Appendix I

New York State ITS Standards Specification Development Guide

Example New York State ITS Project Systems Engineering Analysis Report

Prepared for

New York State Department of Transportation

Prepared by

Consensus Systems Technologies Corp.

November 22, 2006

Table of Contents

Revision History

Filename	Version	Date	Author	Comment
NYStateSpecDevGuide – Apl – Systems Engineering Analysis.doc	0.3	11/22/06	M. Insignares / P. Chan	Initial Draft

1 Introduction

To illustrate the key points of the SEA development process, this section will make use of a project example called the New York City Freeway Expansion project. This example shows only one possible means to satisfy the SEA requirements.

1.1 Portions of the Regional ITS Architecture Being Implemented

The NYC Freeway Expansion Project is a freeway management project focused on the deployment of communications and ITS field equipment. The field equipment will be integrated into a central software system located at the New York City Joint TMC. The development of the New York City Joint TMC (with its central system) and any center to center communications to connect the TOC to other centers are not considered a part of this project for this example. The table below identifies the regional ITS architecture elements being implemented as part of the project.

Table 1-1. SEA Project ITS Elements

Project ITS Element	National ITS Architecture Subsystem
New York City Joint TMC	Traffic Management Emergency Management
NYSDOT R11 Field Equipment	Roadway Subsystem

The figure below shows the specific ITS project elements against a “sausage diagram” for the NYC Sub-Regional ITS Architecture. The sausage diagram shows the regional ITS systems inventory around the generic template “sausage diagram” of the National ITS Architecture. Each of the elements of the ITS systems inventory for the ITS architecture are shown mapped to one or more subsystems or terminators of the National ITS Architecture. ITS project elements are highlighted in italic, bold, blue text.

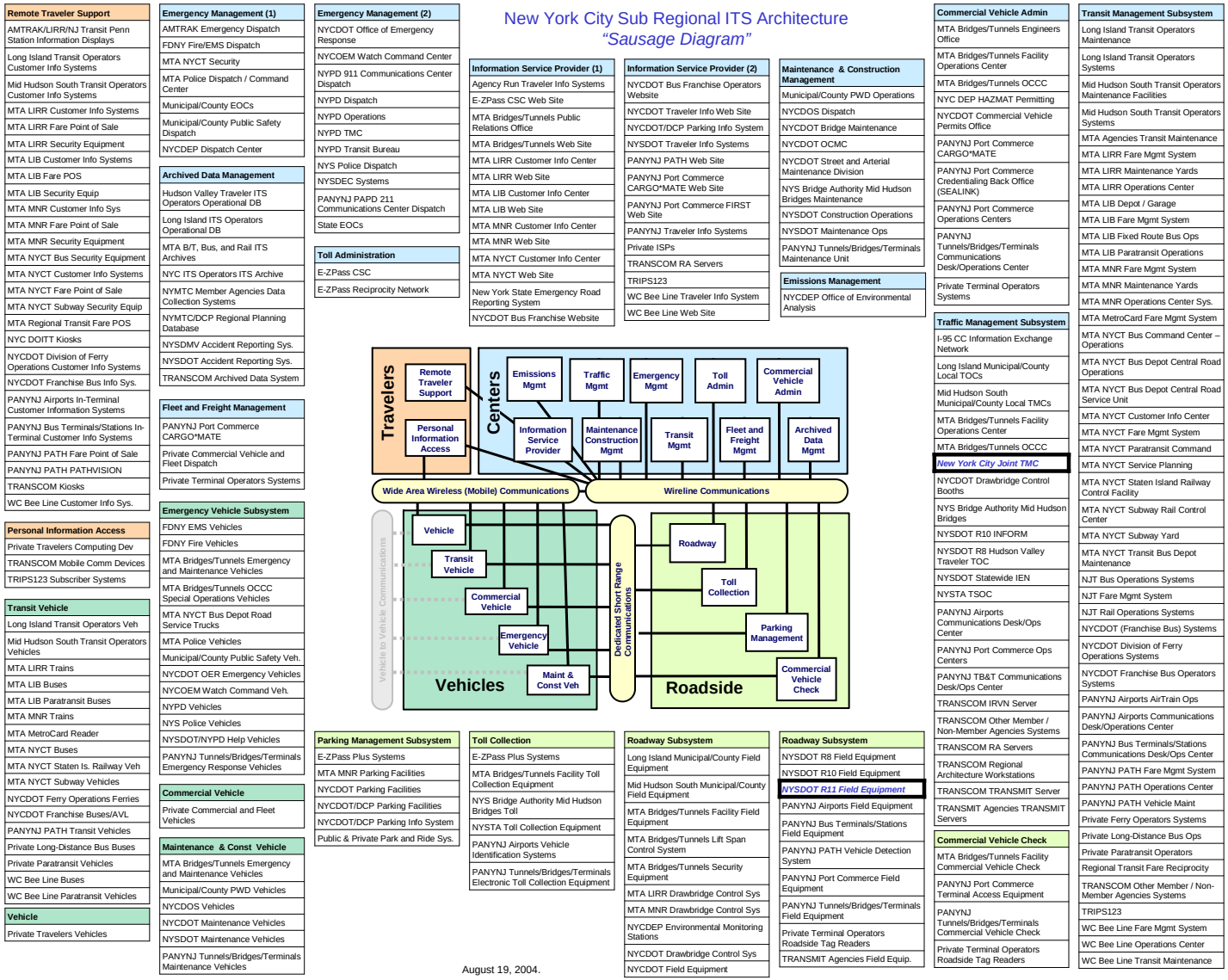

Figure 1-1. Portion of the Regional ITS Architecture Covered by NYC Freeway Expansion Project

1.1.1 Customized Market Package Analysis

The table below lists which customized market packages from the regional ITS architecture apply. Specifically, the table contains all of the market packages that contain the ITS project elements. In this example, customized market package diagrams from the New York City Sub-Regional ITS Architecture are used.

