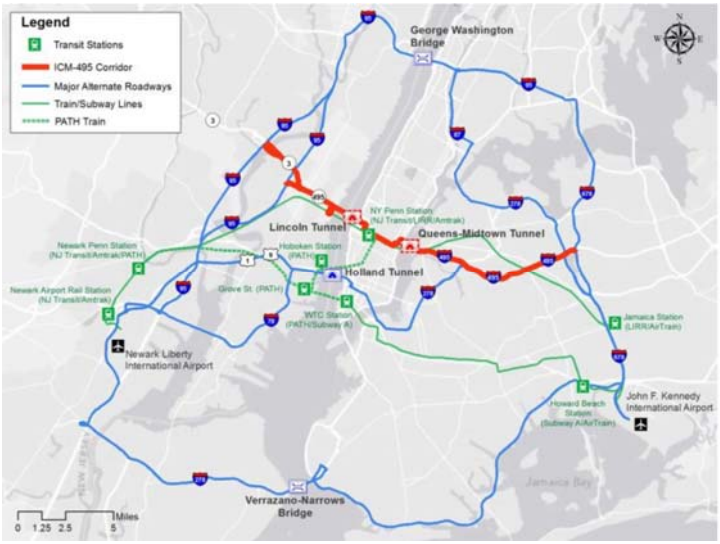

Figure 11. ICM and Alternate Routes

Specifically, given that the Queens Midtown Tunnel (QMT) is under the jurisdiction of NYCDOT, the ITS systems deployed along the QMT include:

1. CCTV cameras and fiber
2. Weather systems covering all the bridge facilities with both surface and atmospheric sensors
3. NTCIP-complaint Variable Message Signs (VMS) and Variable Speed Limit Signs (VSLS)
4. TRANSMIT System
5. Lane Use Signal Control System
6. Video Incident Detection
7. Advanced Traffic Information System
8. The Operations Central Command Center (OCCC) is the nerve center of MTA B&T Operations, including linkages to individual facilities and the JTMC Integrates all the facilities to one another and to OCCC

NYC Connected Vehicle Pilot

With the rapid rise in traffic sensing and communication technologies, vehicles are becoming smarter. Thus many safety and mobility goals can be achieved by means of connecting vehicles to one another and with the infrastructure. The USDOT has set standards for the connected vehicle (CV) technology. It has also setup a program to spur innovation among early adopters of CV technology.

In 2015, USDOT announced the selection of three connected vehicle deployment sites as Wave 1 participants in the Connected Vehicle Pilot Deployment Program. The three sites collectively envision a broad spectrum of applications enabled by connected vehicle technologies driven by site-specific needs. The vehicle-to-vehicle (V2V) and intersection communications can be exploited to improve vehicle flow and pedestrian safety in high-priority corridors in New York City.

CV technology will provide potential and tools for achieving the Vision Zero initiative. The dense urban grid network with many short street blocks, heavy pedestrian traffic, etc. of NYC result in many safety and mobility problems. The CV technology can, potentially, enable solutions for many transportation problems. The safety goals proposed to reduce crashes and pedestrian fatalities and increase the safety of travelers in all modes of transportation. NYC's planned deployment provides an ideal opportunity to evaluate CV technology and applications in tightly-spaced intersections.

The NYCDOT will deploy CV technology at approximately 250 intersections in Midtown Manhattan and central Brooklyn will be instrumented with Roadside Equipment (RSE) to communicate with up to 10,000 vehicles with aftermarket safety devices (ASD). The RSE will also be deployed along a highway, namely, the FDR drive. The instrumented vehicles include approximately:

- 6,000 Taxis - Yellow Cabs (Authorized for "hail" fares in lower Manhattan and airports.)
- 1,500 MTA Buses – which frequent lower Manhattan
- 500 Sanitation & DOT vehicles servicing Manhattan
- 500 UPS vehicles servicing Manhattan

Advanced infrastructure that will be useful in enabling the CV pilot in NYC include:

- 350 Signalized Intersections with CV technology – already "Advanced Traffic Controllers"
- Megabit Wireless communications backhaul covers all 5 Boroughs
- Extensive fiber network for backhaul at key locations
- Central system that integrates all traffic signal and ITS devices City-wide

7. Strategic Vision, Goals and Mission for ITS at NYCDOT

Strategic planning provides a vision, goals, and strategies for building on existing organizational strengths, addressing needs, and overcoming existing and anticipated challenges. To be successful, strategic planning must consider technical, operational, and organizational concerns from multiple stakeholder perspectives. Each stakeholder at NYCDOT needs to understand the comprehensive ITS vision, how the ITS vision supports the Department's strategic priorities, what each stakeholder's role in the ITS picture is, and what the goals are to achieve that vision. To realize those goals, a mission that describes what the organization, as individuals or a team, will do on a daily basis to secure the vision is also required. Together, the ITS Vision, the ITS Goals, and the ITS Mission are intended to help guide stakeholders in making informed ITS investment decisions and overcome challenges.

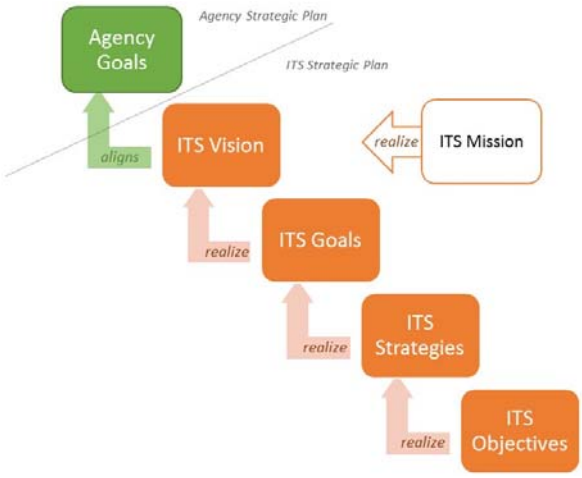

Figure 12. Relationship between the Agency-Wide Strategic Plan and this ITS Strategic Plan

NYCDOT's ITS Strategic Plan contains the following elements:

ITS Vision

Aligned to NYCDOT's overall strategic objectives, this statement encapsulates the over-arching theme of ITS advancement that NYCDOT seeks. It is:

Serving the city and region's transportation needs through the coordinated deployment of leading-edge ITS technologies, making NYCDOT a global example of effective, sustainable ITS management and use in a major metro center.

