New York City Sub-regional ITS Architecture

Project Systems Engineering Analysis Report (PSEAR) Workshop

March 5, 2013

Robert S. Jaffe, Ph.D., CSEP
Manny Insignares
John Baker

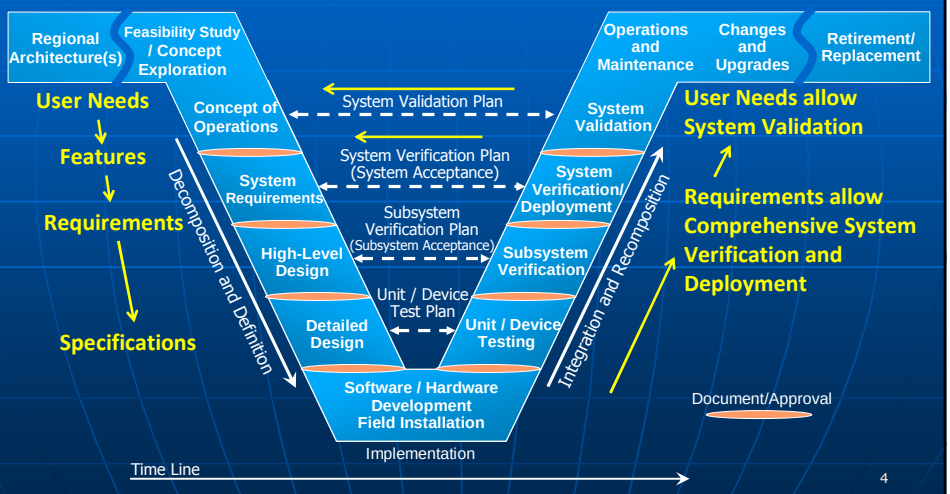
ConSysTec
www.consystec.com

Agenda / Overview

Timetable	Item to Cover
9:30 to 10:00	Module 1 – Introduction
10:00 to 10:30	Module 2 – Overview of FHWA Rule 940 and FTA Policy on Systems Engineering Analysis
10:30 to 11:15	Module 3 – Overview of FTA Triennial Review Section 23 (Systems Engineering Analysis)
11:15 to 11:30	Module 4 - Case Study Overview (Key Ingredients of a PSEAR)
11:30 to 12:30	Module 5 – Case Study 1: Brooklyn Bridge ITS
12:30 to 1:30	Lunch
1:30 to 2:30	Module 6 – Case Study 2: Verrazano-Narrows Bridge ITS (VN-03)
2:30 to 3:30	Module 7 – Case Study 3: Long Island Expy & Brooklyn Queens Expy Travel Time Systems
3:30 to 4:30	Module 8 – Wrap-up and Discussion

Overview:
Systems Engineering Process
Regional ITS Architecture
Systems Engineering Analysis

The Systems Engineering Process



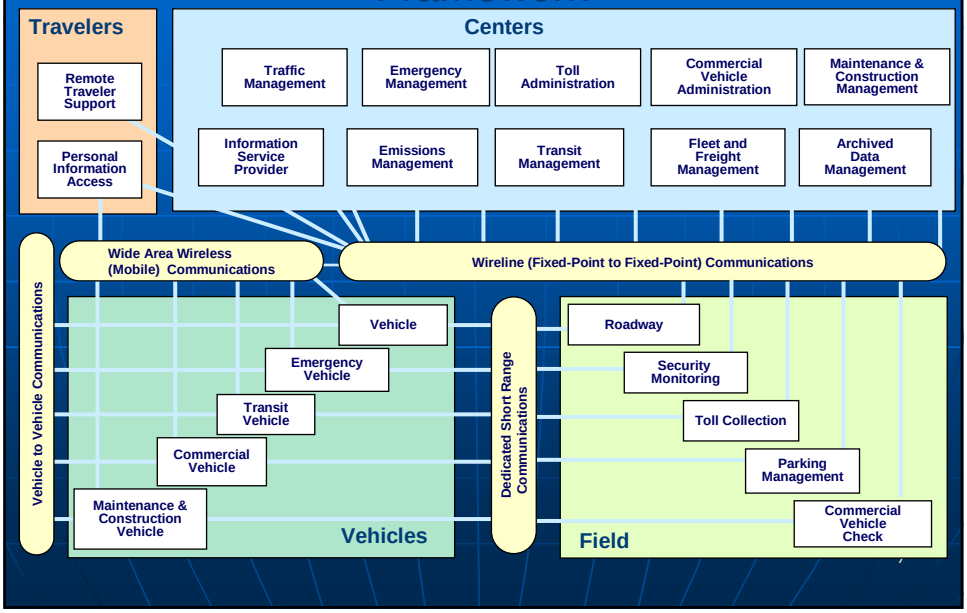
FHWA Rule 940.9 and FTA Policy
Regional ITS Architecture

1. Description of Region
2. Identification of Participating Agencies and Stakeholders
3. Operational Concept, Agency Roles and Responsibilities
4. Required Agreements and MOUs
5. System Functional Requirements
6. System Interface Requirements (to the level of *Architecture Flows*)
7. Identification of Standards
8. Sequencing of Projects and Implementation
9. Maintenance Plan

FHWA Rule 940.11 or FTA Policy
Project Implementation

1. Identification of portions of the regional ITS architecture being implemented
2. Identification of participating agencies' roles and responsibilities
3. Requirements definitions
4. Analysis of alternative system configurations and technology options to meet requirements
5. Procurement options
6. Identification of applicable ITS standards and testing procedures
7. Procedures and resources necessary for operations and management of the system

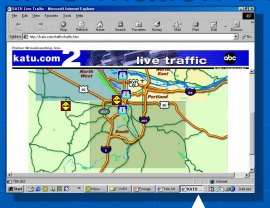
National ITS Architecture Framework



Modeling ITS Architecture Solutions: ITS Service Packages

- The National ITS Architecture introduced the term *Service Package* (previously Market Package)
- *Service Packages* illustrate ITS elements that can be grouped to provide ITS services to transportation system users.

Traffic Information Dissemination



Web Site

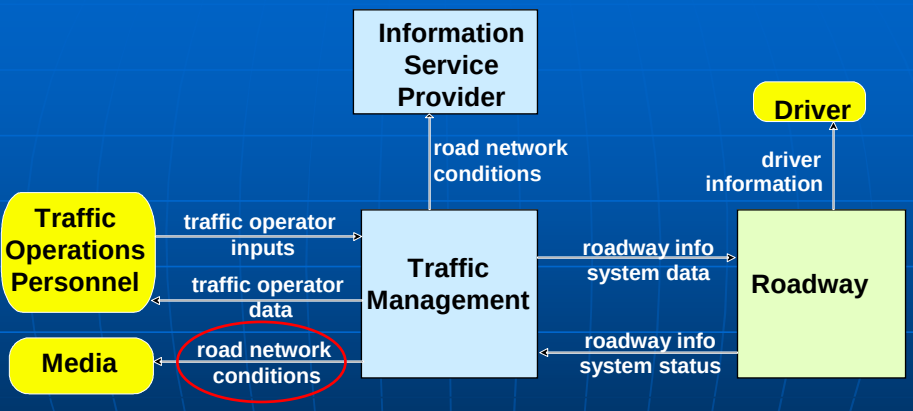
Motorist

Television Station

Traffic Management Center

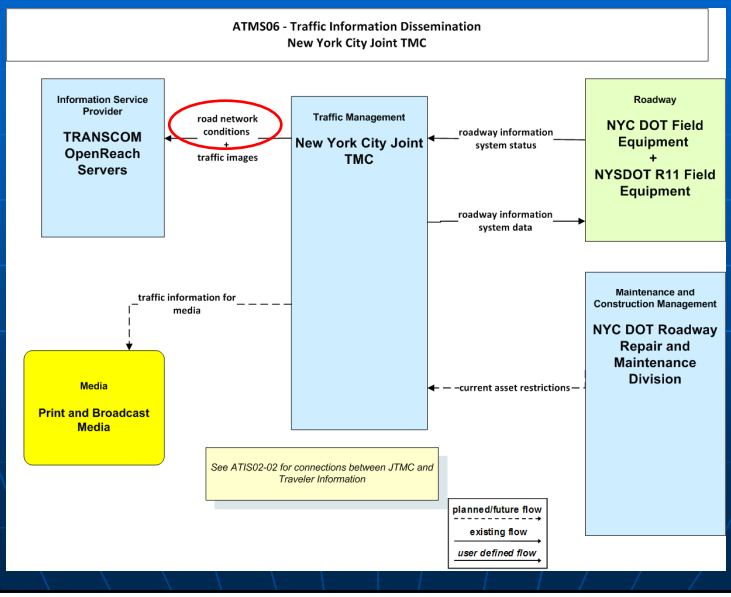
Dynamic Message Signs

ATMS06 – Traffic Information Dissemination [National ITS Architecture]



We'll track *road network conditions* from National ITS Architecture to Regional ITS Architecture and identify applicable ITS standards

ATMS06 – Traffic Information Dissemination [NYC Sub-regional ITS Architecture]



ITS Architecture Flow Mapping to ITS Standards

- road network conditions
  - NTCIP C2C: NTCIP Center-to-Center Standards Group
  - ITE TMDD: Traffic Management Data Dictionary and Message Sets for External TMC Communication (TMDD and MS/ETMCC)