Table 1-2. Customized Market Package Analysis Results

Market Package Diagram	MP Name	Applicable ITS Project Elements
ATMS01-3	Network Surveillance – New York City Joint TMC	New York City Joint TMC, NYSDOT R11 Field Equipment
ATMS04-1	Freeway Control – NYSDOT R8/R10/R11	New York City Joint TMC, NYSDOT R11 Field Equipment
ATMS06-09	Traffic Information Dissemination – NYSDOT Regions	New York City Joint TMC, NYSDOT R11 Field Equipment

The following figures show the relevant portions of the customized market packages and architecture flows. Portions of the market packages that do not apply to the project have been grayed out. In addition, dotted lines between ITS elements indicate future or planned flows and solid lines indicate existing.

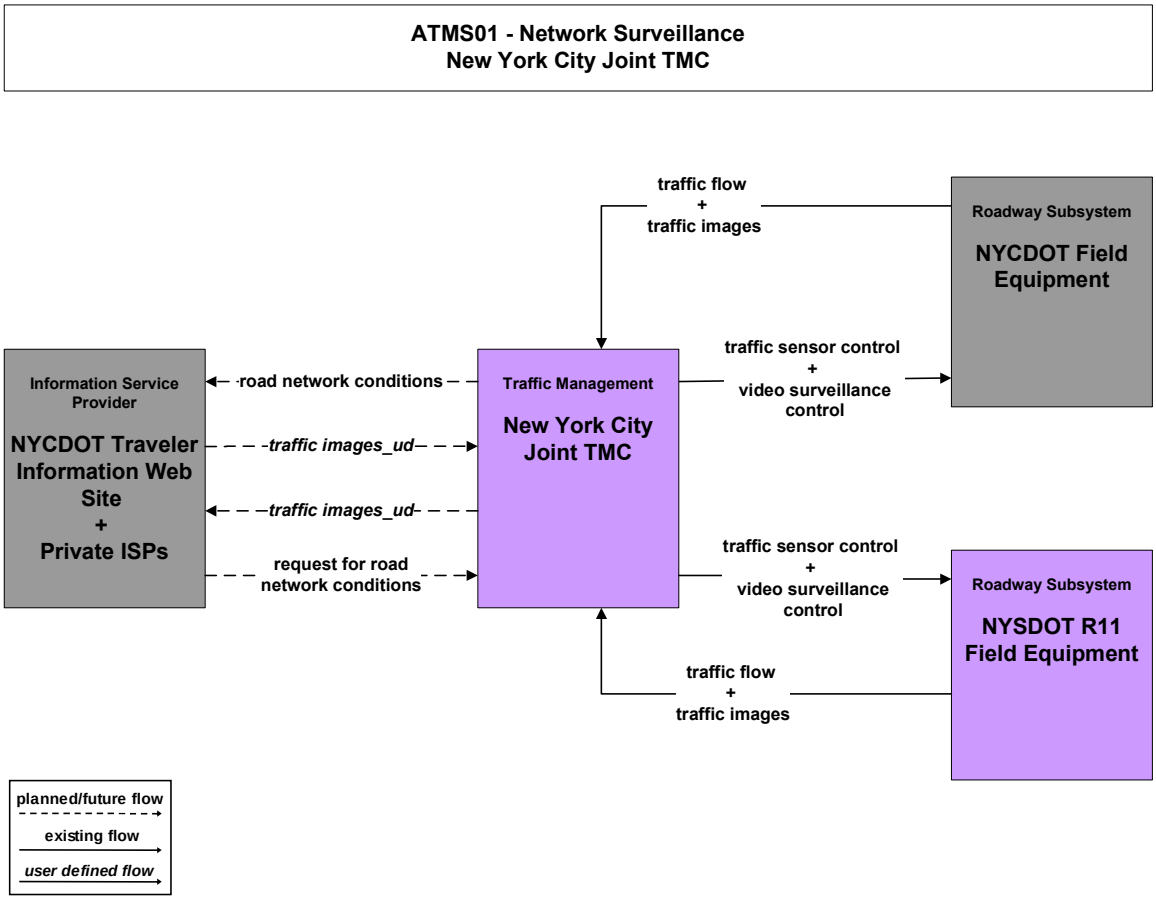

Figure 1-2. ATMS01 - Network Surveillance Customized Market Package

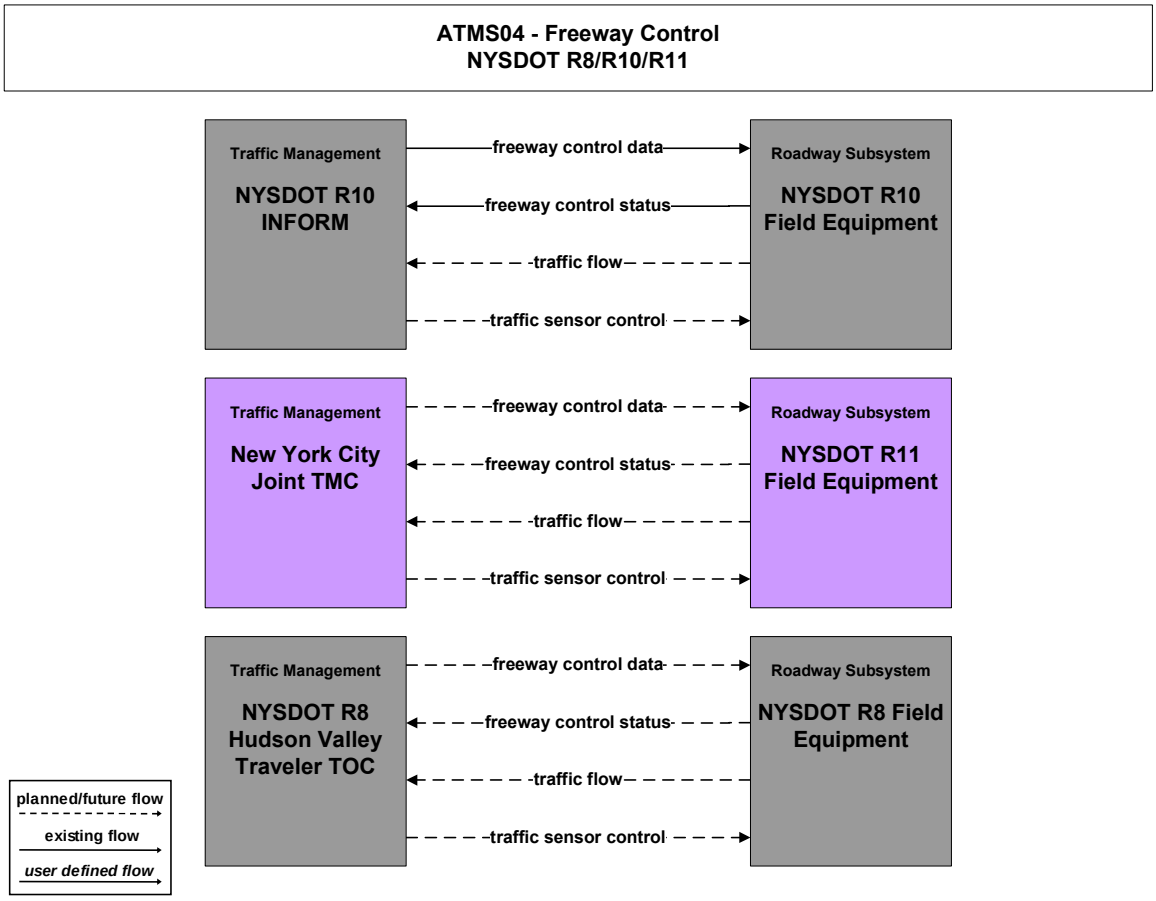

Figure 1-3. ATMS04 – Freeway Control Customized Market Package

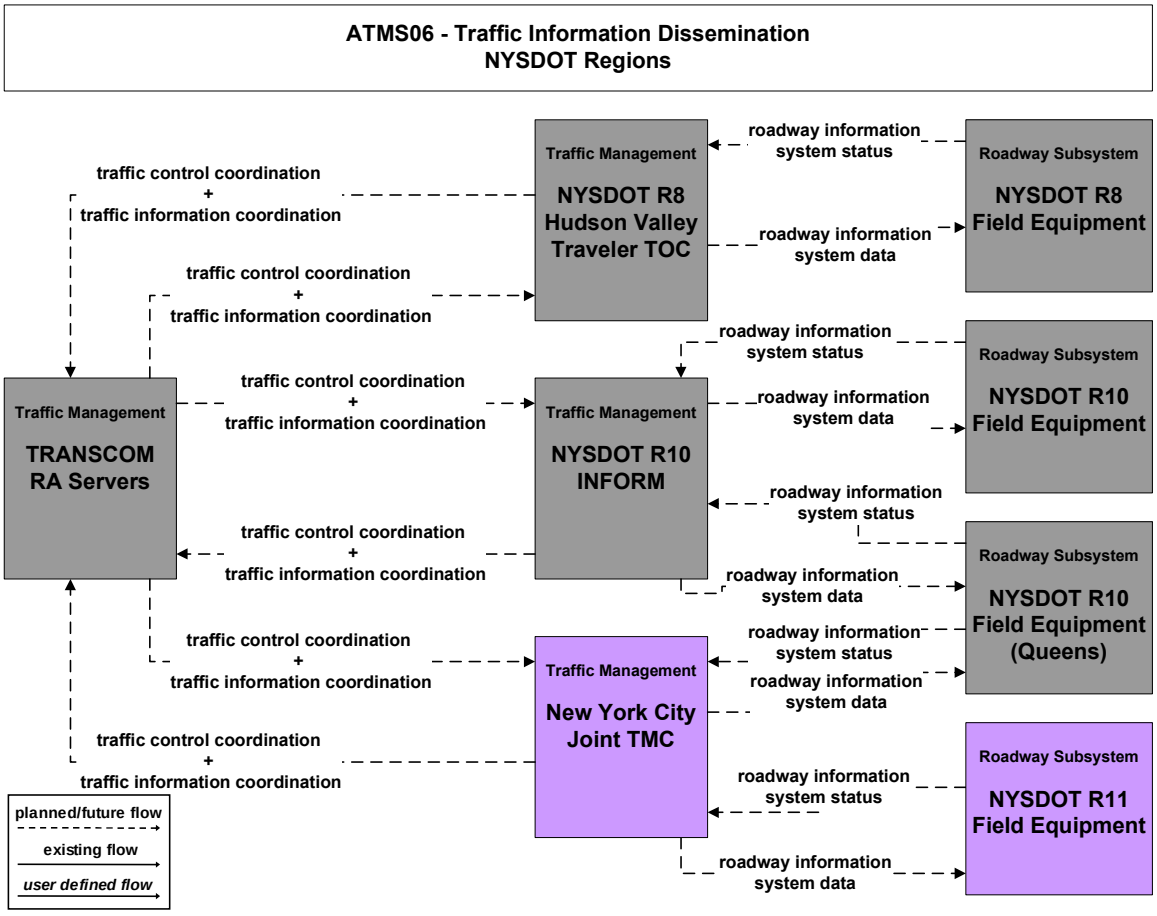

Figure 1-4. ATMS06 – Traffic Information Dissemination Customized Market Package

The table below summarizes the project specific architecture flows between the New York City Joint TMC and the NYSDOT R11 Field Equipment.

Table 1-3. Information Exchange (Architecture Flow) Requirements

Project Element	Direction of Flow	Flow and Definition
Dynamic Message Sign	TMC → DMS	**roadway information system data** - Information used to initialize, configure, and control roadside systems that provide driver information (e.g., dynamic message signs, highway advisory radio, beacon systems). This flow can provide message content and delivery attributes, local message store maintenance requests, control mode commands, status queries, and all other commands and associated parameters that support remote management of these systems.