ITS Goals

Aligned to NYCDOT's overall strategic objectives, these goals are measurable criteria for advancing the vision. They are:

Enabling NYCDOT to achieve its strategic goals through the deployment of tailored ITS technologies that:

a. **achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback tools**

b. **enhance planning and policy development through improved data quality and data analysis**

c. **enhance the quality of communications with the traveling public**

d. **keep pace with evolving local and national ITS capabilities and standards**

e. **enhance the ability of the organization to deliver and manage services given limited organizational resources**

ITS Mission

What the organization seeks to do with regards ITS on a daily basis to achieve the Goals and Vision.

- Better evaluation
- Better control
- Better communication

8. NYCDOT ITS Strategy Areas

Six (6) actionable areas for strategy development are identified as part of this NYCDOT ITS Strategic Plan. These strategy areas describe what NYCDOT must do in order to realize its ITS goals. Within each area are a set of specific strategies with associated objectives and measures of effectiveness.

The areas are aligned with and are designed to serve the achievement of ITS Goals. The areas apply to a broad variety of NYCDOT management functions and operating modes. The areas are provided as follows:

Figure 13. ITS Strategic Areas

- **Enhancing Operational Capabilities –** This strategic area is concerned with identifying and supporting the operational activities that need to be supported by ITS going forward, the manner in which they are supported, and opportunities for these operational activities to be transformed by evolving ITS technologies.

- **Advancing Operational Planning -** This strategic area is concerned with advanced utilization of data in support of real-time operations, and the analysis of historic data to yield operational improvements.

- **Emerging Technology Readiness –** This strategic area focuses on horizon searching; figuring out how to adopt new technologies, what should change operationally or organizationally, and what level of adaption or adoption is needed.

- **Lifecycle Management –** This strategic area is concerned with the management of ITS through development, design, O&M and retirement activities by an organization and process model that is engineered for that purpose. It is designed to ensure that ITS can be designed, procured, and implemented in a flexible and timely manner to meet needs as they are identified.

- **Professional Capacity Building –** This area involves ongoing professional education and increasing awareness of the role of ITS and ITS planning on achieving broader agencies goals and objectives.

- **Outreach and Communication –** This area describes efforts to improve communication with suppliers, vendors, and partners to achieve ITS goals. This area also includes efforts to enhance communication of technology advancements and technology-enabled service enhancements to the public.

Enhancing Operational Capabilities

In order to realize NYCDOT's *operational goals* **in Arterial Management, Parking Management, Expressway Management, Traveler Information, Road Works Management, Transit Management, Cycling Traffic Management, Pedestrian Management, Emissions Management, for Connected Vehicle, Autonomous Vehicle, Conventional Vehicle, Multi-Vehicle Type, Integrated Corridor Management, Emergency Response Management, Incident Management, Congestion and Diversions, Routine Conditions,** the ***ITS Strategies*** are as follows:

ITS Strategies - Enhancing Operational Capabilities	
Strategy OPS-1	**Invest in new ITS technologies and platforms that enhance** ▪ **Situation Awareness** ▪ **Situation Assessment** ▪ **Command and Control** ▪ **Feedback and Communication** **in order to better perform traffic monitoring and management action.**
Description	Increasing NYCDOT's operational capabilities means enhancing the functionalities that ITS delivers to the region. These functionalities would enhance and support those already in use, including those in use at the JTMC/TMC.
Objectives	▪ Refine ATDM capabilities
Strategy OPS-2	**Prioritize ITS Investment based on:** ▪ **Operational Priorities** ▪ **Priority Corridors and Sites** ▪ **Capability Gaps** ▪ **Improved System Resiliency and Reliability** ▪ **Safety and Performance Gaps**
Description	Enhance NYCDOT operational capabilities based on documented needs analyses.
Objectives	▪ Identify investment locations based on challenges at those locations ▪ Identify ITS functionalities that would best address challenges at those locations ▪ Prioritize investments based on available resources and existing and adjacent ITS and ITS programs at those locations
Strategy OPS-3	**Strategically align ITS investment with regional and national:** ▪ **ITS Strategies**

	▪ **ITS Technologies** ▪ **ITS Standards**
Description	Enhance NYCDOT operational capabilities to remain competitive for federal and regional funding opportunities and take advantage of benefits from regional and national ITS coordination.
Objectives	▪ Assess the applicability of certain ITS technologies and platforms to the NYC specific context ▪ Tailor deployments of ITS to fit the NYC specific context ▪ Participate in regional ITS investment coordination and strategy sharing ▪ Sponsoring periodic updates to the NYC Sub-Regional ITS Architecture

The planning process at NYCDOT for traffic operations requires detailed data to be fed back into the design, needs, assessment, prioritization, architecture, concept selection processes as well as validation of conformance to expected performance.

ITS Strategies - Advancing Operational Planning	
Strategy PLA-1	**Better support planning and analysis needs with richer data from ITS investments**
Description	In accordance with TSMO principles, better integrate ITS data collection and usage into project planning.
Objective	▪ Identify which data needs can be best served with ITS ▪ Identify derivative benefits that certain ITS have for planning and analysis ▪ Identify ITS data benefits for internal NYCDOT planning and external planning agencies (e.g., MPO project planning)
Strategy PLA-2	**Integrate planning and analysis needs into ITS investment activities**
Description	Ensure that projects with ITS components include planning needs by further formal integration of planners into the project development process.
Objective	▪ Include Planning Needs and Concerns in ITS Concept Development ▪ Include Planning Needs and Concerns in ITS System Selection ▪ Include Planning Needs and Concerns in ITS Design

Emerging Technology Readiness

With a generational evolution in technology capabilities and expectations, NYCDOT needs to be ready more than ever to integrate emerging technology into to their organization.