Automated Transit Fare Payment

Financial Institution

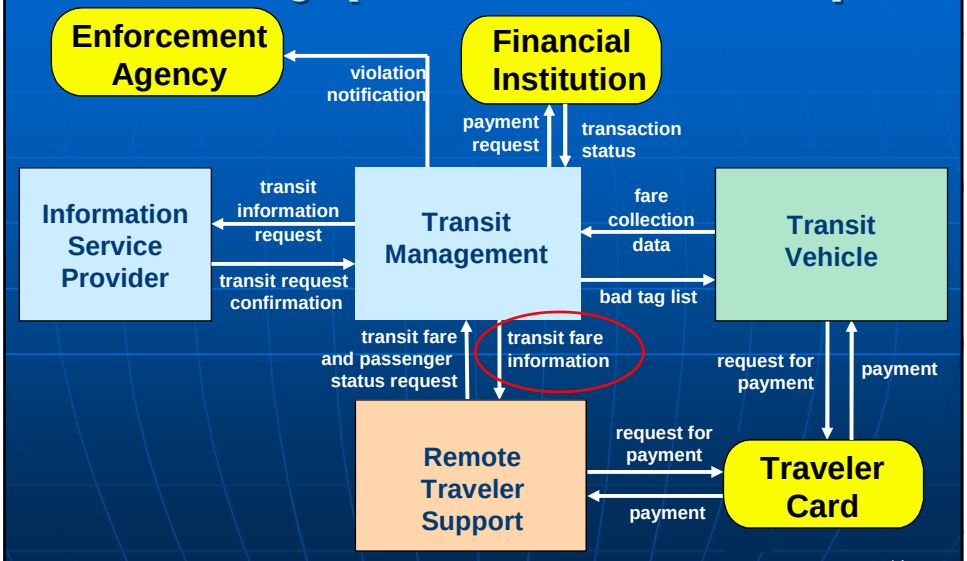
Enforcement

Transit Vehicle

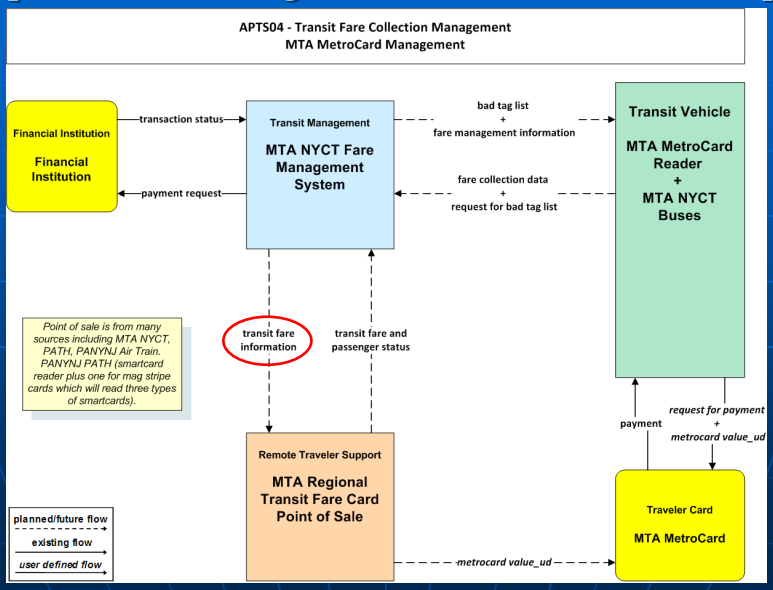
Transit Management Center

Point of Sale / Kiosk

APTS4 - Automated Fare Payment Market Package [National ITS Architecture]



ATMS04 – Automated Fare Payment [NYC Sub-regional ITS Architecture]



ITS Architecture Flow Mapping to ITS Standards

- transit fare information
  - ATIS General Use: SAE J2354 - Advanced Traveler Information Systems (ATIS)
  - APTA TCIP: Standard for Transit Communications Interface Profiles

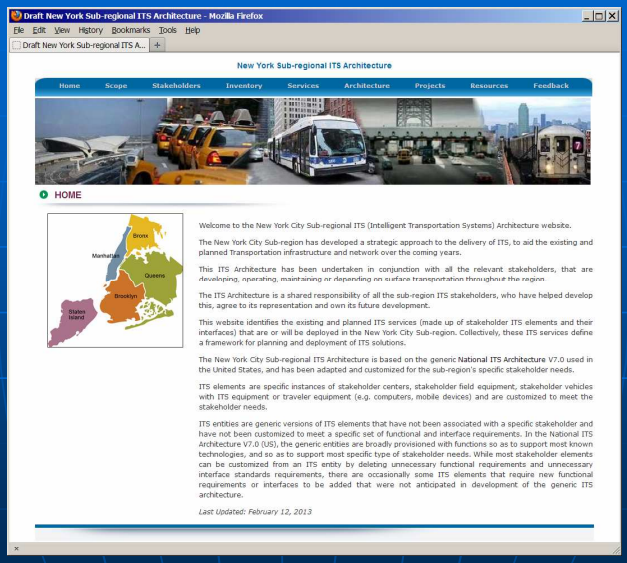
FHWA Rule 940.11 and FTA Policy
Project Implementation

- (a) All ITS projects funded with highway trust funds shall be based on a systems engineering analysis.
- (b) The analysis should be on a *scale* commensurate with the *project scope*.
- (c) The systems engineering analysis shall include, at a minimum: *(items listed on next chart)*

PSEAR Sections

	Systems Engineering Analysis Item	Regional ITS Architecture
1	Identification of portions of the regional ITS architecture being implemented;	Service Packages, ITS Elements, and Element Interfaces
2	Identification of participating agencies' roles and responsibilities;	Operational Concept
3	Requirements definitions;	Functional Requirements (Technology Neutral)
4	Analysis of alternative system configurations and technology options to meet requirements;	**Not covered**
5	Procurement options;	**Not covered**
6	Identification of a) applicable ITS standards and b) testing procedures; and	**1/2 of this item is covered.** Architecture includes identification of applicable ITS Standards.
7	Procedures and resources necessary for operations and maintenance	**Not covered**

New York City Sub-regional ITS Architecture Web Site



http://www.consystec.com/nycsraupdate/web

Web Site Organization

- Home
- Scope
- Stakeholders
- Inventory
  - Inventory
  - Inventory by Entity
  - Inventory by Stakeholder
- Services
  - Services
  - Services by Stakeholder
- Architecture
  - Architecture Interfaces
  - Architecture Flow Descriptions
  - Architecture Schematic
- Projects
  - Projects
  - Projects by Stakeholder

Let's conduct a short walkthrough of the web site.

Overview of NYSDOT Project Development Process

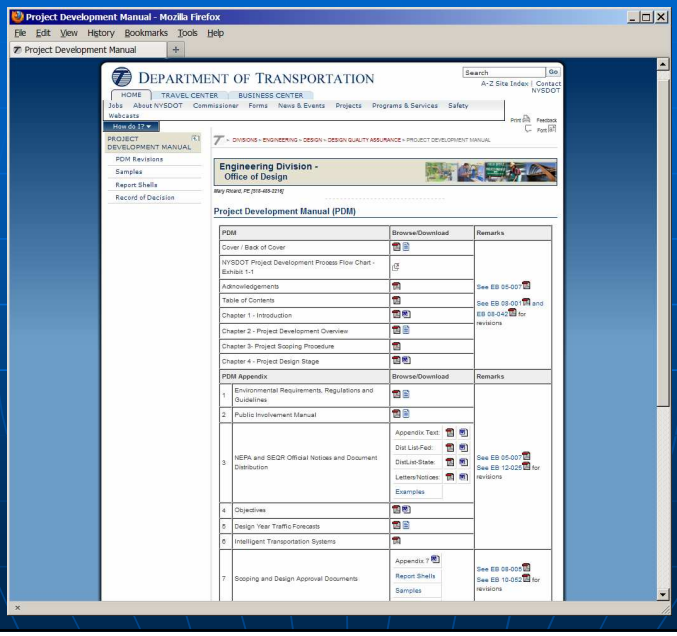
New York State Project Development Process

1. Initial Project Proposal / Project Scoping
2. Project Identification Number (P.I.N.) is assigned and placed into the capital program
3. Expanded Project Proposal (EPP)
4. Project Systems Engineering Analysis Report (PSEAR)*
5. Design Approval Document (DAD)
6. Preliminary Design Report (PDR) (Phase 1 – 4)
7. Advanced Detail Plans (ADP) (Phase 5 – 6)
8. Plans, Specifications & Estimates (PS&E)
9. Letting, Bid Reviews, and Award
10. Construction
11. Test and Acceptance

* For a complex project may start a PSEAR in Step 4, but add detail through Step 8.

New York State Project Development Manual

https://www.dot.ny.gov/divisions/engineering/design/dqab/pdm



Overview of FTA Policy
FTA Triennial Review Section 23

FTA Triennial Review

- Section 23 of the FTA Triennial Review concerns the ITS Architecture
- Basic Requirement:
  - Intelligent Transportation Systems (ITS) projects funded by the Highway Trust Fund and the Mass Transit Account must conform to the National ITS Architecture, as well as to United States Department of Transportation (USDOT) adopted ITS Standards

Question 1 of Section 23

- *Is the grantee or a subrecipient attempting to deploy ITS technologies? If yes, are ITS projects and programs part of a locally approved ITS Architecture?*
- *If a project includes ITS components that implement any of the defined User Services (in NITSA) then it is considered an "ITS Project"*

Question 1 of Section 23

- *Ask the grantee to provide documentation, typically excerpts from the Regional ITS Architecture, showing that the major architecture elements for ITS projects are included in the locally approved Regional Architecture*

Deficiency for Question 1

- The grantee is deficient if ITS projects are not included in the Regional ITS Architecture.
- The grantee is deficient if the final design of the ITS project is inconsistent with the regional architecture.
- *Suggested corrective action:*
  - Direct the grantee to establish and submit to the FTA regional office a plan to have its ITS projects included in the Regional ITS Architecture.
  - Refer to the NYCSRA Maintenance Plan, which includes a Change Request Form in the appendices.

Question 2 of Section 23

- *Has the grantee or subrecipient established a process for the systems engineering analysis of ITS projects that addresses the seven prescribed steps?*
- *Has it applied the process?*
- *If the project scope has changed, has it reviewed the systems engineering analysis and, if necessary, updated it?*

Systems Engineering Analysis

- *FTA's ITS Architecture Policy prescribes 7 steps which correspond with FHWA Rule 940.*
- *In addition, the FTA Policy specifies that ITS Projects should be evaluated as either "low" or "high" risk.*
- *A simplified systems engineering process can be performed for low risk projects.*

8 Characteristics of Risk

	Characteristics	Description
1	Jurisdiction	Does the ITS project include a single or multiple jurisdictions?
2	Software	Does the project require software development or can rely entirely on existing and proven software?
3	Hardware	Does the project require development of hardware or does proven hardware exist?
4	Interfaces	Does the project require new interfaces or will it rely entirely on existing interfaces?
5	Requirements	Will the project's requirements be well defined and fully documented prior to procuring the system?
6	Procedures	Will the project's operating procedures be well documented prior to procuring the system?
7	Technologies	Does the project only use proven and stable technologies?
8	Staff experience	Does the staff implementing the project have prior experience with ITS procurement, implementation and operations?

