Regional Intelligent Transportation System Architecture Development For New York City

Use Plan

New York City Sub-Regional ITS Architecture

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By

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Phases I-VI, Advanced Traffic Management System (ATMS) on Highways

Table of Contents

1 Introduction ... 1
1.1 Background ... 1
1.2 Intended Audience ... 1
1.3 Purpose ... 2
1.4 Report Organization ... 3
2 Regional ITS Architecture ... 4
2.1 What are Intelligent Transportation Systems (ITS)? ... 4
2.2 National ITS Architecture ... 4
2.3 FHWA Final Rule and FTA Final Policy on ITS Architecture and Standards ... 5
2.4 New York City Sub-Regional ITS Architecture ... 6
3 Transportation Planning ... 8
3.1 Introduction ... 8
3.2 The Regional Transportation Plan ... 8
3.2.1 Introduction ... 8
3.2.2 Output from the RTP ... 10
3.2.3 Input to the RTP ... 11
3.2.4 Coordinating ITS Architectures in the NYMTC Region ... 11
3.2.5 Other Roles in the RTP ... 12
3.2.6 Use Case – Contribution to the Regional Transportation Plan ... 12
3.2.7 Summary ... 16
3.3 The Transportation Improvement Program (TIP) ... 16
3.3.1 Introduction ... 16
3.3.2 The TIP Process ... 17
3.3.3 Project Definition ... 17
3.3.4 Project Sequencing ... 19
3.3.5 Use Case – Existing Construction Project – Project Definition ... 21
3.3.6 Summary ... 22
3.4 Stakeholder- and Agency- Specific Transportation Plans ... 23
3.4.1 Introduction ... 23
3.4.2 The Role of the Regional ITS Architecture ... 23
3.4.3 Summary ... 24
4 Project Systems Engineering Analysis ... 25
4.1 Introduction ... 25
4.2 PSEA Requirements ... 25
4.3 PSEA Example ... 27
4.3.1 Portions of the Regional ITS Architecture Being Implemented ... 27
4.3.2 Participating Agencies Roles and Responsibilities ... 32
4.3.3 Requirements Definition ... 33
4.3.4 Analysis of Alternate System Configurations and Technology Options ... 36
4.3.5 Procurement Options ... 37
4.3.6 Applicable ITS Standards and Testing Procedures ... 38
4.3.7 Procedures and Resources Necessary for Operations and Management of the System ... 42

5 Project Implementation 43
5.1 Introduction 43
5.2 Project Detail 44
5.2.1 Project Scope 44
5.2.2 Project Requirements 45
Project Interfaces 47
5.2.3 47
5.2.4 Use Case - Existing Construction Project – Project Implementation 48
5.2.5 Summary 50
5.3 Agency Roles and Responsibilities 50
5.3.1 Discussion 50
5.3.2 Use Case – Agency Roles and Responsibilities 51
5.3.3 Summary 52
5.4 Applicable ITS Standards 52
5.4.1 Introduction 52
5.4.2 Using the Standards 54
5.4.3 Use Case – Developing A DMS Project 56
5.4.4 Use Case – Developing a Center-To-Center Communications Project 59
5.4.5 Summary 63
5.5 Communications Architecture Concepts 63
6 Use Plan in Institutional Agreements 66
6.1 Introduction 66
6.2 Identification of Agreements 66
6.2.1 Interconnects 67
6.2.2 Market Package 68
6.2.3 ITS Elements 68
6.2.4 Next Steps 69
6.2.5 Summary 69
6.3 Agreement Details 70
6.3.1 Types of Agreements 70
6.3.2 Details of an Agreement 70
6.3.3 Use Case – Transportation Archive Data Policy 72
6.3.4 Summary 73