Strategies and objectives in the *Enhance Operational Capabilities* discuss what is needed to be accomplished in terms of specific outcomes for emerging technologies – Connected Vehicles, Autonomous Vehicles, and Integrated Corridor Management.

This section provides the strategies and objectives necessary to ready NYCDOT for the introduction of those new technologies and system platforms, both from a technology readiness, competency model, and organizational change management.

ITS Strategies - Emerging ITS Technology Readiness	
Strategy RED-1	**Assess Emerging ITS Technologies value to NYCDOT, including:** ▪ **Connected Vehicle Technologies** ▪ **Integrated Corridor Technologies** ▪ **Autonomous Vehicle Technologies**
Description	Increased investment in assessing emerging technologies with predicted transformational impact on the transportation network and services.
Objective	▪ Technology Scanning ▪ Assess Emerging ITS applicability to NYC/NYCDOT context ▪ Gap Assessment between 'as-is' and tailored 'to-be' ▪ Transition Planning ▪ Stand-up Emerging ITS Technology Forum ▪ Coordinate Emerging ITS Planning with regional partners
Strategy RED-2	**Prepare NYCDOT for Emerging ITS Technologies**
Description	Prepare NYCDOT for new technologies by continuing to be on the forefront of technology pilot projects, particularly those adapted to a complex urban environment.
Objective	Identify additional pilot projects and scope for ▪ Connected Vehicle Technologies ▪ Autonomous Vehicle Technologies ▪ Pilot ICM Technologies
Strategy RED-2	**Manage the deployment of Emerging ITS Technologies and Platforms**
Description	Provide NYCDOT staff with training and tools to manage emerging ITS technologies.
Objective	Identify additional professional capacity training and education opportunities related to: ▪ Connected Vehicle Technologies ▪ Autonomous Vehicle Technologies ▪ ICM Technologies

	▪ Big Data Analytics Identify management resources and determine if additional professional staff support is necessary.

For a solid system of the future, lower cost, and less burden on the management and business processes that need to be performed by NYCDOT, a strategic lifecycle management approach is necessary. Based on *ISO/IEC 15288:2008 Systems and software engineering - System life cycle processes*, managing the entire lifecycle from point of inception through design and manufacturing and disposal of manufactured products. There are four major activities involved

a. **Establishing Technical Processes;**
b. **Establishing Technical Management Processes;**
c. **Establishing Agreement Processes;**
d. **Establishing Organizational Project-Enabling Processes;**
e. **Tailor to the NYCDOT Context**

ITS Strategies - Lifecycle Management	
Strategy LCM-1	**Acquire ITS Lifecycle Management technologies.**
Description	Identify tools to assist NYCDOT decision-makers in tracking ITS performance throughout its lifecyle.
Objective	▪ Acquire ITS Configuration Management Tools ▪ Acquire ITS Asset Management Tools
Strategy LCM-2	**Embed Core Systems Engineering approach into ITS management.**
Description	Identify opportunities to seamlessly incorporate the V-Diagram into the way ITS projects are planned, designed, operated, maintained, and replaced/upgraded.
Objective	▪ Ensure that ITS Projects document their Systems Engineering process in accordance with federal requirements. ▪ Ensure that the NYCSRA is consulted as ITS projects are planned, designed, and implemented. ▪ Identify potential improvements to project design guidelines to support Systems Engineering approach. ▪ Identify performance measures to be incorporated for ITS during operations and maintenance.
Strategy LCM-3	**Establish ITS Technical Management Processes into ITS management.**
Description	Establish ITS technical management processes into ITS management.
Objective	▪ Project Planning and Checkpoint Review ▪ Project Assessment and Control ▪ Decision Management ▪ Risk Management

	▪ Configuration Management ▪ Information Management ▪ Measurement Process ▪ Quality Assurance Process
Strategy LCM-4	**Establishing Agreement Processes**
Description	Establish processes to refine and streamline agreement on ITS engineering design and procurement.
Objective	▪ Evaluate Source-Selection Strategies in tandem with engineering design ▪ Evaluate Procurement Approach Strategies in tandem with engineering design ▪ Identify New ITS Funding Models ▪ Identify New ITS Procurement Models
Strategy LCM-5	**Establish Organizational Project-Enabling Processes**
Description	Set up processes internal to NYCDOT to enable an efficient and flexible ITS implementation procedure.
Objective	▪ Establish an ITS Asset Management program ▪ Policy and Procedure Strategies ▪ MOU and Agreement Strategies ▪ Stand Up Program Office ▪ Stand Up Standards ▪ Business Process Change

Professional Capacity Building

A critical part of organizational preparedness is the capabilities and support of staff to adopt and utilize new ITS systems and ITS projects and programs. The role of ITS within an organization is classically under the traffic management division. At the same time, several other divisions may utilize those ITS, benefit from them, or integrate them to other divisional units. In addition, other divisional units can themselves adopt their own ITS, meaning parallel programs and concerns in effect at the same time. Coordination in these cases is a key issue.