Deficiency for Question 2

- Determine whether the ITS project is a high risk project by discussing the eight characteristics listed under the risk discussion above. If the project is high risk, ask the grantee to demonstrate that the system engineering analysis addressed the seven steps.
- *The grantee is deficient if it has not established a process for the systems engineering analysis of ITS projects and it has not applied the process to its ITS projects.*
- Suggestive Corrective Action: *The grantee is deficient if it has not established a process for the systems engineering analysis of ITS projects and it has not applied the process to its ITS projects.*

Case Studies Overview

Case Studies Overview

- Regional Experience with PSEAR
  - NYCDOT
  - MTA B&T
  - NYSDOT
    - Has completed 10 Reports
- 3 Case Studies
  - Brooklyn Bridge ITS (NYCDOT)
  - Verrazano-Narrows Bridge – Staten Island Expressway ITS (MTA B&T)
  - Long Island Expy & Brooklyn Queens Expy Travel Time Systems (NYSDOT)

PSEAR Key Ingredients

1. Portions of the Architecture Being Implemented
   - Identify project relevant ITS Services and service packages.
   - Identify project relevant ITS Elements and Information Flows.
   - Identify stakeholders responsible for operation and maintenance of the ITS Elements.

PSEAR Key Ingredients

2. Participating Agencies' Roles and Responsibilities
   - A brief paragraph about each agency's role in the project.
   - Identify which agency (ies) will have command/control, and which will receive status and information only.
   - Identify any new agreements necessary (where information or maintenance crosses an institutional boundary).
     - 1 of the 3 Case Studies identifies a new agreement necessary for maintenance of ITS infrastructure
   - The ITS Architecture includes:
     - Roles and responsibilities for each stakeholder
     - List of Agreements

PSEAR Key Ingredients

3. Requirements Definitions
   - Select which of the ITS Architecture functional requirements assigned to each ITS Element are project relevant
   - The ITS Architecture defines Functional Requirements for each ITS Element
   - Note change in nomenclature:
     - *Functional Area* is new term for Equipment Package
     - *Functional Requirement* is the new term for Process Specification (Pspec)
     - Use these new terms that better align with Rule 940 and FTA Policy terminology

PSEAR Key Ingredients

4. Alternative System Configurations and Technology Options
   - Identify alternative ways of connecting and implementing system elements
   - Technology Options Analysis
     - Existing technology
       - If system expansion of field equipment, then outline existing technology features, options, and life-cycle cost
     - New technology
       - Consider defining attributes to do or prepare for a trade-study of technology options
       - Benefits (perhaps weighted)
         - Operational
         - Maintenance
         - Infrastructure
         - Life-Cycle Cost

Example Technology Trade Off Matrix

The sensing technologies delineated in Table 1 that appear to meet the essential operational criteria of positive identification in a matched pair of collection points, time-stamping, and all-weather operation, are compared in Table 2. This assessment assumes that any of the technologies in Table 2 will perform technically in an acceptable manner and that software with which to calculate travel time can be developed (if it is not already in use for that purpose). The format is a stoplight chart that makes subjective judgments about how nearly the sensing technology meets the ideal.

A green circle indicates the best category of performance in a particular category. A red square may indicate the least amount of performance in that category or it may mean inability to perform in that category, depending on the context. Red, for example, does not indicate a show-stopping inability that would preclude the use of that particular technology but rather a relative perspective of how it compares to the other technologies compared to cost, convenience, or collateral features. Thus, some red in a given row does not signify that the technology cannot be expected to perform in that application. There is no technology listed in Table 2 that does not have some red. A yellow triangle signifies an intermediate position; for example, it may indicate progress toward meeting a need but something short of a mature technology for the application.

Table 2 therefore focuses more on practical aspects of a limited number of sensing technologies, any one of which should be able to perform the functions required. The comparison assumes that AVI technologies (e.g., smart cards with RF transponders) are not used with all vehicles. Likewise, not all drivers will be using their cell phones as they cross the border. As the Table 2 footnote 1 explains, two of the categories have no intermediate positions: a technology either fits the category or it doesn't.

Table 2. Summary Matrix of Candidate Sensing Technologies

Technology	Geolocation/ Travel Time Accuracy	% of Vehicles Recorded	Cross-Border Installation Required[1]	Mature Technology for Application	Infrastructure Cost	Total Hourly Count[2]
AVI Laser	●	△	■	●	●	■
AVI RF tags	●	△	■	●	●	■
AVI RF Smart Tags	●	△	■	●	●	■
AVI Smart Cards with RF Transducers[3]	●	△	■	●	△	■
AVI IR Tags	●	△	■	●	●	■
AVI Smart Cards with IR Transducers[3]	●	△	■	●	△	■
Common Inductive Loop	●	●	■	■	△	●
Signature Inductive Sensors	●	●	■	■	△	●
Mobile Phone Locating	■	■	●	△	●	■
License Plate Reader	●	●	■	●	■	●
Vehicle Matching System	●	●	■	●	■	●

● = Green (best performance) △ = Yellow (intermediate) ■ = Red (poor)

1. Installation either required or not.
2. Technology either counts every vehicle or not.
3. This technology is in use at some border crossings for toll purposes.

http://ops.fhwa.dot.gov/freight/freight_analysis/auto_tech/sect_4.htm

PSEAR Key Ingredients

5. Procurement Options
   - Identify source of funding:
     - Federal
     - State
     - Municipal
     - Public-Private Partnership
   - Identify cost for:
     - Equipment
     - System Integration
     - Operations and Maintenance
   - Where appropriate, consider alternative procurement methods
     - Design-Bid-Build
     - Design-Build

PSEAR Key Ingredients

6. Applicable ITS Standards and Testing Procedures
   - Identify Applicable ITS Standards
     - If copying table from ITS Architecture, remove ("x-out" or "grey-out") ITS Standards that do not apply
   - Identify Testing Procedures
     - Identify Test Phases (design approval test, factory acceptance test, performance test, lab test, field demonstration test, System Acceptance Test)
     - Standards Testing (e.g., NTCIP, TMDD, TCIP, IEEE 1512)
       - Follow test procedure in standards or guidance documents
       - Additional detail provided in Case Study 1

PSEAR Key Ingredients

7. Resources necessary for operations and management of the system
   - Identify organization and staffing for
     - Operations
     - Maintenance
     - System Administration and Integration Support (where appropriate)

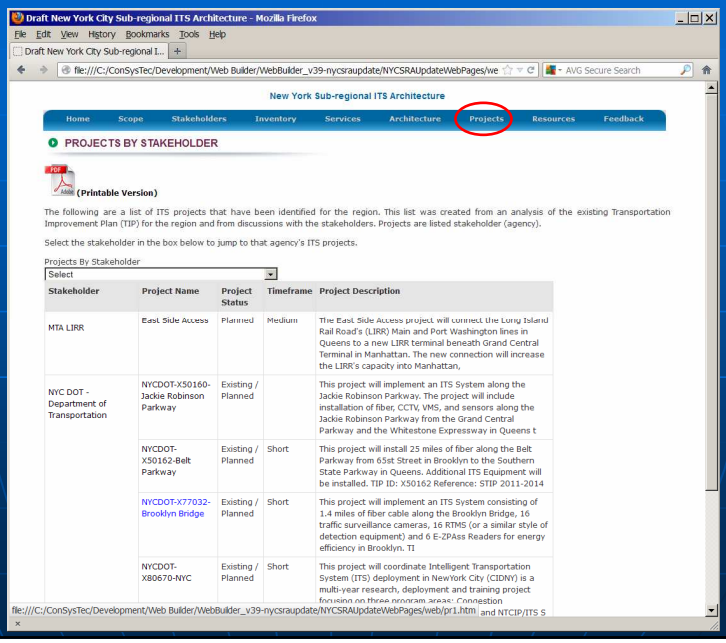
Case Study 1
Brooklyn Bridge ITS

Case Study 1:
NYC DOT Brooklyn Bridge ITS

- Project Objective:
  - To improve traffic management, through active traffic management and incident management.
  - The scope of this project interfaces downtown Brooklyn and Manhattan local streets and highways on approaches.
- PSEAR Report Status:
  - Submitted 3 years ago.
  - Contains a revision history.
  - City received funding a few months ago.

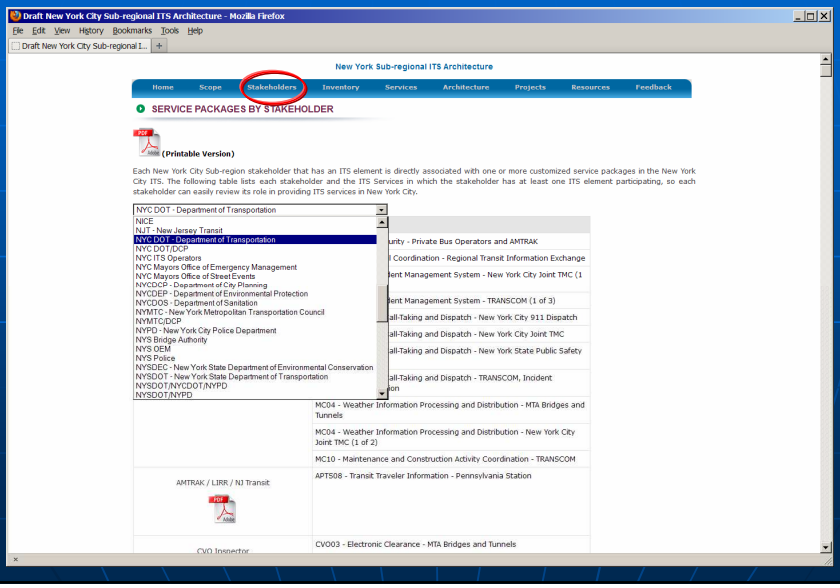
Table of Contents

The NYCSRA Includes a List of ITS Projects



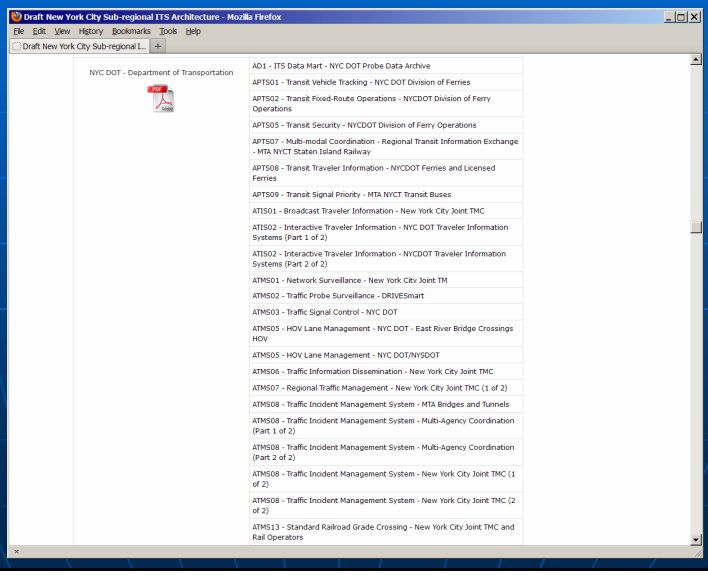
1. Portion of the Architecture Being Implemented