Appendix A Example Concept of Operations – DMS A-1

Appendix B Example DMS Specifications B-1

Appendix C Example Center-To-Center Specifications C-1

Table of Figures

Figure 2-1. National ITS Architecture Version 4.0 Sausage Diagram 5
Figure 3-2. Regional Transportation Plan Process 10
Figure 3-3. Use Case - Transportation Services - Fleet Administration 14
Figure 3-4. Use Case – Transportation Services – Freight Administration 14
Figure 3-5. Use Case – Transportation Services – Electronic Clearance 15
Figure 3-6. Use Case – Transportation Services – CV Administrative Process 15
Figure 4-1. Use Case - Portion of the Regional ITS Architecture Covered by NYC Freeway Expansion Project 28
Figure 4-2. Use Case - ATMS01 - Network Surveillance Customized Market Package 30
Figure 4-3. Use Case - ATMS04 – Freeway Control Customized Market Package 30
Figure 4-4. Use Case - ATMS06 – Traffic Information Dissemination Customized Market Package 31
Figure 5-2. ITS Procurement Process 43

List of Tables

Table 3-1. Use Case – Transportation Services 13
Table 4-1. Use Case - PSEA Project ITS Elements 27
Table 4-2. Use Case - Customized Market Package Analysis Results 29
Table 4-3. Use Case - Information Exchange (Architecture Flow) Requirements 31
Table 4-4. Use Case - Participating Agencies Roles and Responsibilities 32
Table 4-5. Use Case - Requirements Definition Table 34
Table 4-6. Use Case - Procurement Options 37
Table 4-7. Use Case - List of Applicable ITS Communications Standards 38

Revision History

Filename	Version	Date	Author	Comment
UsePlan-Outline.doc	0.00.01	11/11/03	PChan	First draft - Outline submitted to F. Lai/NYSDOT.
UsePlan.doc	0.00.02	01/06/04	PChan	Second draft.
UsePlan-Draft.doc	0.00.03	01/19/04	PChan	Submitted draft to NYCSRA Steering Committee
UsePlan – Draft1.doc	0.01.00	03/18/05	PChan	Final draft.
UsePlan – Final.doc	0.02.00	04/29/05	PChan	Final Report

1 Introduction

1.1 Background

In December 2002, Consensus Systems Technologies Corp. (ConSysTec), was sub-contracted by Edwards and Kelcey, to develop a New York City Sub-Regional ITS Architecture for the five boroughs of New York City. This work was performed under a supplemental agreement (S.A. #26) between Edwards and Kelcey and New York State Department of Transportation, Contract D008598, PIN X735.48, Traffic System Services for Traffic & Safety, Preliminary & Final Design Services, Western Queens Regional Area.

Under this supplemental agreement, ConSysTec was to develop a New York City Sub-Regional ITS Architecture (NYCSRA) that was in accordance with the April 8, 2001 Final FHWA Rule and FTA Policy on Intelligent Transportation System Architecture and Standards. This Rule/Policy required that each region deploying ITS Projects funded through the highway trust fund must develop a "regional ITS architecture". This regional ITS architecture, which is to based on the National ITS Architecture, is intended to foster the deployment of integrated regional ITS systems in a cost-effective, practical manner.

With the participation and support of various transportation agencies in the New York City region, the NYCSRA was developed through a series of functional area meetings, workshops, and individual discussions. The results and outputs of the NYCSRA, which includes detailed information exchange requirements documented using the customized market packages (available on the project web site), are presented in a separate document.

However, the Final FHWA Rule /FTA Policy on Intelligent Transportation System Architecture and Standards also require that each region and its participating stakeholders must use the regional ITS architecture that has been adopted. The real success of the regional ITS architecture hinges on the effective use of the architecture by the stakeholders once the architecture has been developed. This document, Use Plan - New York City Sub-Regional ITS Architecture, presents the different methods that the various stakeholders in the region can used the NYCSRA to support both transportation planning and project implementation in the region.

This document is the third of four documents that comprise the New York City Sub-Regional ITS Architecture. The first document contains the descriptions of the ITS systems and the identified interfaces between these systems. The second document, the Implementation Plan, summarizes the outputs from the NYSRA. The fourth document, the Maintenance Plan, defines a change management process for updating the NYCSRA in the future.

1.2 Intended Audience

The following are users will benefit the most from reading this Use Plan document:

- Planners - Planners can be from transportation agencies or metropolitan planning organizations. This Use Plan document will guide these planners in developing their transportation and future project plans, including Regional Transportation Plans, Transportation Improvement Plans (TIPs) and internal agency long range project plans.