	DMS → TMC	**roadway information system status** - Current operating status of dynamic message signs, highway advisory radios, beacon systems, or other configurable field equipment that provides dynamic information to the driver.

Project Element	Direction of Flow	Flow and Definition
CCTV	TMC → CCTV	**video surveillance control** - Information used to configure and control video surveillance systems.
	CCTV → TMC	**traffic images** - High fidelity, real-time traffic images suitable for surveillance monitoring by the operator or for use in machine vision applications. This flow includes the images and the operational status of the surveillance system.
Vehicle Sensors	TMC → Sensors	**traffic sensor control** - Information used to configure and control traffic sensor systems.
	Sensors → TMC	**traffic flow** - Raw and/or processed traffic detector data which allows derivation of traffic flow variables (e.g., speed, volume, and density measures) and associated information (e.g., congestion, potential incidents).

1.2 Participating Agencies Roles and Responsibilities

This section of the SEA should include a list of project ITS elements, stakeholders, and roles. This information is summarized in the table below.

Table 1-4. Participating Agencies Roles and Responsibilities

Stakeholders	Project ITS Elements	Roles and Responsibilities
New York City Joint TMC	New York City Joint TMC	NYCDOT and NYSDOT jointly manages and operates the Joint TMC. From the Joint TMC various project freeway field equipment will be operated and controlled.
NYSDOT – New York State Department of Transportation	NYSDOT R11 Field Equipment	Freeway management field equipment operated and maintained by NYSDOT.