Navigate to Service Packages by Stakeholder



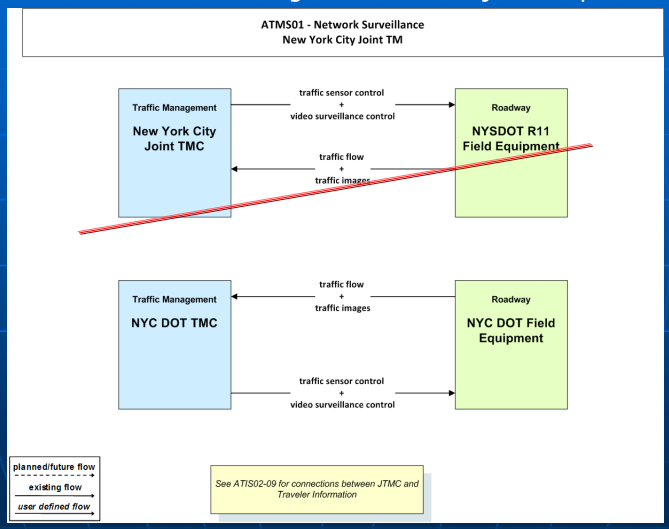
1. Portion of the Architecture Being Implemented

Navigate to Service Packages by Stakeholder



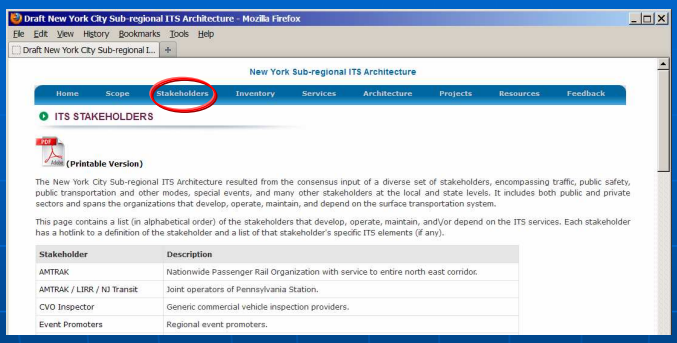
1. Portions of the Architecture Being Implemented

Edit Service Package to reflect Project Scope

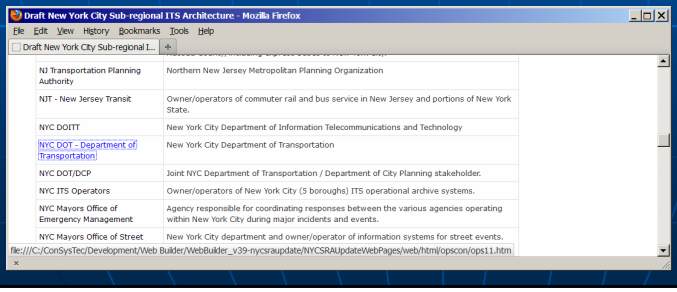


Continue with additional Project Relevant Service Packages

2. Participating Agencies' Roles and Responsibilities



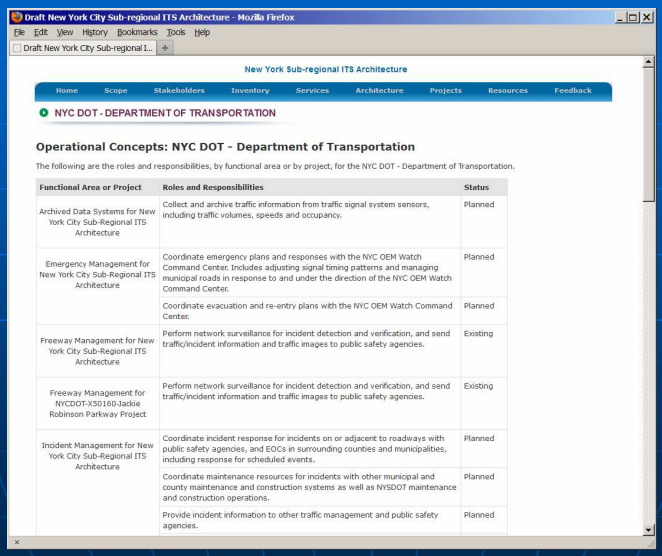
Navigate to ITS Stakeholders



Scroll down to NYCDOT

2. Participating Agencies' Roles and Responsibilities

Operational Concept for NYCDOT

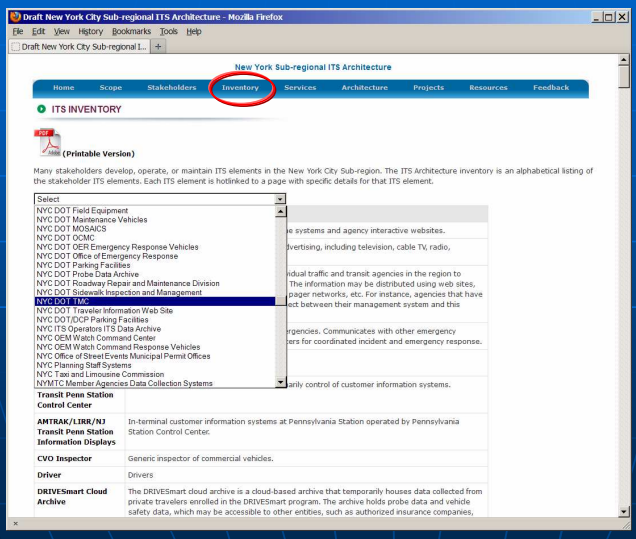


2. Participating Agencies' Roles and Responsibilities

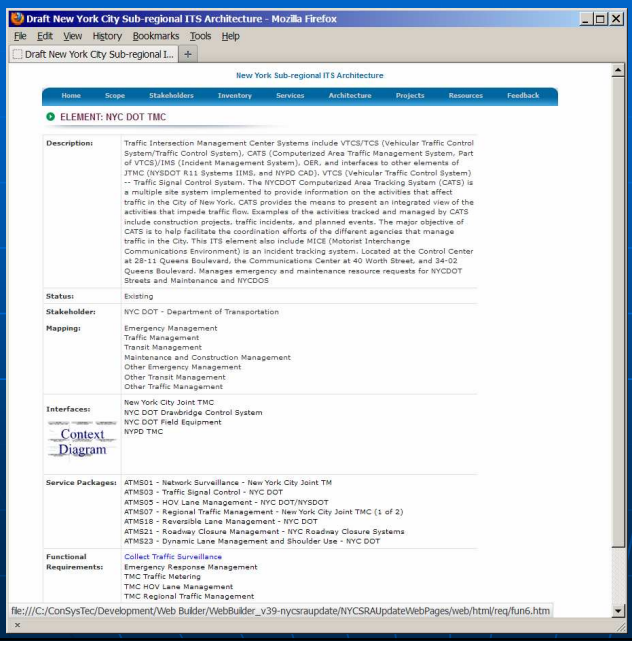
- NYCDOT
  - Role: Lead Agency
  - Responsibilities: Command, Control, Operate, and Maintain
- NYSDOT R10 & R11, and TRANSCOM
  - Role & Responsibility: Receive roadway traffic information and equipment status

3: Functional Requirements

Navigate to Inventory Page. Select NYC DOT TMC.

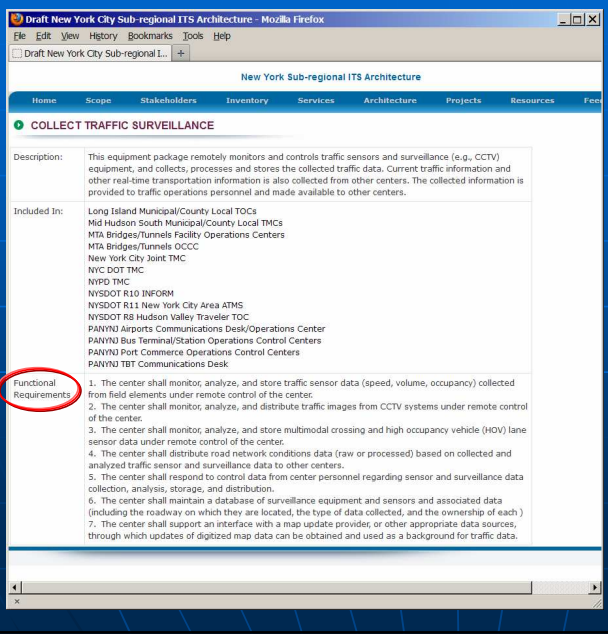


3: Functional Requirements



Click on Project Relevant Functional Areas to View Requirements.

3: Functional Requirements



Select Project Relevant Functional Requirements.

4. Alternative System Configuration and Technology Options Discussion

- Existing Technology:
  - If the agency has a sense of what kinds of equipment will be used, consider describing the technology features of center equipment, field equipment, and vehicle equipment.
- New Technology:
  - Can compare and rank options based on cost, technology options, and risk.
  - Can develop a matrix to document trade off analysis
- Describe the configuration of equipment and how it will be integrated into a system.
  - E.g., Include a block diagram

4. Alternative System Configuration and Technology Options

- Transponder Readers
- Vehicle Transponders – E-ZPass
- Dynamic Message Signs
- Cameras
- Detection
  - Alternatives included microwave sensors, but possibly change to video detection
- Center – NYC DOT TMC
- Network connectivity for the above:
  - Fiber and Wireless options

5. Procurement Options Discussion

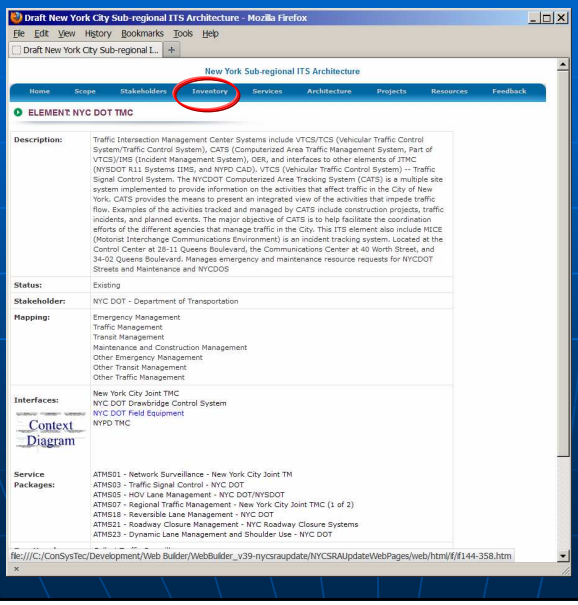
- Methods of funding include:
  - Federal Aid
  - State
  - Municipal/County/Local
  - Agency Funded (Non-Federal Aid Project)
- Describe combinations of the above
  - Are there any dependencies ?
  - Is an agreement required ?
- Discuss capital cost funding
- Discuss operations/maintenance cost funding
- Discuss funding time-frame

5. Procurement Options Excerpt

The Brooklyn Bridge ITS Improvement project is a project identified in the region's Transportation Improvement Program, New York City DOT's Capital Plan, and NYCDOT ITS Strategic plan. The design, specification development and procurement documents will follow NYCDOT's contract administration procedures. This will include development of plans, specifications and estimates (PS&E) for the project prior to bid. In addition, portion of this project will be done by NYCDOT in house and will be in compliance with what is mentioned above.