There are three key strategies in this area:

ITS Strategies - Professional Capacity Building	
Strategy PRO-1	**Run NYCDOT ITS Training Programs for Department staff and Partners**
Description	Raise ITS understanding and awareness at all levels within NYCDOT.
Objective	Perform Professional Capability Assessment and Development Roadmap ▪ On deployed Systems ▪ On ITS/Systems Engineering
Strategy PRO-2	**Provisioning Staff with the Competencies to Succeed**
Description	Provide training and education opportunities to technical staff to establish robust and resilient institutional knowledge regarding ITS
Objective	▪ Identify Gaps in Current ITS professional staff and ITS capabilities ▪ Ensure future ▪ Identify new methods of attracting staff ▪ Retaining ▪ Developing

Outreach and Communication

As part of raising public awareness about safety and mobility, NYCDOT needs to communicate to the world what ITS is available to assist in delivering certain operational capabilities. What ITS systems and services are available and to whom needs to be communicated. What ITS projects and programs that require integration of regional stakeholders needs to also be communicated. How to source new ITS also needs to be addressed via networking, conferencing, and discussion with others.

There are:

ITS Strategies - Outreach and Communication	
Strategy OUT-1	**Identifying ITS Funding Sources**
Description	Identify funding sources for ITS projects, including federal, state, and local intiatives, new business models, and potential private-public partnerships.
Objective	Identify new Funding Models ▪ For capital equipment ▪ For O&M Trail new funding model on non-critical infrastructure projects Identify new Funding Sources
Strategy OUT-2	**Foster Partnerships in ITS Investment and Operation**
Description	Establish strong institutional relationships with regional partners.
Objective	Perform Needs Gathering Engagements with regional partners Develop ITS Agreements (MOUs, etc.) with regional partners
Strategy OUT-3	**Public Outreach**
Description	Provide additional public outreach to raise awareness of ITS initiatives and benefits provided by ITS.
Objective	Identify opportunities for Public Outreach, such as: ▪ Public Information Campaigns ▪ Advertising ▪ Schools Programs

Common Approaches

In addition to the strategic areas described above, several approaches to achievement of NYCDOT's ITS goals and objectives can be considered common across all the areas. Though these are not strategic considerations of themselves, they do provide guidance in strategy adoption. Common approaches are provided as follows.

ITS Guidance – Common Approaches	
Approach CMA-1	**Regional Collaboration and Resource Sharing**
Description	Explore opportunities for regional collaboration to take advantage of competitive funding advantages, economies of scale, and seamless service provision.
Tactics	▪ Sharing approved Strategic Plans for wider coordination and implementation ▪ Utilizing ITS Architecture in Planning Process ▪ Engagement and contribution in regional forums and committees
Approach CMA-2	**Phased Development**
Description	Focus ITS developments on phased development and deployments to establish early success and build on success as resources and capabilities evolve.
Tactics	▪ Pilot Programs ▪ Incremental Builds
Approach CMA-3	**Leaner Processes**
Description	Explore lean methods to enhance efficiency of business processes.
Tactics	▪ Supplement project management processes with agile and lean methods ▪ Establish working group to investigate improve business process flows
Approach CMA-4	**Performance Measures**
Description	Develop additional ITS Performance Measures.
Tactics	▪ Monitor federal performance measure requirements, including recent notice of proposed rule-making ▪ Establish working group to define ITS performance measures to comply with federal requirements ▪ Assess the need for additional performance measures on a project-by-project basis

9. Achieving the ITS Vision and Goals

To support achievement of the strategies and objectives described in this 2016 ITS Strategic Plan, NYCDOT will advance the plan in four key ways.

Embedding ITS Strategy in the Agency-Wide Strategic Plan

Through a facilitated approach, this 2016 ITS plan will be provided as an input to the Agency-wide strategic plan describing the transportation strategy for New York City. Updates to both plans based on alignment of their goals, strategies, and objectives, will also be performed.

Implementing the ITS Strategies

The Strategic Plan should be translated into an ITS implementation plan –identifying specific projects that may have ITS components and relative timeframes for deployment. Specific actions would include:

- Classifying ongoing and planned projects against each strategic area
- Characterizing NYCDOT's capability in each of the strategic areas
- Identifying capability needs, gaps, or risks
- Prioritizing specific projects in each of the strategic areas based on goals and constrains
- Plotting timeline of development in each strategic area over the next 5-15 years
- Utilizing the plan in support of future ITS project development and funding requests

Inserting NYCDOT's ITS Strategy into the Regional Transportation Effort

This 2016 ITS plan will serve as an input to the regional strategic MPO planning efforts, and shall be introduced through existing and newly created forums.

Revisiting the Strategic Plan as a Living Document

This plan will be periodically revisited by NYCDOT to remain consistent with NYCSRA, the agency Strategic Plan, and other local and regional transportation efforts. Two general approaches will be adopted:

a. Re-assessment of the plan every 12 months, where the Agency will briefly examine the progress of ITS against the Strategic Plan, and determine what adjustment in planning priorities, or the Strategic Plan, that need to be made.

b. Refresh of this plan every 36 months.

Appendix A – ITS-related projects implemented by NYCDOT[34,35]