- Project Managers - This Use Plan document will guide project managers who are responsible for implementing projects, writing project specifications, writing project requirements and applying for federal funding for ITS projects.
- Managers – This Use Plan will assist managers identify areas where institutional agreements are needed to facilitate the implementation of the NYCSRA and the integration of disparate ITS systems in the region.
- Federal and State Agencies - Besides the planners and managers in state and local agencies responsible for implementing ITS projects, this Use Plan document will also guide the federal agencies and other entities responsible for checking that ITS projects complies with the developed NYCSRA.

1.3 Purpose

The NYC Sub Regional ITS Architecture can be used to support both transportation planning and project implementation. The Use Plan will discuss four aspects of using the NYCSRA:

- The first aspect is using the NYC Sub Regional ITS Architecture in the transportation planning process. This document will discuss how the NYCSRA supports the development of the ITS aspects of the New York Metropolitan Transportation Council (NYMTC) Regional Transportation Plan (RTP) and the Transportation Improvement Plan (TIP) for the New York City Metropolitan Region.
- The second aspect of the Use Plan discusses how the NYC Sub Regional ITS Architecture supports the Project Systems Engineering Analysis (PSEA). The PSEA is a systems engineering process that must be completed to apply for and to use federal highway trust funds for ITS projects.
- The third aspect of the Use Plan discusses how the NYC Sub Regional ITS Architecture can be used to develop project specifications and in project implementation. This includes a method for evaluating future projects to assure their compliance with the NYCSRA; and how the architecture and its products can be used to support project implementation (i.e. functional analysis and standards based interface design).
- The fourth aspect of the Use Plan is to identify when institutional agreements are needed between stakeholders to facilitate the implementation of the NYCSRA and the integration of disparate ITS systems in the region. This discussion will include what information should be included in the agreements and how to extract that information from the regional architecture.

In addition, use case studies are provided throughout this document to illustrate examples on how the regional ITS architecture can be used.

1.4 Report Organization

This Use Plan has been prepared in support of the New York City Sub-Regional ITS Architecture. This Use Plan is presented in 6 sections:

- **Section 1: Introduction** – This section provides introductory and background information about this document, its purpose and why it is needed.
- **Section 2: Regional ITS Architecture** – This section contains a description of National ITS Architecture, a review of the FHWA Rule and FTA Policy, and a summary of the New York City Sub-Regional ITS Architecture.
- **Section 3: Use Plan in Planning** – This section presents how agency planners may use the NYCSRA to develop each agency's Transportation Improvement Plans (TIP), and plan future ITS projects.
- **Section 4: Use Plan in the PSEA** – This section presents to use the NYCSRA to complete the Project Systems Engineering Analysis, which must be completed to obtain federal funding for ITS projects.
- **Section 5: Use Plan in Project Implementation** – This section presents how project managers may use the NYCSRA to develop project scopes, functional requirements, and what standards to specify.
- **Section 6: Use Plan in Institutional Agreements** – This section discusses how to the use the NYCSRA to determine what agreements are needed to implement the NYCSRA and to guide the development of these agreements.

Readers who are unfamiliar with regional ITS architectures and their benefits should skim through Chapter 1, Introduction and read Chapter 2, which provides information about regional ITS architectures and their uses.

Planners should read Chapter 3, which provides information on how to incorporate the NYCSRA in the Regional Transportation Plans (RTP), Transportation Improvement Plans (TIP), and agency-specific transportation plans.

Project managers should skim through Chapter 3 to obtain a general understanding of how their specific projects fit in the scheme of the regional ITS architecture and the regional goals and needs. Chapter 4 describes how the NYCSRA is used to support the Project Systems Engineering Analysis for obtaining federal funding, while Chapter 5 describes how the NYCSRA can be used to develop project definitions, functional requirements, and identify applicable ITS Standards.

Managers should read Chapter 6, which discusses some of the institutional issues, and how to identify areas where institutional agreements may be needed to facilitate the implementation of ITS projects to attain regional, and agency-specific, goals and objectives.