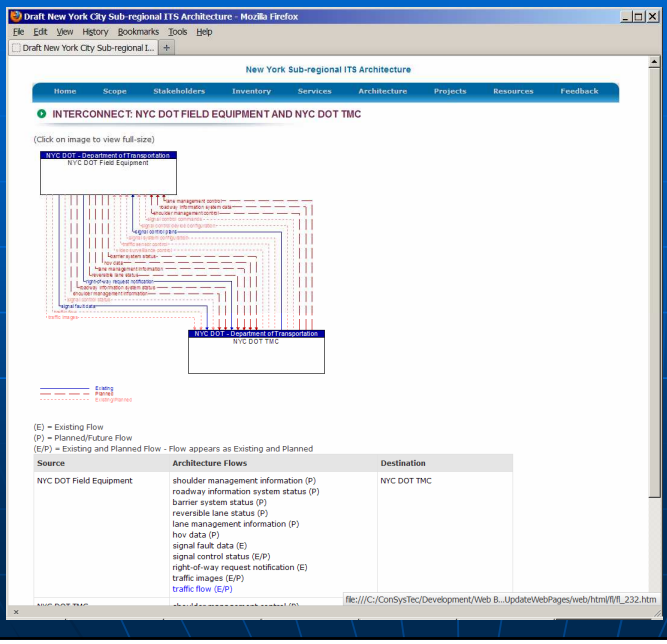
6: Applicable ITS Standards

Navigate to Inventory Web Page



Click on Project Relevant Interfaces to View Architecture Flows

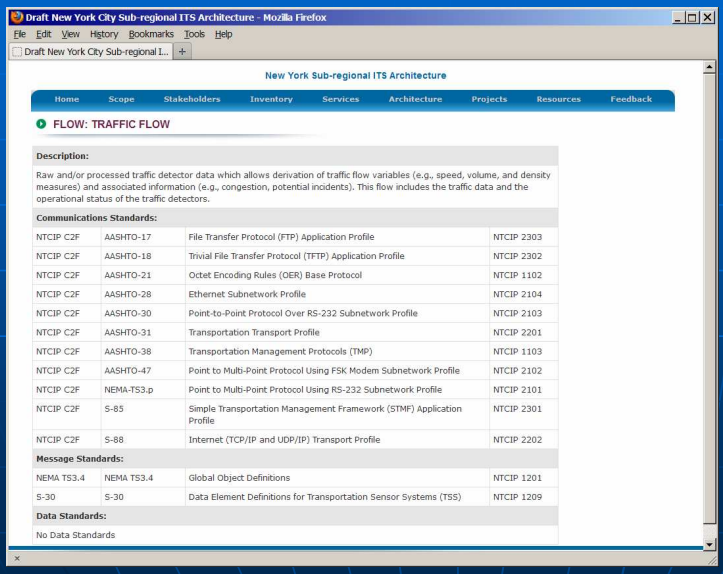
6: Applicable ITS Standards



Select Project Relevant Architecture Flows.

6: Applicable ITS Standards

Add a chart to show the down-select.



Select Project Relevant Applicable ITS Standards.

6. Test Procedures

- If specifying NTCIP Standards
  - State that the contractor will document test procedures using *NTCIP 8007 Testing and Documentation within NTCIP Standards*
  - If you are specifying NTCIP 1203 DMS, or NTCIP 1204 ESS, then test procedures are included in the standard.
  - Read through guidance document *NTCIP 9012 Testing Guide for NTCIP Center-to-Field Communications*
- If specifying IEEE 1512
  - Read through *Guide for Implementing IEEE Std 1512™ Using a Systems Engineering Process.* Chapter 7 contains a complete example of test documentation, based on *IEEE 829 IEEE Standard for Software Test Documentation*.
- Otherwise, suggest specifying that all test documentation be based on IEEE 829 standard

6. Test Procedures

- Sub-sections of the PSEAR included:
  - System Testing
  - NTCIP (Standards) Testing
  - System Acceptance
  - Interpretation Resolution

6. Test Procedures Excerpt

The following five (5) types of tests shall be required for each unit of equipment furnished under this contract. NYCDOT personnel will be present all the following 5 tests :

- Design Approval Tests,
- Factory Demonstration Tests,
- Stand-Alone Tests,
- Site Verification Test, and
- System Acceptance Test.

In addition, staging tests shall be performed for the communications system and CCTV subsystem; and performance verification tests shall be performed for the communications network. Other tests applicable to a specific type of equipment are specified in the special specifications for the equipment type.

7. Operations and Management Discussion

- Identify who is responsible for operations and maintenance of the system elements
- If multiple agencies, identify who and under what conditions, which agency has command/control priority

7. Operations & Management Excerpt

The Brooklyn Bridge ITS Improvement project ITS elements will be integrated into the existing New York City TMC, which operates and manages the existing ITS infrastructure along the Brooklyn Bridge.

No additional operations and management resources will be requested under this project. The existing NYCDOT resources will also be utilized to maintain the additional ITS elements provided under this project.

Case Study 2
Verrazano-Narrows Bridge ITS

Case Study 2: Verrazano-Narrows Bridge ITS

- Project Objective:
  - Relocation and Upgrade of Detection, Message Signs on VN-SIE Approaches
- PSEAR Report Status:
  - FHWA Approved May 2011.

Verrazano-Narrows Bridge PSEAR Outline

TABLE OF CONTENTS

1. Portions of Architecture Being Implemented

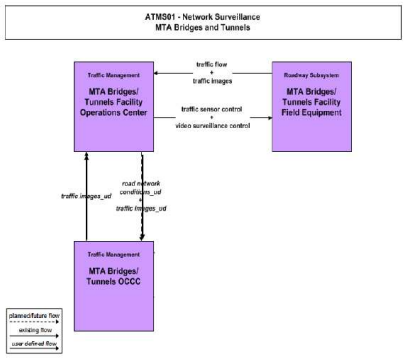
3.3 Customized Market Package Analysis

When discussing the system interfaces for a particular system, it is necessary to review the ITS elements in the NYC Sub Regional ITS Architecture, as defined for this project. The table below maps the customized market packages that are attributable to the VN-SIE Approaches ITS Subsystems installation project:

Table 2. Customized Market Packages for the VN-SIE Approaches ITS Project

Market Package Diagram	Market Package Name	Applicable ITS Project Elements
ATMS01	Network Surveillance	- VN ATMS & OCCC - VN ATMS Field Equipment
ATMS04	Freeway Control	- VN ATMS - VN ATMS Field Equipment
ATMS06	Traffic Information Dissemination	- VN ATMS & OCCC - VN ATMS Field Equipment

Figure 4. ATMS01 – Network Surveillance vs the VN-SIE Approach ITS Subsystems Project



2. Participating Agencies' Roles and Responsibilities

4.1 Agencies operating or directly benefiting from the VN-SIE ITS Subsystems:

The VN-SIE-ITS Subsystems will be owned and operated by the MTA B&T. However, close cooperation and coordination will take place in particular with NYSDOT on whose jurisdiction these subsystems will be deployed. For instance, messages posted on the VN-SIE-Approach VMS will be serving the traffic that flows both on SIE and the VN Bridge. This VMS could especially be useful during major incidents that may potentially impact both agencies. Whatever impact is felt on traffic in SIE could affect the VN and vice versa. As a result, the two agencies will directly benefit from the ITS subsystems in place at the SIE approaches, regardless of who owns it or deployed it, including the VN-SIE ITS Subsystems. A 3rd party that could indirectly benefit from these ITS Subsystems is the PANY&NJ which owns the Goethals Bridge, on the western end of the SIE.

Thus the agencies that directly or indirectly benefit from the VN-SIE ITS Subsystems are:

- MTA B&T (owner and operator)
- NYSDOT (partner providing access right to jurisdiction)
- PANY&NJ (partner sharing traffic on SIE
- Others (NYCDOT, NYPD & Fire)

4.2 Regional Stakeholder Agencies

4.2.1 MTA B&T

This project is initiated and managed by MTA B&T, in cooperation with NYSDOT. The VN-SIE Approach ITS Subsystems will interface with the ATMS at the bridge. Whatever interface with the planned NYSDOT Staten Island ATMS or the JTMC in LIC will have to go through this ATMS, which will be determined later. It is possible the VN ATMS could share some limited information such as traffic video scenes in direct interface with the SI TOC, perhaps bypassing the MTA B&T OCCC in Randall's Island and NYSOT/NYCDOT JTMC in LIC. This requires a policy decision not just technical solution. This is because as it stands now, all out of agency communications or ITS sharing from the MTA B&T has to go from the central gateway; the OCCC.

In addition, for future connection of Staten Island ATMS system to JTMC via dedicated fiber, NYSDOT R11 will eventually request communications connectivity/redundancy at the Verrazano Narrows Bridge toll plaza from the Metropolitan Transportation Authority Bridges and Tunnels Operations

3. Functional Requirements

5. SYSTEM FUNCTIONAL REQUIREMENTS

Three ITS elements are identified for the VN-SIE Approach Subsystem project, based on the NYC Sub Regional ITS Architecture, including:

- MTA B&T Field Equipment (CCTV)
- MTA B&T Field Equipment (VMS/CMS)
- MTA B&T Field Equipment (Lane Control Signals-LCS)
- For each of above ITS elements, equipment packages (functional areas) and functions requirements were identified in the NYC Sub Regional ITS Architecture and summarized in Table 3.