#	Title	Year	Estimated Cost ($M)
Systems Engineering Support Services			
1	Engineering Design & Inspection for an ITS Related and Planning, Contract-A Project 1 a, TOPICS-IV	2005	5.0
2	Engineering Design & Inspection for an ITS Related and Planning, Contract-B	2005	5.0
3	Systems Engineering Agreement # 11 for TOPICS-IV.	2005	-
ITS Systems Center to Center Integration			
4	New York City Multi-agency Integrated Transportation Management System (ITMS) a. Design phase-Functional Requirements b. Hardware/Software Integration, TMC to TMC Interconnectivity, Equipment MTA Jamaica Station and Randall Island TMCs	2005	0.9 1.8
TOPICS-IV Traffic Signals Computerization, Brooklyn/Bronx			
5	Communications-Wireless Network	2005-2006	8.0
6	Field Construction (Furnish & Install)	2006	8.0
7	Retiming of 1503 traffic signals for 33 major routes in the four Outer-boroughs and 300 intersections in Manhattan	2008-2014	3.0
Procurement of Actuated Signals Traffic Controllers (ASTC)			
8	Actuated Signals Traffic Controllers (ASTC) Procurement Phase-1 1000 units	2002-2005	5.5
9	ASTC Procurement Phase-2, 5000 units 2200 for TOPICS-IV Brooklyn/Bronx 2800 for Non-VTCS applications	2005-2008	30.0
10	Battery Back-Up System for 1000 signals	2005	2.0
11	Adaptive Traffic Control System (S.I. College)	2006	-
12	Procurement of Advanced Solid-State Traffic Controllers (ASTC)	2002-2013	45.0
13	Smart lights-Adaptive Control	2012-2014	0.5
Advanced Traffic Management Systems Expansion			
14	Local Streets Network and Incident Management System (Install fiber Cable Williamsburg Bridge to Battery park)	2006?	4.0
15	FDR Drive ITS Elements (CCTV, DMS, Detection). To Harlem river drive.	2005-06	4.0
16	Fiber Network for Brooklyn, Bronx and Queens	2006-09	4.6
17	Lower Manhattan ITS	2005	-
18	Williamsburg Bridge ITS Elements	2004	-
19	Queens Borough Bridge ITS Elements	2004	-
20	Manhattan Bridge ITS Elements	2004	-
21	Third Avenue Bridge ITS Elements	2006	-
22	Early Action for Implementing of ITS system along the Belt Parkway	2010-Present	5.0
23	Brooklyn Bridge ITS	2014-Present	5.0

[34] NYCDOT, Email conversations with NYCDOT staff regarding recent ITS-related projects, August 2015.
[35] New York City Department of Transportation, Strategic Intelligent Transportation Systems (ITS) Deployment Plan for New York City, Prepared by UITSC, Polytechnic University, December 2005.

#	Title	Year	Estimated Cost ($M)
24	Flushing Active Traffic Management	2015-Present	1.0
25	Midtown In Motion – Active Traffic Management	2010-2013	3.5
Advanced Traffic Management Systems for New York City Expressways CMAQ (Congestion Management and Air Quality) Funded			
26	Implementation of ITS System Along New England Thruway (I-95) (Pelham Parkway-City line- BRONX)	2007	2.45
27	Jackie Robinson Parkway (GCP- Jamaica Ave., six miles)-Queens	2006	2.2
28	Cross Island Parkway (Whitestone Parkway to Southern State Parkway)-Queens	2007	1.35
29	Henry Hudson Parkway (GWB-City line)	2007	3.2
30	Belt Way , Brooklyn-Queens (65 street to Southern State Parkway)	2006 2007 2008 2009	2.0 1.5 1.5 3.1
31	Korean War Memorial Veteran Parkway, Staten Island (Richmond Ave. to Outer Bridge Crossing)	2008	2.5
32	Implementing of ITS system along the Jackie Robinson Parkway	2010-Present	3.0
33	Implementing of ITS system along the Korean War Veterans Pkwy	2010-Present	3.0
Advanced Public Transportation System (APTS)			
34	Traffic Signal Priority Control for Transit Vehicles-Staten Island (10 intersections on Victory Blvd.)	2005	0.7
Advanced Traveler Information System (ATIS)			
35	Advanced Traveler Information System –for 15 miles Citywide installation, 50 CCTV, 630 RTMS detectors for travel time display	2006?	4.0
Web-based Traveler Information ATIS			
36	Vehicle-flow rates, Maps, Sensor Network for Travel time estimation	2006	-
Video Based-Radiation Detection System for Evacuation			
37	Commercial-Truck Detection System for Radio Activity	2006	-

Appendix B – Comparison of U.S. ITS Strategic Plans

In order to put NYCDOT's ITS needs into the national perspective, the project team surveyed the ITS plans which are available online. The table below summarizes the number of ITS plans surveyed.

Table B-1: Number of Surveyed ITS Studies

	Before 2010	After 2010	Total
City ITS Plans	5	8	13
NYC Region	8	3	11
Other States and Regions	19	14	33

Below is a complete list of ITS plans reviewed:

NYC Metropolitan Region and Around

1. NYSDOT, Intelligent Transportation Systems Strategic Plan Draft Technical Memorandum # 2 "Regional Architecture", August 2002.
2. Delaware Valley Regional Planning Commission, Philadelphia Traffic Operations Center: Concept of Operations, December 2010.
3. PennDOT, Regional ITS Architecture, November 2004.
4. New York City Department of Transportation, Strategic Intelligent Transportation Systems (ITS) Deployment Plan for New York City, Prepared by UITSC, Polytechnic University, December 2005.
5. The Port Authority of NY&NJ, INTELLIGENT TRANSPORTATION SYSTEM INTELLIGENT TRANSPORTATION SYSTEM REPLACEMENT PROGRAM, November 2012.
6. NJDOT, ITS Investment Strategy 10-Year Program, FY07-16, Prepared by Statewide Traffic Operations ITS Engineering, March 2007.
7. New Jersey Highway Authority, ITS Deployment Planning Study, December 1997.
8. Connecticut DOT, Intelligent Transportation Systems "ITS": A Strategic Plan for the Capitol Region, November 1997.
9. South Western Regional Planning Agency, Intelligent Transportation Systems Strategic Plan, October 2008.
10. Cambridge Systematics, South Western Region ITS Strategic Plan, July 2009.
11. National Park Service U.S. Department of the Interior, Cape Cod National Seashore Intelligent Transportation Systems Implementation Plan, March 2011.