2 Regional ITS Architecture

2.1 What are Intelligent Transportation Systems (ITS)?

Until recently, the building and improvement of a transportation infrastructure meant the civil and mechanical construction or enlargement of roads, bridges and tunnels, as well as the associated enterprises that provide the vehicles (including public and private transit agencies, trucking, public safety and personal) that travel on the infrastructure. The use of ITS technologies to more efficiently operate and manage a region's transportation systems is increasingly important as travel demand steadily increases and the opportunities to build new infrastructure becomes prohibitively expensive because of the high costs and lack of available resources, including land space. This makes the deployment of ITS technologies to make more efficient use of the existing transportation network an attractive alternative.

As one component of a larger transportation infrastructure, ITS refers to the application of data processing, data communications, and systems engineering methodologies with the purpose of improved management, safety and efficiency of the surface and public transportation network. These ITS technological and management advances can address the following: the overall mobility needs of a region, the travel requirements of transportation network users, and the development, operation, management and maintenance needs of the transportation system providers, both public and private.

ITS provides agencies and their customers a means to address current urban problems, as well as anticipate and address future demand through a coordinated, intermodal approach to transportation. The application of ITS allows agencies to use modern technologies to better monitor their systems, providing the agencies with more accurate information to make more informed decisions on safely operating their systems. ITS also allows agencies to distribute this information to other agencies and to the public, so each can make more informed transportation decisions.

2.2 National ITS Architecture

The National ITS Architecture provides a common framework for planning, defining, and integrating intelligent transportation systems and defines:

- The functions (e.g., gather traffic information or request a route) that are required for ITS.
- The physical entities or subsystems where these functions reside (e.g., the roadside or the vehicle).
- The information flows and data flows that connect these functions and physical subsystems together into an integrated system.