In the example project, all the ITS roadway elements, as identified in the project and in the regional ITS architecture, will be integrated into the New York City Joint TMC. The New York City Joint TMC as a whole is jointly operated by New York City Department of Transportation, New York State Department of Transportation, and New York City Police Department, however, the ITS roadway elements for this project will be managed and maintained by NYSDOT.

Some existing information flows in this example project, such as traffic images and traffic flow data, is already being shared by NYSDOT in the New York City Joint TMC with the other operating agencies, specifically New York City Department of Transportation and New York City Police Department. Thus, the roles and responsibilities of each agency for these information flows has already been established, and will remain the same after the deployment of this example project.

This includes:

- the conditions when information is to be shared (event-driven, periodic basis);
- the functions of each agency when information is shared (e.g., who controls the pan, tilt and zoom function for CCTV cameras);
- the responsibilities for control and maintenance (e.g., which agencies tracks and performs maintenance);
- the format of the information is shared, such as the communications protocol to be used, the data structure, the data format, and any standards; and
- the restrictions, if any, on how the information that was exchanged can be used for (e.g., for incident management only)

1.3 Requirements Definition

This section of the SEA includes high level functional requirements that may be derived directly from the statewide or regional ITS Architecture. The high level requirements for each of the subsystems in the project have been defined in the Turbo Architecture database which provides a mechanism for exporting functional requirements into a text file. The requirements shown in the table below are those defined in Turbo Architecture and exported to the text file format.