Cities

1. Metropolitan Information Center Metropolitan Washington Council of Governments, Strategic Plan for the Metropolitan Washington Management, Operations, and Intelligent Transportation Systems (MOITS) Planning Program, National Capital Region Transportation Planning Board Metropolitan Washington Council of Governments, June 2010.
2. Kimley-Horn and Associates, Inc., City of Tempe ITS Strategic Plan, April 2012.
3. Seattle Department of Transportation, ITS Strategic Plan 2010-2020, March 2010.
4. Genesee Transportation Council, Intelligent Transportation Systems (ITS) Strategic Plan for Greater Rochester, Prepared by IBI Group, February 2011.
5. PB Farradyne Battelle, Intelligent Transportation System Plan, 2011.
6. Metro Los Angeles County Metropolitan Transportation Authority, Los Angeles County Arterial Intelligent Transportation System (ITS) Inventory and Architecture Project, Prepared by Meyer, Mohaddes Associates, December 2004.

7. Iowa Department of Transportation, Intelligent Transportation System Plan, 2008
8. Denver Regional Council of Governments, Denver Regional Intelligent Transportation Systems Strategic Plan, October 2010.
9. Denver Regional Council of Governments, Regional Intelligent Transportation Systems Deployment Program, June 2014.
10. Des Moines Area MPO, Des Moines Metropolitan Area ITS Strategic Plan, Center for Transportation Research and Education, December 1997.
11. Parsons Transportation Group, Consensus Systems Technologies, and National Engineering Technology (NET), Northeastern Illinois ITS Deployment Plan Update, Prepared by Chicago Area Transportation Study Advanced Technology Task Force (ATTF), July 2005.
12. Mass DOT, Regional ITS Architecture for Metropolitan Boston, Prepared by IBI Group, December 2011.
13. Bellevue ITS, City of Bellevue ITS Master Plan, Prepared by DKS Associates, July 2004.

Other States and Regions

1. Virginia Department of Transportation, Intelligent Transportation Systems Strategic Plan, Prepared by IBI Group, August 2009.
2. US Department of Transportation, USDOT Intelligent Transportation System (ITS) ITS Strategic Plan 2015-2019, May 2014.
3. USDOT, Transforming Transportation through Connectivity, http://www.its.dot.gov/strategicplan/pdf/ITS%20Strategic%20Plan%20Update%202012.pdf, October 2012.
4. U.S. DOT, An Open Dialogue on the Draft Focus and Themes for the Next ITS Strategic Research Plan, December 2012.
5. U.S. DOT, Intelligent Transportation Systems (ITS), January 2006.
6. Center for Transportation Studies, University of Minnesota, Intelligent Transportation Systems (ITS) Institute Strategic Plan, 2007
7. McFarland Management, ITERIS, Treasure Valley Intelligent Transportation Systems (ITS) Strategic Plan, September 2006.
8. Texas Department of Transportation, Research to Develop an ITS Strategic Plan for Texas, Prepared by Texas A&M Transportation Institute April 2014.
9. Tennessee DOT, 2005 ANNUAL REPORT, Prepared by Intelligent Transportation Systems Coordinating Committee, December 2005.
10. Rockingham Planning Commission, Strafford-Rockingham Region ITS Strategic Plan, Prepared by IBI Group, June 2012.
11. U.S. DOT, Strategic Plan for Coordinating Rural Intelligent Transportation System (ITS) Transit Development in the Great Smoky Mountains National Park, November 2002.
12. Kimley-Horn and Associates, Inc. San Diego Region Intelligent Transportation Systems Strategic Plan, August 2011.
13. U.S. DOT Research and Innovative Technology Administration, Intelligent Transportation Systems (ITS) Standards Program Strategic Plan for 2011-2014, April 2011.
14. Kimley-Horn and Associates, Inc., Orange County Intelligent Transportation Systems (ITS) Strategic Deployment Plan, 2013.
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22. U.S.DOT, INTELLIGENT TRANSPORTATION SYSTEMS STRATEGIC PLAN, Kentucky Transportation Center, University of Kentucky, May 1998.
23. Michiana Area Council of Governments, Michiana Area Council of Governments (MACOG) REGIONAL ITS ARCHITECTURE 2010 - 2020, May 2010.
24. Illinois Department of Transportation, Illinois Statewide Intelligent Transportation Systems (ITS) Architecture and ITS Strategic Plan, August 2005.
25. Kimley-Horn and Associates, Inc., Idaho ITS Strategic Plan Update, March 2011.
26. Georgia's ITS/CVO Working Group, ITS/CVO STRATEGIC & BUSINESS PLAN For the State of Georgia, December 1997.
27. Fresno Council of Governments, FRESNO COUNTY INTELLIGENT TRANSPORTATION SYSTEMS (ITS) PLAN UPDATE, 1999.
28. Florida Department of Transportation, The 2005 Update of Florida's Intelligent Transportation System Strategic Plan, May 2005.
29. Florida Department of Transportation, Florida's Intelligent Transportation Systems Strategic Plan, October 2014.
30. U.S. DOT, Intelligent Transportation Systems (ITS) Projects Book, 2005.
31. Colorado Department of Transportation, CDOT Region 4 Intelligent Transportation Systems Strategic Implementation Plan, June 2011.
32. Tahoe Gateway Counties, Intelligent Transportation Systems Strategic Deployment Plan Report #2, May 2002.
33. Pima Association of Governments, Intelligent Transportation Systems Strategic Deployment Plan for the Tucson Metropolitan Area, July 1996.

Comparison of Other Metropolitan City ITS Plans
In order to compare NYC, a total of 4 metropolitan cities were selected for further investigation.

- *Los Angeles* – Regional Integration of Intelligent Transportation Systems (RIITS) 10-Year Strategic Plan (2010)
  "The Regional Integration of Intelligent Transportation Systems (RIITS) 10-Year Strategic Plan identifies and prioritizes future investments to enhance the functionality of the multimodal, multi-agency RIITS transportation data exchange network."

- *Chicago* – Northeastern Illinois ITS Deployment Plan Update (2005)
  Built on previous "ITS Plan Update" by Advanced Technology Task Force of the Chicago Area Transportation Study (CATS).
  "The ITS Plan Update also relates projects to the Regional ITS Architecture for northeastern Illinois, which was adopted in 2003. The architecture is a 15 year roadmap for integrating transportation systems in the region."