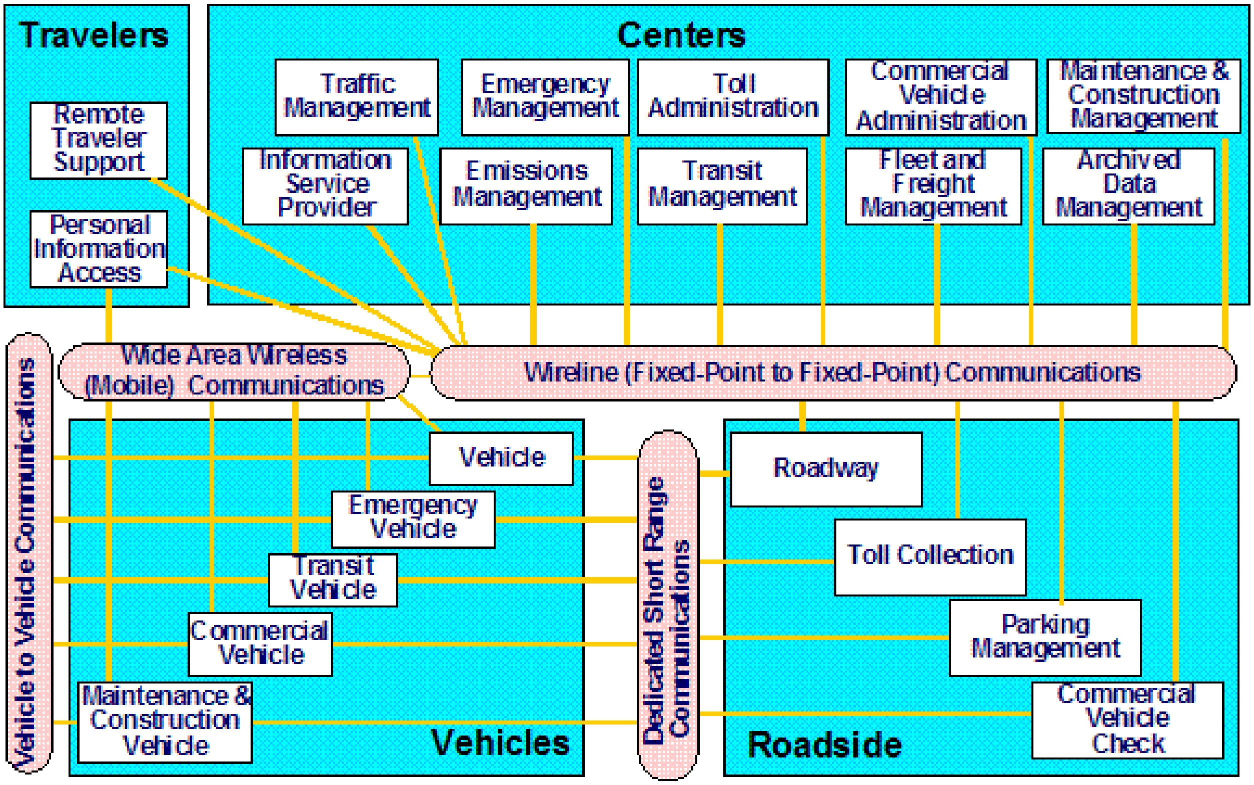

Figure 2-1. National ITS Architecture Version 4.0 Sausage Diagram

The National ITS Architecture also introduces the concept of Market Packages. Market packages define potential ITS deployments in both narrative and diagrammatic form. Market package diagrams show which ITS systems are required to work together (across different operators, whether public or private) to deliver a given transportation service. Market packages are designed to address specific transportation problems and needs and relate back to the ITS services and their more detailed requirements.

2.3 FHWA Final Rule and FTA Final Policy on ITS Architecture and Standards

In 1997, Congress passed the Transportation Equity Act for the 21st Century (TEA-21) to address the need to begin working toward regionally integrated transportation systems. To implement Section 5206(e) of TEA-21, which requires ITS projects to conform to the National ITS Architecture (NITSA) and Standards, the Federal Highway Administration (FHWA) issued 23 Code of Federal Regulations Parts (CFR) 655 and 940, entitled “Intelligent Transportation Systems (ITS) Architecture and Standards” on April 1, 2001. Concurrently, the Federal Transit Administration (FTA) issued a Final Policy entitled “National ITS Architecture Policy on Transit Projects”. The intent of the FHWA Final Rule (commonly referred to as Rule 940) and FTA Final Policy is to provide policies and procedures by which to implement ITS projects in an efficient manner and to conform to the National ITS Architecture.

The purpose of the Final Rule/Final Policy is to accelerate the deployment of integrated Intelligent Transportation Systems (ITS) by requiring development of a regional ITS architecture. This regional ITS architecture, which is based on the National ITS Architecture but customized to meet a region's particular needs, provides a plan by which a region can efficiently deploy ITS systems in a manner allowing for integration of these systems.

The Final Rule/Final Policy defines 9 required components that make up a regional ITS architecture. These components are:

1. Description of the region
2. Identification of participating agencies and other stakeholders
3. Operational concept
4. Agreements required for implementation
5. System functional requirements
6. Interface requirements
7. Identification of ITS standards
8. Sequence of projects required for implementation
9. Process for maintaining your Regional ITS Architecture

2.4 New York City Sub-Regional ITS Architecture

With the participation and support of various transportation agencies in the New York City region, the NYCSRA was developed through a series of functional area meetings, workshops, and individual discussions. These functional area meetings, or workshops, focus on the issues, services, and interfaces of a set of stakeholders from a common area of ITS.

A *Draft* and *Final* functional area workshop was held for each area of ITS relevant to the New York City region. These areas were Traffic Management, Advanced Public Transportation, Incident Management/Emergency Management, Commercial Vehicles/Electronic Toll Collection, Maintenance and Construction, and Traveler Information Systems.

In the Draft Workshop, stakeholders made initial decisions about what stakeholders will participate in which ITS services, and key architectural decisions were framed and collected. "Customized" Market Packages were interactively created during the workshops. The emphasis of the first workshop is ITS architecture (what information is exchanged between which stakeholder ITS elements), plus a sense of the priority of various services. The draft architecture for the functional area was published for stakeholder review on the website shortly after the draft workshop. Stakeholders commented on the draft ITS architecture and their comments collected, categorized and analyzed.