Table 3. Customized ITS Equipment Packages for the VN-SIE Approach ITS Subsystems

ITS Element	Applicable Equipment Packages	Requirement
1. MTA B&T Field Equipment (CCTV)	Roadway Basic Surveillance	The field element shall monitor, process, and send traffic images to the VN facility ATMS center for further analysis and distribution. The field element shall return operational status for the CCTV to the control center.
2. MTA B&T Field Equipment (LCS)	Freeway Control	Lane Control Signals shall provide Lane Status (open/closed).
3. MTA B&T Field Equipment (VMS/CMS)	Traffic Information Dissemination	The field element shall include dynamic messages signs for dissemination of traffic and other information to drivers, such as incidents and travel time under center control; the VMS/CMS will be LED based signs.

5.1 ITS Element #1. MTA B&T Field Equipment (CCTV):

Applicable Equipment Package - Roadway Basic Surveillance

This equipment package provides the capabilities to monitor traffic flow by collecting, processing, and analyzing traffic data from ITS equipment CCTV. The field element shall collect, process, compress, and send traffic sensor data (image, speed, volume, and occupancy) to the VN ATMS for further analysis and storage, under center control. The following Pspec are involved under this equipment package:

- Process Traffic Images (Pspec ID 1.3.1.3)

This process shall process raw traffic image data received from CCTV located on the SIE approach to VN. Where any of the data is provided in analog form, the process shall be responsible for converting it into digital form and calibrating. The process shall transform the image data to the ATMS center for traffic surveillance and incident detection. It shall also act as the control interface through which the images of traffic conditions can be adjusted by the camera Pan/Tilt/Zoom. This process shall also provide operational status (state of the device, configuration, and fault data) to the controlling process.

4. Alternative System Configuration and Technology Options

6.2 Concept of Operations:

As indicated above, the three ITS Subsystems (VMS, CCTV & Lane Control Signals) are owned and operated by MTA B&T. However, since all of the three devices will be located on NYSDOT jurisdictions, coordination between the two agencies is essential, in areas as highlighted below.

Coordination in such areas as traveler information postings, lane closures, operations and maintenance will be critical. After the full deployment of these subsystems, there will still be coordination areas between the two agencies, in particular for maintenance. The MTA B&T maintenance crew at the Verrazano-Narrows Bridge will be responsible for routine and emergency maintenance of these devices. However, coordination with NYSDOT will be needed since the signs are in their jurisdictions. This coordination arrangement will be worked out between the two agencies in some form of an agreement. In addition, in some cases (especially during major incidents or constructions) NYCDOT and others (including the NYC Police Department) may need to provide assistance, as they do routinely.

However, operation and control of the three sub-systems and devices will be carried out solely by the MTA B&T operations staff at the Traffic Operations Center of the Verrazano-Narrows Bridge. This is essential to provide smooth operation of the facility for the public.

However, there could be times that NYSDOT and other regional agencies request to post a message on a VMS on a B&T Facility, or vice versa. For instance, NYSDOT may request MTA B&T to post such as public service, amber alert or statewide sit belt campaign messages on its VMS signs. Cooperation in these areas are expected and arrangements will be made by the two agencies, as needed. his can be done through TRANSCOM or center to center connection (OCCC to JTMC) and follow the established TBTA Procedures for VMS and TRANSCOM VMS Request (Addendum A+B). In brief the procedure calls for OCCC to serve as the primary contact between regional agencies and MTA B&T Facilities for requests submitted through TRANSCOM.

The CCTV cameras will be connected to or integrated with the Traffic Operations Center for the facility and the OCCC. The VMS will also be connected to the control centers similar to the other existing VMS at the bridge. However, the LCS and CMS will be functioning as standalone subsystems. They will be controlled by the Verrazano-Narrows Bridge Traffic Operation Center.

6.3 Communication Network Options

MTA B&T has redundant wide area communications networks to connect its nine facilities (seven bridges and two tunnels) and the two main hubs, which are located in Randall's Island and at 2 Broadway, in Lower Manhattan. These communications networks include Fiber, Switched Ethernet, ATM backbones and T-1 (for voice). Currently, there are a few facilities without a direct connection by fiber with the two communications hubs, mentioned above. Planning is underway to complete a direct connection for all facilities to the two hubs with fiber. This will significantly increase the capacity of the Authority to have a robust wide area communications network, which is critical for reliable, efficient and sustainable transmission of video and data as well as voice. The robust communications network will also be valuable to the growth and development of the MTA B&T ITS Architecture.

5. Procurement Options

7. SYSTEM PROCUREMENT, OPERATIONS, AND MANAGEMENT OPTIONS

MTA B&T is coordinating with NYSDOT for the procurement of the three ITS subsystems. In order to maintain compatibility and interoperability with existing or legacy subsystems and devices, it is necessary for MTA B&T to procure proprietary devices and equipment for the old signs. However, MTA B&T is currently transitioning its VMS to NTCIP compliant systems by requiring all new signs to meet the standard. For interoperability, the devices for the subsystems (CCTV, VMS/CMS and LCS) that will be acquired under the SIE project, with the help of NYSDOT, will have to be identical to the existing systems at the facilities, in particular the Verrazano-Narrows Bridge, in order to perform similar functions and operate seamlessly.

The two agencies have also agreed to have the procurement and installation of these devices completed under a NYSDOT contract. MTA B&T will facilitate coordination and provide assistance to NYSDOT, as needed, in order to accomplish the required procurement tasks. Funding arrangements will also be worked out between NYSDOT & MTA B&T for the procurement and installation of these devices and subsystems, as part of an existing MOU.

7.1 Construction Phasing

Construction of the VN SIE ITS Subsystems will be progressed in compliance with the stipulations provided by the New York City Department of Transportation, Office of Construction Mitigation and Coordination (OCMC), in coordination with NYSDOT. Existing ITS equipment at the approaches and toll plaza operations will be maintained throughout the construction phase and traffic crossing at the bridge will not be adversely impacted.

Maintenance and Protection of Traffic may consist of lane closures, on/off ramp closures and detour plans reviewed and approved by OCMC to facilitate the necessary construction operations of the project.

7.2 Project Cost Estimates:

- Lane Control Signals
- VMS & CMS
- CCTV Cameras

The engineer's estimate for the project's equipment, construction and system integration is currently approx $ 1.7 Million. This estimate is for the ITS subsystems that will be installed by MTA B&T. It doesn't include those to be installed by NYSDOT (2 VMS and 1 CMS) for MTA B&T use, as part of the VN-03 project.

7.3 Operations and Maintenance Costs:

The cost estimate for Operation and Maintenance of the ITS Subsystems (VMS/CMS, CCTV and LCS) is approximately $20,000/year. This includes preventive maintenance for the CCTV cameras and VMS in particular. The estimate also takes into consideration the cost potentially associated with possible lane closures and operations during maintenance.

6. Applicable ITS Standards and Test Procedures

8.1 Standards and Protocols:

As a key participant in the ITS Architecture development effort both in the Regional and NYC-Sub-Regional ITS Architectures, MTA B&T fully supports the growth and strengthening of these agreements, and strives to implement applicable standards to the extent possible. As a result, it continues to strive in transitioning its old legacy ITS systems into open standards, which will make it easier to interface both internally and externally with regional agency systems. For instance, the old VMS signs are being replaced with NTCIP compliant systems. The CCTV cameras are also standard.

However, the lane controllers will be operated as a stand-alone system and will not be connected or interface with an ITS device or subsystem. As a result, communications and inter-operability related issues will not arise with these systems.

Applicable NTCIP Standards

Document Number	Document Title Involved
NTCIP 1101	Simple Transportation Management Framework (STMF)
NTCIP 1102	*Octet Encoding Rules (OER)*
NTCIP 1201	Global Object Definitions
NTCIP 1203	Object Definitions for Dynamic Message Signs (DMS)
NTCIP 1205	Object Definitions for Closed Circuit Television (CCTV) Camera Control
NTCIP 1208	Object Definitions for Closed Circuit Television (CCTV) Switching
NTCIP 2101	Point to Multi Point Protocol (PMPP) Using RS-232 Sub network Profile
NTCIP 2103	Point-to-Point Protocol (PPP) Over RS-232 Sub network Profile
NTCIP 2201	Transportation Transport Profile ("NULL" Transport Profile)
NTCIP 2202	Internet (TCIP/IP and UDP/IP) Transport Profile
NTCIP 2301	Simple Transportation Management Framework (STMF) Application Profile
NTCIP 2306	Application Profile for XML in ITS Center to Center Communications

8.2 NTCIP & System Acceptance Testing

MTA B&T adheres to rigorous testing procedures and processes during procurement, design, installation and operations of its technology devices, systems and subsystems in the ITS Implementation Program. An all rounded hardware/software and communications testing is carried out before a project is declared completed and systems are accepted by the Authority. This will apply to the three subsystems VMS, CCTV & Lane Control Signals.

The VMS will be thoroughly tested in separate phases for factory and field performances, before deployment and integration. Finally, a full end-to-end test with limited operation and integration will also be conducted (consisting hardware/software and communications tests) with the ATMS at the facility operation centers, before they are officially accepted or their warranty expires.

The same process applies to the CCTV cameras as well. The Lane Control Signals will also undergo a rigorous testing process. As part of the planning and design phases of the project, a detailed Systems Acceptance Test Plan will be prepared for testing these ITS Subsystems and devices.

8.2.1 NTCIP Testing

The contract documents (PS&E - Specifications) provide details requirements regarding NTCIP testing and compliance, including relevant Management Information Base (MIB) requirements. The contractor will test the ITS devices and demonstrate compliance with the NTCIP requirements.

8.2.2 System Acceptance Testing (SAT)

The VMS manufacturer will have to submit a NTCIP test plan a minimum of 90 days prior to NTCIP acceptance testing. This NTCIP acceptance Test Plan must be submitted and test be conducted in accordance with the NTCIP test plan submissions and SAT requirements, which will be laid out in the design specs and contract documents.

7. Operations and Management

9.1 Concept of Operations – O&M

As detailed above (Section 6.2), the concept of operations for this project will be coordinated in all areas between the two regional agencies, in particular traveler information postings, lane closures, operations and maintenance. An agreement will be made between the MTA B&T (the owner of the ITS Subsystems) and NYSDOT (the owner of the jurisdiction where the ITS Subsystems will be installed) on how to operate and maintain the systems including in times of emergency.

9.2 Design, Installation, Testing and Verification process:

The design for the MTA B&T VN-03 project, which incorporates the VN-SIE ITS Subsystems deployment, is currently completed 100%. The final design will include comments from NYSDOT, Region 11 Engineers, who are responsible for the SIE approaches upgrade. Construction is scheduled to start in 2012.