- *Boston* – Regional ITS Architecture for Metropolitan Boston (2011)
  Not a vision or strategic document per se, but aims to coordinate ITS efforts: *"To fully maximize the potential of ITS technologies, ITS deployment requires an approach to planning, implementation, and operations that emphasizes collaboration between relevant entities and compatibility/interoperability of individual systems. At the core of this process is an architecture that provides overall guidance to ensure coordination and integration of individual ITS deployment projects, without limiting stakeholder design options."*

Similar to Chicago, update of an existing study: *"This Architecture was initially developed in 2005 to meet federal regulatory requirements. This report is the outcome of a periodic formal update to the Architecture defined as part of its required ongoing maintenance process."*

- *Washington D.C*. - Strategic Plan for the Metropolitan Washington Management, Operations, And Intelligent Transportation Systems (MOITS) Planning Program (2010)
  "This Strategic Plan defines and promotes potential regional projects or activities for the management, operations, and application of advanced technology for the region's transportation systems, as well as to advise member agencies on management, operations, and transportation technology deployments for meeting common regional goals and objectives"

The ITS plans of the above listed cities have multiple stakeholders who contributed to the report and the strategy. Each report lists priorities, objectives, overarching goals, etc., categorizing under different titles/sections (Please see following tables for summaries of Los Angeles, Chicago, Boston, Washington D.C. plans, respectively.) For instance, the Boston ITS plan documents the regional needs based on stakeholder input, identify expected benefits, set forth major themes and lists the relevant ITS architecture market packages. Meanwhile, the Los Angeles study identifies regional "challenges" following a similar stakeholder input, set forth vision, and lists initiatives with corresponding project costs. The Washington D.C. plan involves "key tactical actions" similar to priorities in other studies, identifies emphasis areas, proposed projects and overall anticipated benefits. The Chicago plan is more focused on existing and planned projects with some overarching priorities.

Table B-2: Overview of ITS Strategic Plan for Los Angeles

Regional Challenges	Vision	Initiatives
• Transportation System Management & Operations • Performance Measurement • Freight Mobility. • Emergency Management. • Transportation Sustainability and Climate Change	• Multimodal" • Information Services • Flexible Platform • Regional Mobility, Safety, and Sustainability Goals	Integration of Regional Networks • Leverage the RIITS interagency platform to provide connectivity among regional ITS systems and devices • Provide reliable, timely, and comprehensive data feeds to other ITS applications like 511 and Congestion Pricing; • Allow third-party and private sector Information Service Providers to build upon the power of RIITS to deliver innovative information services. Regional Data Management • Build on the foundation of the baseline ADMS that is providing a data storage and management capacity to RIITS; • Consolidate and store regional transportation data derived from multiple source systems of participating agencies; and • Present data in a format that is accessible and valuable to participating agencies for a variety of applications. Operations Support Initiatives • Support transportation and emergency operations in the region through real-time exchange of operations data, video, and/or event information; • Develop enhanced 'Situational Awareness' capabilities, providing real-time information on regional, multi-modal regional transportation system performance for operations and emergency response.

Table B-3: Overview of ITS Strategic Plan for Chicago

ITS Priorities	Targeted ITS Service Qualities	ITS Update Study Components
• Accumulation and dissemination of real-time travel information includes information on networks and travel routes, travel times and congestion, and incidents. • Pro-active incident management covers not only detection and verification, but also response and clearance of the incident, as well as site and area traffic management. • Traffic management of freeways and arterials includes facility surveillance, ramp metering, surface street traffic signal control and electronic toll collection.	• Informed • Seamless • Reliable • Secure • Safe • Effective • Predictable • User-friendly • Valued • Cost-effective • Equitable • Efficient • Positive Image • Performance-based • Accessible • Customer Service-oriented	• A regional vision for ITS deployment in northeastern Illinois and major goals to achieve. • A prototype operational concept for incident management, which documents agencies' roles and responsibilities (at a high level) in the operation of the regional ITS system. • A guide for estimating the benefits of ITS projects. • An action plan addressing the ITS funding shortfall, early action projects that serve as building blocks for later deployments, gaps between the ITS Plan Update and the Regional ITS Architecture, and updates to be made to the Regional Architecture. • A discussion of how the ITS Plan Update supports the goals and objectives of Shared Path 2030, the region's long-range transportation plan.

Table B-4: Overview of ITS Strategic Plan for Boston

Expected Benefits	Regional Needs	Major Themes	Regional ITS Architecture Market Packages
• Improved Interagency Coordination • Cost Savings • Improved Services to the Public	• Safety and Security • Mobility Management • Transit Management • Information Sharing • Communications Infrastructure • Operations and Management • Maintenance and Asset Management • Access to ITS Data	• All-Hazards Emergency Management • Information Sharing • Communications Infrastructure • Operations and Maintenance	• Traffic Management Network Surveillance; Traffic Probe Surveillance; Surface Street Control; Freeway Control; HOV Lane Management; Traffic Information Dissemination; Regional Traffic Management; Incident Management System; Electronic Toll Collection; Emissions Monitoring and Management; Standard Railroad Grade Crossing; Railroad Operations Coordination; Parking Facility Management; Drawbridge Management; Roadway Closure Management • Maintenance & Construction Management Maintenance and Construction Vehicle and Equipment Tracking; Maintenance and Construction Vehicle Maintenance; Road Weather Data Collection; Weather Information Processing and Distribution; Roadway Automated Treatment; Winter Maintenance; Roadway Maintenance and Construction; Work Zone Management; Work Zone Safety Monitoring; Maintenance and Construction Activity Coordination; Infrastructure Monitoring • Public Transportation Transit Vehicle Tracking; Transit Fixed-Route Operations; Demand Response Transit Operations; Transit Fare Collection Management; Transit Security; Transit Fleet Maintenance; Multi-modal Coordination; Transit Traveler Information; Transit Signal Priority; Transit Passenger Counting • Traveler Information Interactive Traveler Information; ISP Based Trip Planning and Route Guidance; Dynamic Ridesharing • Commercial Vehicle Operations CV Administrative Processes; Weigh-In-Motion; Roadside CVO Safety • Emergency Management Emergency Call-Taking and Dispatch; Emergency Routing; Mayday and Alarms Support; Roadway Service Patrols; Transportation Infrastructure Protection; Disaster Response and Recovery; Evacuation and Reentry Management • Archived Data Management ITS Data Mart; ITS Virtual Data Warehouse