The requirements table shows the following:

- For each ITS element, specific equipment packages (high level functional area requirements) were extracted. The applicable equipment packages for each ITS element are identified in the ITS architecture Turbo Architecture database. Using Turbo Architecture, the equipment package selections were customized (those not needed to support the project were de-selected) to match the project needs.
- For each equipment package, functional requirements were identified and those that applied to the project were kept. The functional requirements represent more detailed (but still high-level) functional requirements for the ITS element given the role of the ITS element within a project context. The functional requirements define what actions or activities the ITS element must perform to satisfy the project needs.

Table 1-5. Requirements Definition Table

ITS Element	Functional Area (Equipment Package)	Functional Area Description	Requirement
NYSDOT R11 Field Equipment (CCTV)	Roadway Basic Surveillance	Field elements that monitor traffic conditions using loop detectors and CCTV cameras.	The field element shall collect, process, and send traffic images to the center for further analysis and distribution.
NYSDOT R11 Field Equipment (CCTV)	Roadway Basic Surveillance	Field elements that monitor traffic conditions using loop detectors and CCTV cameras.	The field element shall return sensor and CCTV system operational status to the controlling center.
NYSDOT R11 Field Equipment (CCTV)	Roadway Basic Surveillance	Field elements that monitor traffic conditions using loop detectors and CCTV cameras.	The field element shall return sensor and CCTV system fault data to the controlling center for repair.
NYSDOT R11 Field Equipment (DMS)	Roadway Traffic Information Dissemination	Driver information systems, such as dynamic message signs and Highway Advisory Radio (HAR).	The field element shall include dynamic messages signs for dissemination of traffic and other information to drivers, under center control; the DMS may be either those that display variable text messages, or those that have fixed format display(s) (e.g. vehicle restrictions, or lane open/close).
NYSDOT R11 Field Equipment (DMS)	Roadway Traffic Information Dissemination	Driver information systems, such as dynamic message signs and Highway Advisory Radio (HAR).	The field element shall provide fault data for the driver information systems equipment (DMS, HAR, etc.) to the center for repair.
NYSDOT R11 Field Equipment (DMS)	Roadway Equipment Coordination	Field elements that control and send data to other field elements (such as environmental sensors that send data to a DMS or coordination between traffic controllers on adjacent intersections), without center control.	The field element shall include sensors (such as traffic, environmental, and work zone intrusion detection sensors) that receive control information from other field element devices, without center control.
New York City Joint TMC	Collect Traffic Surveillance	Management of traffic sensors and surveillance (CCTV) equipment, and distribution of the collected information to other centers and operators.	The center shall monitor, analyze, and store traffic sensor data (speed, volume, occupancy) collected from field elements under remote control of the center.
New York City Joint TMC	Collect Traffic Surveillance	Management of traffic sensors and surveillance (CCTV) equipment, and distribution of the collected information to other centers and operators.	The center shall monitor, analyze, and distribute traffic images from CCTV systems under remote control of the center.

ITS Element	Functional Area (Equipment Package)	Functional Area Description	Requirement
New York City Joint TMC	Collect Traffic Surveillance	Management of traffic sensors and surveillance (CCTV) equipment, and distribution of the collected information to other centers and operators.	The center shall maintain a database of surveillance and sensors and the freeways, surface street and rural roadways, e.g. where they are located, to which part(s) of the network their data applies, the type of data, and the ownership of each link (that is, the agency or entity responsible for collecting and storing surveillance of the link) in the network.
New York City Joint TMC	Collect Traffic Surveillance	Management of traffic sensors and surveillance (CCTV) equipment, and distribution of the collected information to other centers and operators.	The center shall distribute road network conditions data (raw or processed) based on collected and analyzed traffic sensor and surveillance data to other centers.
New York City Joint TMC	Collect Traffic Surveillance	Management of traffic sensors and surveillance (CCTV) equipment, and distribution of the collected information to other centers and operators.	The center shall respond to control data from center personnel regarding sensor and surveillance data collection, analysis, storage, and distribution.
New York City Joint TMC	TMC Traffic Information Dissemination	Controls dissemination of traffic-related data to other centers, the media, and travelers via the driver information systems (DMS, HAR) that it operates.	The center shall remotely control dynamic messages signs for dissemination of traffic and other information to drivers.
New York City Joint TMC	TMC Traffic Information Dissemination	Controls dissemination of traffic-related data to other centers, the media, and travelers via the driver information systems (DMS, HAR) that it operates.	The center shall remotely control driver information systems that communicate directly from a center to the vehicle radio (such as Highway Advisory Radios) for dissemination of traffic and other information to drivers.
New York City Joint TMC	TMC Traffic Information Dissemination	Controls dissemination of traffic-related data to other centers, the media, and travelers via the driver information systems (DMS, HAR) that it operates.	The center shall collect operational status for the driver information systems equipment (DMS, HAR, etc.).
New York City Joint TMC	TMC Traffic Information Dissemination	Controls dissemination of traffic-related data to other centers, the media, and travelers via the driver information systems (DMS, HAR) that it operates.	The center shall collect fault data for the driver information systems equipment (DMS, HAR, etc.) for repair.
New York City Joint TMC	Traffic Maintenance	Monitoring and remote diagnostics of field equipment - detect failures, issue problem reports, and track the repair or replacement of the failed equipment.	The center shall collect and store sensor (traffic, pedestrian, multimodal crossing) operational status.
New York City Joint TMC	Traffic Maintenance	Monitoring and remote diagnostics of field equipment - detect failures, issue problem reports, and track the repair or replacement of the failed equipment.	The center shall collect and store CCTV surveillance system (traffic, pedestrian) operational status.