The technologies behind the field equipment being proposed under this project's detailed design have previously received verification through other successful regional ITS projects already in-place, where such systems have satisfied the region's unique functional requirements. The CCTV and VMS subsystems in this project are similar to what are already in place at the other MTA B&T facilities. The Lane Control Signals (LCS) have also been operational at the Verrazano-Narrows Bridge for many years.
Nonetheless, ITS standards and testing procedures will be continually identified by the MTA B&T ITS project and will be specified in its PS&E to be applied during its construction phase. Previous sections of this report present the selection of applicable ITS standards, including NTCIP communications standards, and system testing procedures, which consist of pre-installation testing, factory/manufacturer testing, stand-alone assembly testing, group site verification testing, subsystem integration testing and finally, the system acceptance test.

Case Study 3
Long Island Expy & Brookly Queens Expy Travel Time Systems (Transmit Expansion)

Case Study 3:
LIE & BQE Travel Time Systems

- Project Objective:
  - Expansion of the Transmit system along Long Island Expressway and Brooklyn Queens Expressway
- PSEAR Report Status:
  - Get this from Raj.

Table of Contents

1. Portions of Architecture Being Implemented

2.1 Portions of the Regional ITS Architecture Being Implemented

The Western Queens & Brooklyn Sub Regional ATMS is a transportation management project focused on the installation of the vehicles tag readers and the travel time signs to supplement existing tag readers and variable message signs (VMS). The equipment will be integrated into the existing central software system located at the New York City Joint Transportation Management Center (JTMC). Modification of the central system is not part of this project. The table below identifies the regional ITS architecture elements being implemented as part of the project.

Table 1. Transmit Expansion Project Elements

Project ITS Elements	NYC Sub Regional ITS Architecture Elements	National ITS Architecture Subsystem
Central System (existing)	New York City JTMC	Traffic Management Emergency Management
Transmit detectors	NYSDOT REGION 11 Field Equipment	Roadway Subsystem
Travel Time signs	NYSDOT REGION 11 Field Equipment	Roadway Subsystem

1. Portion of Architecture Being Implemented

2.1.1 Customized Market Package Analysis

The table below maps the project elements to the NYC Sub Regional ITS Architecture customized market packages. Specifically, the table contains all of the market packages that contain the New York City, NYSDOT R10, PANYNJ, JTMC and the NYSDOT R11 Field Equipment elements. The rows shown in bold indicate the customized market package models relevant functionality that relates to the TTS project.

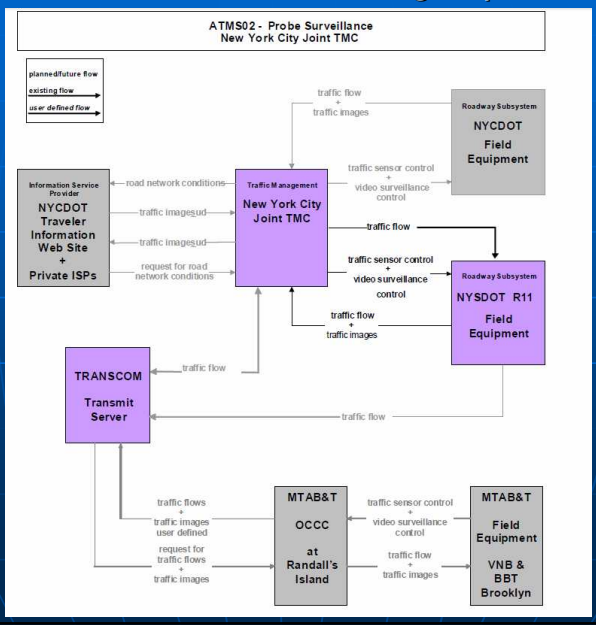
***Table* 2. Customized Market Package Analysis Results**

Market Package	Market Package Name
ATMS01	Network Surveillance
ATMS02	**Probe Surveillance**
ATMS03	Surface Street Control
ATMS04	Freeway Control
ATMS06	**Traffic Information Dissemination**
ATMS07	Regional Traffic Control
MC03	Road Weather Data Collection

** Bold indicates in project

The figures on the following pages (Figures 3,4 and 5) show the relevant portions of the customized market packages and architecture flows. The gray boxes indicate the portions of the market packages that do not apply to the project. In addition, dotted lines between ITS elements indicate

1. Portion of Architecture Being Implemented



2. Participating Agencies' Roles and Responsibilities

2.2 Participating Agencies- Roles and Responsibilities (Concept of Operations)

TTS project is proposed to supplement existing network surveillance equipment constructed or proposed by NYSDOT R11, R10, NYC DOT and MTA B&T. Sharing and coordinating of network information with MTA B&T and R10 is important as these corridors connect to their facilities.

The surveillance equipments installed along R11 highways such as radars, vehicle classification detectors and cameras provide reliable information regarding spot speed and lane occupancy. The information acquired by the devices is not sufficient for the accurate travel time estimation.
R11 strives to install E Z pass detectors on all major interstate highways and traffic generation points, like area Airports and sport complexes to provided travel time information benefiting significant number of the traveling public. The project equipments will allow generating a corridor flow map for NY 511 system.

Data collected by proposed equipments will be sent to the JTMC, for real time travel time estimation, and raw or processed data will be shared with all participating agencies in particular NYCDOT, R10 & MTA Bridges & Tunnels. Sharing information with the aforementioned agencies would be beneficial as Long Island Expressway is the major connector between NYC and Nassau & Suffolk Counties, as well as to New England, through Long Island bound bridges.
Additionally collected data will be archived and analyzed to determine long time traffic trends and provide O-D matrix. A coordination effort with other agencies by Traffic Engineering & Safety and ITS Squad of NYSDOT, R11 under this project includes:

- Meetings held on September 9, 2010 & June 14, 2011, had facilitated this project's coordination between R10 & NYC DOT.
- NYSDOT R11 is in continuous coordination with TRANSCOM agencies (particularly for this project) of NYCDOT, MTA B&T, PA NYNJ and downstate Regions, to evaluate the effectiveness of the real time travel time information and to further develop region-wide system in order to provide seamless travel time information to the regional travelers.
- Providing NYCDOT, R10, MTA Bridges &Tunnels and other metropolitan agencies with ADP, Pre-PS&E and PS&E level contract plans for their reference in the on-going coordination effort
- The ITS Elements of NYSDOT R11 Field Equipment as identified in the project and in the NYC Sub Regional ITS Architecture, will be jointly operated and managed by NYSDOT and NYCDOT. Under this project, additional field equipments will be integrated into the existing New York City JTMC.

3. Functional Requirements

2.5 Requirements Definition

The functional requirements defined in this analysis report were derived from the information contained in the NYC Sub Regional ITS Architecture. Requirements for four ITS elements are defined below as follows:

- NYSDOT Field Equipment –Sensors
- NYSDOT Field Equipment – Travel Time Signs
- New York City JTMC (Informational Only)
- TRANSCOM RA Servers (Informational Only)

The requirements were developed as follows:

1) For each ITS element, specific equipment packages (high level functional area requirements) were extracted and listed below. The applicable equipment packages for each ITS element are identified in the NYC Sub Regional ITS Architecture. The equipment package definitions were customized (the text re-written) to match the project needs.
2) For each equipment package, the process specifications from the National ITS Architecture were identified and the process specification kept (if it applied to the project needs) or removed (where the process specification did not apply). The process specifications represent more detailed (but still high-level) functional requirements for the ITS element given the role of the ITS element within the project context. The process specifications, like functional requirements, defined what actions or activities the ITS element must perform to satisfy the project needs.

2.2.1 ITS Element: NYSDOT Field Equipment (Sensors)

Equipment Package – Roadway Basic Surveillance

This equipment package provides the capabilities to monitor traffic flow on major freeways and monitor road conditions using fixed equipment such as vehicle sensor technologies and CCTV cameras.

2.2.1.1.1 Process Specification – Process Traffic Sensor Data (ID: 1.1.1.1)

This process shall be responsible for collecting traffic sensor data. This data shall include traffic parameters such as speed, volume and travel lane occupancy, as well as video images of the traffic. The process shall provide sensor status and fault indications. Where any of the data is provided in analog form, the process shall be responsible for converting it into digital form and calibrating. The converted data shall be sent to other processes for distribution, further analysis and storage.

4. Alternative System Configuration and Technology Options

2.3 Analysis of Alternate System Configurations and Technology Options

As this project is an expansion of the ITS systems for transportation management, a number of technology choices, communications and technical designs of the ITS implementation will be inherited from the existing implementation. This includes:

1. Functional compatibility of new transmit equipment with previously constructed transmit equipment. Communication between new and existing equipment will be compatible with approved NTCIP protocol specifications.

2. Design of communications including: fiber, wireless, and a selection of network equipment (e.g., modems, Ethernet communications equipment, microwave and fiber communications equipment) and communications protocols. To maintain compatibility with the existing system, fiber communications will be used between the existing central system and new field elements.

5. Procurement Options

2.4 Procurement Options

TTS project is identified in the Region's Transportation Improvement Program and New York State DOT's Capital Plan. TTS project scheduled for September 2012 letting has not been defined as a significant project. The design, specification development and procurement documents will follow NYSDOT's contract administration procedures.

The TTS Construction Schedule:

Project letting is scheduled for September 2012, with construction duration 18 months.

2.4.1 System Integration and Life Cycle Costs

The total estimated construction cost of TTS project including system integration is $2.5 million. The annual cost of operation and maintenance (O&M) were developed from information derived from ITS Maintenance contracts let by R11.

Total Project Cost

The following comprises the field elements to be constructed and integrated into the existing central system under this project:

- Six (6) EZ-Pass Transmit Antennas sites
- One (1) Travel Time Signs

System Integration

The system integration component of the project is $15,000, broken down as follows:

- Materials (shop drawings and materials): $5,000
- Equipment (test equipment, equipment rental): $0 (cost included under various pay items)
- Labor (project management, electrician and laborer): $10,000

No additional cost of operation is expected due to additional equipment added under TTS project.

Cost of Maintenance

The annual maintenance cost for this project is composed of a central software / control center component, a field equipment component and a communications component. The maintenance cost associated with the control center building, associated equipment and software would not increase significantly, when this project is brought on-line.

Table 4 provides the maintenance cost estimate for this project. The estimated number of spares is based on the equipment quantities listed in Section 2.4.