Table B-5: Overview of ITS Strategic Plan for Washington D.C.

Key tactical actions	Emphasis Areas	Proposed Projects	Anticipated Benefits
• Provide regional situational awareness of transportation system conditions and of incidents or factors that may impact transportation conditions • Develop and maintain regionally coordinated standard operating procedures • Inform travelers in a timely and effective manner so those travelers will make good transportation decisions • Integrate technical systems and processes to maximize interoperability and ensure the beneficial and synergistic impacts of those systems working together	**1.** ITS data warehouse **2.** Multi-modal coordination **3.** Transit signal priority **4.** Interactive traveler **5.** Transportation operations data sharing **6.** HOV lane management **7.** Regional traffic management **8.** Regional parking management **9.** Maintenance and construction activity coordination	**1.** Operate and Maintain the Metropolitan Area Transportation Operations Coordination (MATOC) Program and the Regional Integrated Transportation Information System (RITIS) **2.** Upgrade the Regional Integrated Transportation Information System (RITIS) to Enhanced Capabilities as the Regional Intelligent Transportation Systems (ITS) Data Warehouse and Regional Traveler Information Data Engine **3.** Enhance Regional Integrated Transportation Information System (RITIS) Capabilities for Intermodal Transportation Operations Data Sharing **4.** Support the Development of Multi-Modal Regional Trip Planning Tools Using Regional Data **5.** Deployment of Integrated Corridor Management Technologies on Significant Regional Corridors **6.** Deploy Real-Time Parking Availability Information Systems at Key Metrorail or Other Publicly-Owned Park-and-Ride Facilities **7.** Develop a Regional Set of Transportation Management Plans or Major Planned Events **8.** Develop a Regional Managed Lanes Operations Coordination Process for the Washington Metropolitan Area **9.** Develop and Initiate a Venue and Process for Maintenance and Construction Coordination **10.** Develop and Initiate a Venue and Process for Interjurisdictionally Coordinated Signal Timing for Regional Corridors	• Safety • Reduced delays • Better availability of information • Better quality of information • Better responsiveness of transportation systems to traveler needs • Increased travel options

Table B-6: Overview of ITS Strategic Plan for New York City

Questions for ITS	ITS Functional Areas	Implementation Strategy Components
• How can we use ITS to release congestion on major arterials? In CBDs? • Are we looking at the whole picture or just a part of it? • How can we inform the public, so they can make better decisions on travel? • Estimated travel times need to be accurately calculated and transmitted. • How can we exchange information among local agencies and improve • Coordinated traffic management?	1. Traffic Management and Operational Efficiency 2. Freeway Management Systems (FMS) Expansion 3. Congestion management in Central Business Districts (CBDs) 4. Traffic Incident Management (TIM) 5. Emergency Management 6. Travel Management 7. Information for Public 8. Transportation Security and CVO-Truck Tracking 9. Surface Public Transit Coordination 10. Traffic Management Center (TMC) 11. Local and Regional Coordination	1. NYC Sub-Regional ITS Architecture/ITS Standards 2. Communication Backbone 3. Integration 4. Interoperability 5. ITS Research, Training, and Education Support by UITSC 6. Systems Engineering Process (SEP)

Comparison with USDOT ITS Strategic Plan

As noted in the document, one of the most important documents that describe the vision and future deployment of ITS in the U.S. is the strategic plan prepared by USDOT Intelligent Transportation Systems (ITS) Joint program Office (JPO). The table below shows potential relationships between NYCDOT ITS functional categories and USDOT ITS strategic plan program categories.

: Potential Relationships between NYCDOT ITS Functional Categories and USDOT ITS Strategic
gram Categories.

nctional Areas	**USDOT ITS Strategic Plan Program Categories**					
	Connected Vehicles	Automation	Emerging Capabilities	Enterprise Data	Interoperability	Accelerating Deployment
pport services						✓
center					✓	
computerization	✓	✓				
ed signals traffic battery backup		✓				
gement system for			✓			
systems expansion						✓
ridges			✓			✓
s communication						✓
rmation systems			✓	✓		
mation			✓	✓		
ck tracking system			✓	✓		
ement center					✓	
ing & education						✓

Comparison of Neighboring Regions' ITS Plans

New York Metropolitan area is the densest urban area in the United States. NYC is particularly a hub for economic and social activities. In these respects, transportation activities in NYC metropolitan region (i.e. New Jersey and Connecticut) are closely related to NYC. The project team surveyed New Jersey (NJ) and Connecticut (CT) – particularly Southwest CT – ITS deployments. The overall finding is that despite heavy influence of NYC on the roadway and transit traffic, the ITS plans do not necessarily address specifics of ITS in NYC. The ITS related interactions of NYC with the proximity areas are mainly through the commuter rail connections and I-95 corridor. The coordination of the ITS activities at these facilities are monitored by multi-state initiatives like TRANSCOM and I-95 corridor coalition. Besides such established agencies/programs, the ITS plans at the neighboring states/regions do not adequately refer to the deployments on the other side of the jurisdictional boundaries.