ITS Element	Functional Area (Equipment Package)	Functional Area Description	Requirement
New York City Joint TMC	Traffic Maintenance	Monitoring and remote diagnostics of field equipment - detect failures, issue problem reports, and track the repair or replacement of the failed equipment.	The center shall collect and store sensor (traffic, pedestrian, multimodal crossing) fault data and send to the maintenance center for repair.
NYSDOT R11 Field Equipment (Vehicle Detectors)	Roadway Basic Surveillance	Field elements that monitor traffic conditions using loop detectors and CCTV cameras.	The field element shall collect, process, digitize, and send traffic sensor data (speed, volume, and occupancy) to the center for further analysis and storage, under center control.
NYSDOT R11 Field Equipment (Vehicle Detectors)	Roadway Basic Surveillance	Field elements that monitor traffic conditions using loop detectors and CCTV cameras.	The field element shall return sensor and CCTV system operational status to the controlling center.
NYSDOT R11 Field Equipment (Vehicle Detectors)	Roadway Basic Surveillance	Field elements that monitor traffic conditions using loop detectors and CCTV cameras.	The field element shall return sensor and CCTV system fault data to the controlling center for repair.

1.4 Analysis of Alternate System Configurations and Technology Options

This section of the SEA should focus on providing a high level overview of the design alternatives and options that will ultimately affect the ITS cost of the project. One approach to representing the high level design alternatives for consideration is to break down the design issues into the following two categories:

- Technology alternatives for delivery of the required ITS functionality
- Communications alternatives

Each is reviewed briefly below:

- **Alternatives for Delivery of Required ITS Functionality**. This section should propose various design alternatives for system or equipment to meet the desired ITS functionality. For example, a number of technologies may be considered to fulfill the requirements of the "NYSDOT Vehicle Detectors" subsystem including: radar detectors, inductive loops, and magnetometers. Likewise, fulfilling the requirements of the "NYSDOT CCTV" may be done with still frame, slow scan, or full motion video cameras. Each of these alternatives may carry additional or reduced cost to the project.
- **Communications Alternatives**. Communications alternatives will depend on some of the factors included in the bullets above (number of centers involved, the location of equipment, and the bandwidth of information that needs to be transferred. Communication options may include: fiber, dial-up, wireless, and a wide selection of network equipment (e.g., modems, Ethernet communications equipment, and fiber communications equipment) and communications protocols.

As with many projects, this example project is an expansion of capabilities provided by other earlier projects, and therefore a number of technology choices, communications, and technical design of the ITS implementation may be inherited from the other implementations. For the purposes of this example, assume that existing fiber communications system will be used between the existing central system and new field elements (signs, cameras, and detectors).

1.5 Procurement Options

This section of the SEA will focus on a presentation of the cost and funding sources/alternatives for the project. As such the project may be funded through federal, state, and local sources.

For the purposes of this example one can assume that the NYC Freeway Expansion project was identified in the NYMTC Regional Transportation Plan, the NYMTC Transportation Improvement Program (TIP), the Statewide Transportation Improvement Program (STIP), and NYSDOT Capital Plan. It should also be stated that the scoping, design, specification development and procurement documents will follow NYSDOT Project Development Process.

A table showing the STIP and Capital Program identifiers and funding available for the project may be included to show traceability to the funding documents. An example is shown below.

Table 1-6. Procurement Options

Project Document	Project ID	Funding
NYSDOT State TIP	NYS-12345	$X million
NYSDOT Capital Plan	NYSDOT-12345	$Y00,000

System life cycle cost information that may be highlighted in the section include:

- ITS Equipment Cost
- System Integration and Engineering Support Cost
- Operations and Maintenance Cost

1.5.1 Example ITS Equipment Cost

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

- Dynamic Message Signs
- 10 Closed-Circuit Television Cameras
- 20 Sensors

The total project estimate for equipment, construction, and system integration is $*X million*.

1.5.2 Example System Integration and Engineering Support Cost

The system integration component of the project is $*X00,000*, broken out as follows:

- Materials (shop drawings and materials): $*W0,000*
- Equipment (test equipment, equipment rental): $*X,000*
- Labor (project management, electrician, and laborer): $*Y00,000*
- Central Software Enhancements and Firmware: $*Z00,000*

1.5.3 Example Operations and Maintenance

Operations and maintenance annual cost for the field components and communications is estimated at $*Z million*. The O&M annual cost were estimated as 8% of the total project cost of $*X million*.

If additional staff would have been required as part of system operation, this should be included in this section.

1.6 Applicable ITS Standards and Testing Procedures

This section will review how to determine which ITS Standards may be applicable to an ITS project, and discuss how to test the implementation for conformance to the ITS Standards.