Table 4. Annual Maintenance Cost Estimate

DESCRIPTIONS	COSTS
1. THREE (3) MAINTENANCE TECHNICIANS AND VEHICLE FOR TWELVE (1/2) DAYS	$16000
2. ANNUAL COST OF SPARE EQUIPMENT	$1000
3. SPARE HARDWARE REQUIRED FOR MAINTENANCE:	$6000
TOTAL ANNUAL MAINTENANCE COST	$23,000

6. Applicable ITS Standards and Test Procedures

Table 5. List of Applicable ITS Communications Standards

Document Number	NTCIP 9001 v03.02, October 2002 Document Title Involved
NTCIP 1101	**Simple Transportation Management Framework (STMF)**
NTCIP 1201	**Global Object Definitions**
NTCIP 1203	Object Definitions for Dynamic Message Signs (DMS)
NTCIP 1205	Object Definitions for Closed Circuit Television (CCTV) Camera Control
NTCIP 1208	Object Definitions for Closed Circuit Television (CCTV) Switching
NTCIP 2101	**Point to Multi Point Protocol (PMPP) Using RS-232 Sub network Profile**
NTCIP 2103	**Point-to-Point Protocol (PPP) Over RS-232 Sub network Profile**
NTCIP 2201	**Transportation Transport Profile ("NULL" Transport Profile)**
NTCIP 2202	**Internet (TCIP/IP and UDP/IP) Transport Profile**
NTCIP 2301	**Simple Transportation Management Framework (STMF) Application Profile**
NTCIP 2306	Application Profile for XML in ITS Center to Center Communications

2.2.5 System Testing

To accomplish system testing of the ITS elements, the following types of tests will be required for each unit of equipment furnished:

1. Design Approval Tests
2. Performance Verification Tests (communications network)
3. System Acceptance Test

The tests outlined above are test identified for ITS systems that will be specified in the PS&E. Other tests applicable to a specific type of equipment are specified in their special specifications.

The three testing categories mentioned above form an overall testing philosophy and are described in the following paragraphs. The individual specifications may provide more detailed requirements and supersede these special provisions. The Contractor shall be responsible for developing detailed test procedures for each type of equipment and for conducting the specified acceptance test to verify satisfactory operation of the equipment. The test procedures shall be submitted to the Engineer for approval prior to the tests. Only approved test procedures shall be used for the test. Unless otherwise specified, a minimum of fifteen (15) days shall be allowed for the Engineer's review and approval of the test procedures.

Unless otherwise specified, the Engineer shall be notified in writing a minimum of ten (10) days in advance of the time when these tests are to be conducted. The results of each test shall be compared with the requirements specified herein. Failure to conform to the requirements of any test shall be deemed as a defect, and equipment shall be subject to rejection by the engineer. Rejected equipment by be offered again for retest provided all non-compliance's have been corrected and retested by the Contractor and evidence thereof submitted to the Engineer.

The tests on one type of equipment must be completed within five (5) days and any delays in performing all these tests will result in the Contractor paying the additional costs of providing the Engineer's representatives for the additional testing.

7. Operations and Management

2.4.2 Procedures and Resources for ITS O&M

The project's ITS elements will be integrated into the exiting New York City JTMC, which operates and manages the existing ITS infrastructure in R11. No additional operations and management resources will be required by this project. The existing NYSDOT resources will also be utilized to maintain the additional ITS elements provided under this project.

2.4.3 IT Support

The "IEN", (Information Exchange Network) and "WTA", (Winter Travel Advisory) are both part of the R11 ATMS, maintained by in-house IT staff. When problems with these systems occur, JTMC will notify the Department's "HELP DESK" who will generate a trouble ticket to initiate an investigation of the problem. These systems are a part of the Regional System Architecture and are used on a 24/7 basis and are fully supported by the State's IT Division with Help Desk.

Currently, there is one workstation located at the JTMC for the statewide IEN, where information related to incidents and emergencies are entered. This incident information is then formatted and reported to the general public thru the CARS network. Associated with the IEN system is another reporting network called the "WTA" which is used mainly during the colder months by the Department to report information related to adverse weather conditions that may impact the traveling public. These reporting networks are directly related to the SMARTS System at JTMC and used routinely by JTMC operators in carrying out their daily activities.

SMARTS software is currently being developed and will ultimately integrate these systems to the Region's ATMS. At this time the SMARTS software and associated hardware is supported by those Consultants developing it on a 24/7 basis by means of a series of supplemental agreements. In general, off the shelf software is used as much as possible with custom development limited to ITS functionality. However, the State's IT Division is reviewing and approving the procurement of equipment and miscellaneous software for use with the SMARTS software.

Case Study 4: Managed Use Lane Study (Interactive Walkthrough)

Project Overview

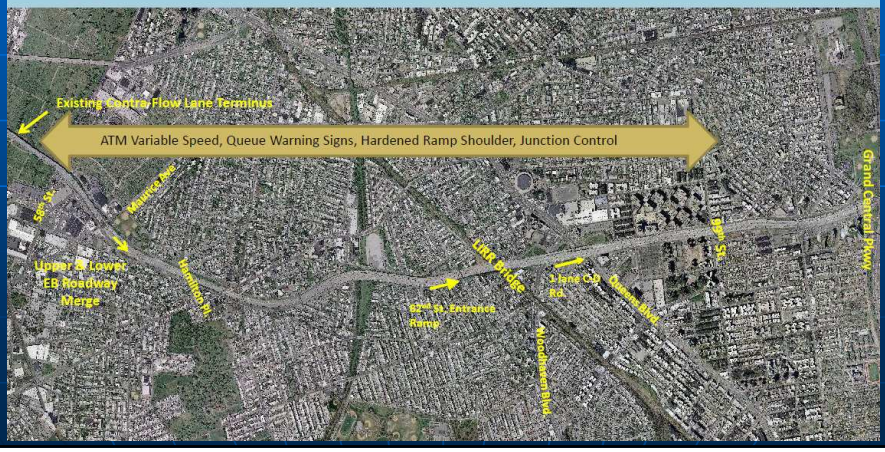
MUL Study Elements

- **A multi-agency collaborative effort to:**
  - Develop a toolbox of MUL strategies to proactively improve movement of people and goods on selected expressways and arterial corridors in and adjacent to New York City;
  - Apply state-of-the-art technologies and management techniques to maximize the use of the existing arterial system in and adjacent to NYC;
  - Develop strategies that coordinate with and support regional mobility and congestion management plans
- **Initial focus has changed to a two to five year horizon**

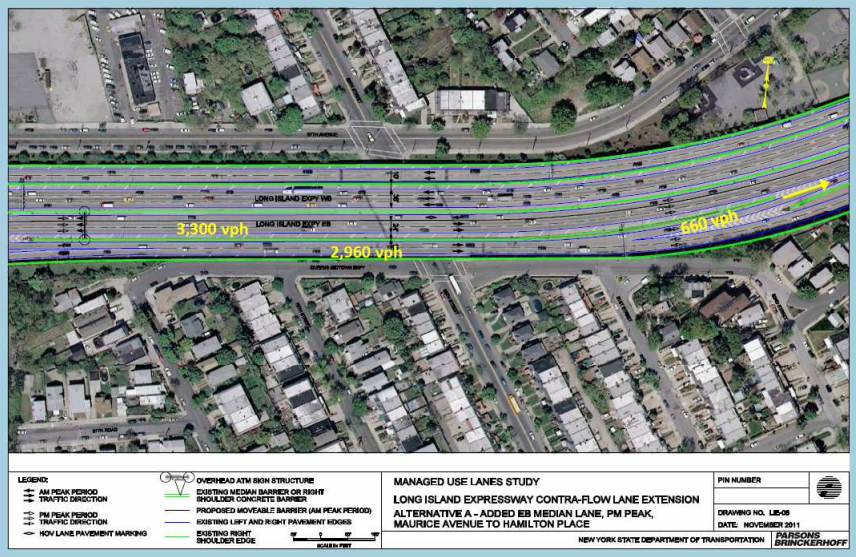
ITS Elements

SELECTED LIE MUL STRATEGY

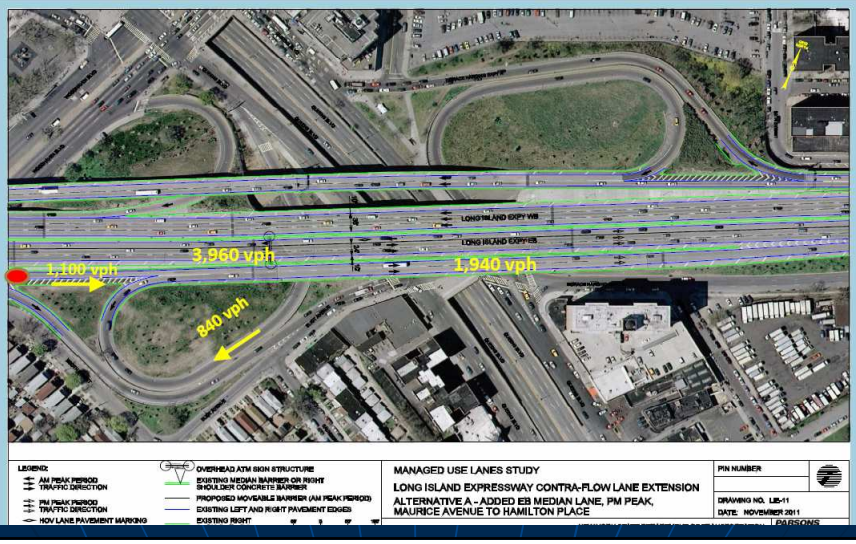
Extension of Existing AM Peak Period Contra-Flow Lane, 58th Street to 99th Street



EASTBOUND ENTRANCE RAMP TRAFFIC FROM SERVICE ROAD @ 82ND St.

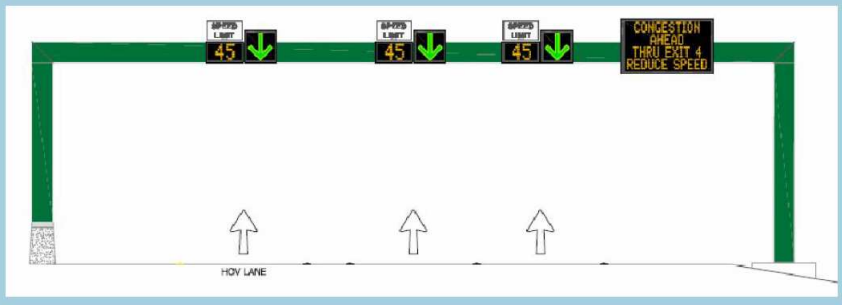


SINGLE LANE EB SERVICE ROAD SECTION, WOODHAVEN BOULEVARD



ITS Elements

ATM VARIABLE SPEED & QUEUE WARNING SIGNS



Discussion about using Systems Engineering in Your Projects and Wrap-up