1.6.1 Discussion - Relationship of ITS Architecture to Standards

The National ITS Architecture provides a mapping of architecture flows to individual ITS standards. Since the architecture flows of the National ITS Architecture form the basis for information exchanges of statewide or regional ITS architectures, this mapping of interfaces to standards is available for these architectures as well. The figure below shows the relation of the ITS standards activities to the National ITS Architecture.

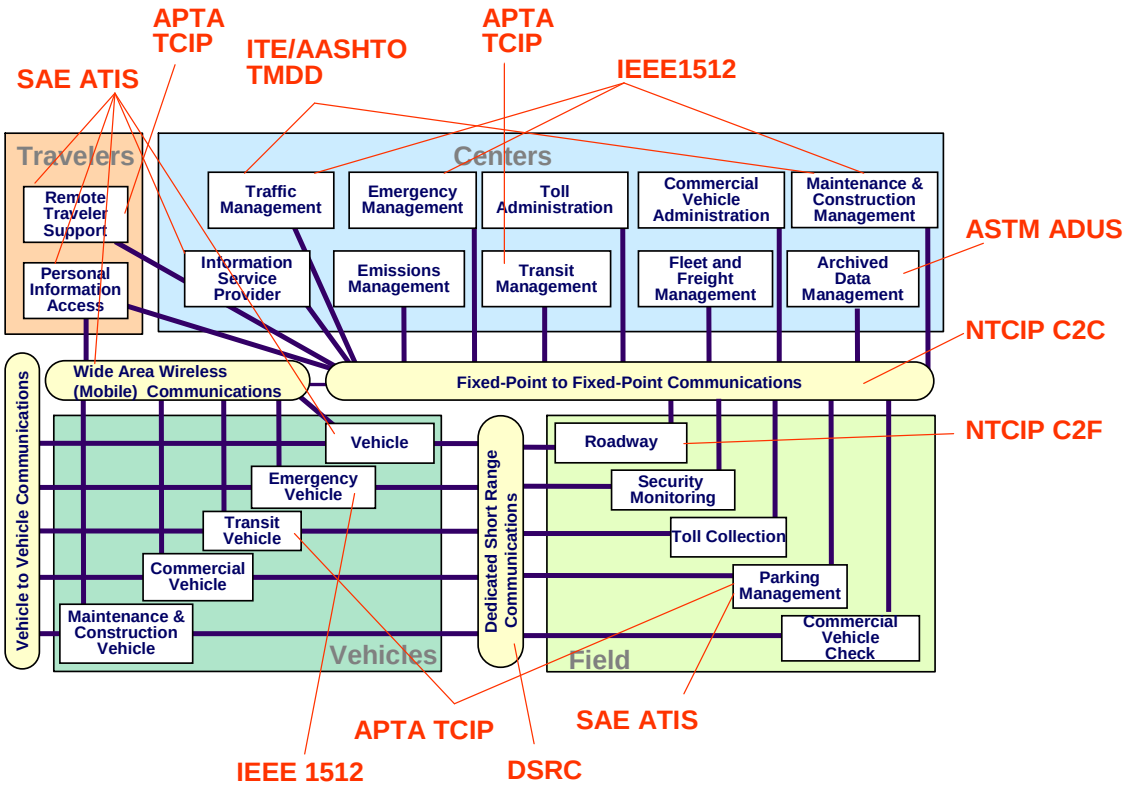

Figure 1-5. Relationship of the National ITS Architecture to ITS Standards

ITS standards address the interfaces between ITS systems. These interfaces, and the information flows between the interfaces are identified during the development of the regional ITS architecture through the consensus process. Based on the identified data flow and interfaces, the regional ITS architecture indicates what standards may be applicable. The regional ITS architecture list of applicable ITS standards is not usable directly by deployers of specific ITS projects, but is rather a starting point for further project analysis.

1.6.2 Selection of Applicable ITS Standards

Based on an analysis of the architecture flows and market package selections for the example project, this section of the SEA will identify applicable ITS standards and test procedures. The table below shows an example of applicable NTCIP center to field communications standards, as derived from a regional ITS architecture.

Table 1-7. List of Applicable ITS Communications Standards

Document Number	Document Title Involved	Project Applicability
NTCIP 1101	Simple Transportation Management Framework (STMF)	Yes
NTCIP 1201	Global Object Definitions	Yes
NTCIP 1203	Object Definitions for Dynamic Message Signs (DMS)	Yes
NTCIP 1205	Object Definitions for Closed Circuit Television (CCTV) Camera Control	Yes
NTCIP 1206	Object Definitions for Data Collection and Monitoring (DCM) Devices	No
NTCIP 1208	Object Definitions for Closed Circuit Television (CCTV) Switching	No
NTCIP 1209	Data Element Definitions for Transportation Sensor Systems	Yes
NTCIP 2101	Point to Multi Point Protocol (PMPP) Using RS-232 Sub Network Profile	Yes
NTCIP 2103	Point-to-Point Protocol (PPP) Over RS-232 Sub network Profile	Yes
NTCIP 2201	Transportation Transport Profile (“NULL” Transport Profile)	Yes
NTCIP 2202	Internet (TCIP/IP and UDP/IP) Transport Profile	Yes
NTCIP 2301	Simple Transportation Management Framework (STMF) Application Profile	Yes

1.6.3 ITS Standards Related Considerations

It is possible that standards may exist or are being developed, but will not be used in the project. In this case the project applicability column in the section above would be ‘No’. Additional information that may warrant further consideration with regard to ITS standards implementation include:

- Adding NTCIP communications may require modification to the central software. The previously developed central software may be based on non-standard , proprietary protocols of the manufacturers. To integrate NTCIP compliant field equipment, the

central software will need to be modified to support SNMP (Simple Network Management Protocol), as defined by NTCIP as the transport of objects to/from ITS devices. In addition, the central software may need to continue to support the existing (legacy) equipment. Additional effort, measured in terms of cost and schedule, may be necessary to incorporate the ability of the central software to communicate with the field equipment.

- It may be possible that the agency has developed an SNMP MIB (Management Information Base) that may be re-used under this project. Or, NYSDOT may choose to develop a MIB (Management Information Base), as defined by the NTCIP, as the method of specifying device object definitions for the various devices (CCTV, video switches, and sensors). The following summarizes the minimum necessary actions to develop the necessary project-specific NTCIP device object (specifications) for field equipment:
  - Develop an operational concept and requirements for the devices.
  - Develop an NTCIP MIB for each of the device types that is conformant with NYSDOT's operational concept and requirements, and the NTCIP conformance statement.
  - Develop performance requirements for communications between the central system and devices
- While manufacturers advertise that their products are NTCIP conformant, this does not mean that NYSDOT *project* requirements will be met. That is, the products may conform to the NTCIP standards, but do not comply with all the functional requirements in the specifications. It would therefore be prudent to test any devices destined for the field in a controlled environment (e.g., factory acceptance test) for compliance to the specifications and to conformance to the ITS Standard.

1.6.4 System Testing

The section of the SEA should outline what should be tested, and what system tests should or must be included in the PS&E. An example set of system testing considerations for the NYC Freeway Expansion project is included below.

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

- Design Verification Tests
- Power-On Tests
- Stand-alone Tests
- Final Acceptance Test

- System Interface Tests
- System Performance Tests, and
- 30 Day Operational Tests

The tests outlined above are test identified for ITS systems that will be specified in the PS&E.

These tests 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 NYSDOT Engineer for approval prior to the tests. Only approved test procedures shall be used for the test. Unless otherwise specified, a minimum of *XX* 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 *YY* 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 conducted as a defect, and equipment shall be subject to rejection by the Engineer. Rejected equipment may 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 *X 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.

1.6.5 NTCIP Testing

The following information regarding NTCIP Testing should also be included in the PS&E.

Documentation

The manufacturer should always provide NTCIP and MIB documentation in electronic form. Statements similar to the following should be included in the SEA and the PS&E.

NTCIP documentation shall be provided on a CD-ROM and shall contain ASCII versions of the following Management Information Base (MIB) files in Abstract Syntax Notation 1 (ASN.1) format:

- The relevant version of each official standard MIB modules referenced by the device functionality.

- If the device does not support the full range of any given object within a standard MIB Module, a manufacturer specific version of the official standard MIB Module with the supported range indicated in ASN.1 format in the SYNTAX and/or DESCRIPTION fields of the associated OBJECT TYPE macros shall be provided. The filename of this file shall be identical to the standard MIB Module except that it will have the extension ".man".
- A MIB module in ASN.1 format containing any and all manufacturer specific objects supported by the device with accurate and meaningful DESCRIPTION fields and supported ranges indicated in the SYNTAX field of the OBJECT-TYPE macros.
- A MIB containing any other objects supported by the device.

NTCIP Acceptance Testing

Several NTCIP testing units exist. This section should specify which testing units will be used and a statement similar to the following should be included:

- The acceptance test will use the NTCIP *Wiz-Bang* Testing Unit or other testing tool.
- The manufacturer will submit an NTCIP test plan a minimum of 30 days prior to NTCIP acceptance testing. NTCIP acceptance testing will be performed on one of the field devices manufactured under this contract. Testing will be performed at the manufacturer's (or agency's, if this applies) facility.

NTCIP Interpretation Resolution

Finally, a statement that reflects what will be done in the event of a conflict in interpreting the NTCIP specifications should be included, such as the following:

> If the State, State's representative, or manufacturer discovers an ambiguous statement in the standards referenced by this procurement specification, the issue shall be submitted to the appropriate NTCIP Working Group for resolution. If the Working Group fails to respond within 90 days, the project shall develop an interpretation of the specification.

1.7 Procedures and Resources Necessary for Operations and Management of the System

This section of the SEA should outline the organizational procedures that will be put in place for the operations and management of the project's capabilities (in this example freeway device operations). In addition, any resources necessary for operations and management would be considered.

In this example, the NYC Freeway Expansion Project ITS field elements will be integrated into the New York City Joint TMC. The New York City Joint TMC will be operated by the NYSDOT Region 11 Operations Division, which operates and manages the ITS infrastructure within New York City. In the case of the NYC Freeway Expansion Project, procedures relating to the operation of the freeway devices would be considered, such as who can monitor CCTV images and who can control the cameras. Regarding resources, no additional operations and management resources will be requested under this project. The existing NYSDOT resources will be utilized to maintain the additional ITS elements provided under this project.