In the Final functional area workshop, the ITS architecture was quickly presented, and all comments received beforehand. Especially where a comment requested a change that requires other stakeholder's concurrence, these comments were formally prepared and presented, and stakeholder discussion was encouraged. Other comments (not submitted beforehand) from the participating stakeholders were also welcome and encouraged. Comments were generally stimulated by the review of the draft architecture as it pertained to the functional area.

A draft ITS deployment plan and integration strategy was then presented based on stakeholder input from the workshops. Stakeholder comments were collected, and used afterwards to develop the updated draft deployment plan and integration strategy documentation for each functional area. The results and outputs of the NYCSRA, which includes detailed interconnects and information flows based on the customized market packages, are presented in the Implementation Plan document.

3 Transportation Planning

3.1 Introduction

The goal of the transportation planning process is to make informed decisions pertaining to the efficient investment of public funds on regional transportation systems and services. Similarly, the objective of the regional ITS architecture is to support the effective and efficient deployment of intelligent transportation systems (ITS) projects that address those transportation needs of the region. The regional ITS architecture focuses on the integration of systems to gain the maximum benefit of each system's information and capabilities across the transportation network. The regional ITS architecture defines "what" needs to be put in place to address the transportation needs and requirements of the region.

This chapter presents an approach for integrating the regional ITS architecture into the transportation planning process. The approach facilitates and provides a mechanism for the projects identified in the NYCSRA Implementation Plan to be deployed in an orderly and integrated fashion in support of the transportation planning process. The regional ITS architecture can be used to support these planning activities, and to mainstream ITS into the traditional decision-making of planners and other transportation professionals. The approach will leverage the regional ITS architecture as a roadmap to project sequencing and interdependency to achieve an integrated transportation system that addresses those strategic objectives.

The regional ITS architecture can be used to support transportation planning on three different levels; the Regional Transportation Plan (RTP), the Transportation Improvement Plan (TIP) and agency- or stakeholder- specific transportation plans. For the New York City Sub-Regional ITS Architecture (NYCSRA), the RTP and TIP are developed under the auspices of the region's Metropolitan Planning Organization (MPO), the New York Metropolitan Transportation Council (NYMTC). Both these plans are fed by numerous transportation planning activities at a regional and local level. The third level of transportation planning are those developed by each stakeholder and agency for its internal use and planning.

3.2 The Regional Transportation Plan

3.2.1 Introduction

The Regional Transportation Plan (RTP) is one of the principal products of the transportation planning process in the New York City Metropolitan Region. It is the representation of the region's long-term approach to constructing, operating, and maintaining the transportation systems in the region. It is also the forum for balancing transportation investments among modes, geographic areas, and institutions.

The RTP documents the policy direction for the region and describes how transportation projects and programs will be implemented over a 20-year (or longer) period. Federal requirements dictate that the RTP be updated every three years and that an RTP be maintained for each region as part of the process for long-range transportation planning. Federal regulations also specify several requirements on what information must be included in the RTP. These requirements include:

- Present both long-range and short-range strategies/actions leading to the development of an integrated intermodal transportation system that facilitates the efficient movement of people and goods.
- Assess capital investment and other measures necessary to preserve existing transportation systems and make the most efficient use of existing transportation facilities to relieve vehicular congestion and enhance the mobility of people and goods.
- Include design concepts and scope descriptions of all existing and proposed transportation facilities in sufficient detail in non-attainment and maintenance areas to permit conformity determinations.
- Include a financial plan that demonstrates the consistency of proposed transportation investments with already available and projected sources of revenue.

However, the transportation planning process, and the development of the RTP, is an iterative process. Once a transportation plan is created, projects are developed and implemented to satisfy the goals outlined in the transportation plan. As those goals are met via implementation of the projects and new needs and priorities are identified, the transportation plan is updated to reflect achievments of old goals and to indicate the new goals. New projects are then developed to satisfy the new goals and the transportation planning cycle begins again.

Likewise, the role of a regional ITS architecture in the transportation planning process, including the RTP, is an iterative process, as shown in Figure 3-1. As depicted in the figure, once the RTP is developed for the region, strategies and transportation services required to meet the regional goals are identified. The regional ITS architecture is a reflection of the RTP, indicating ITS can be deployed to meet and satisfy the strategies and transportation services identified for the region.

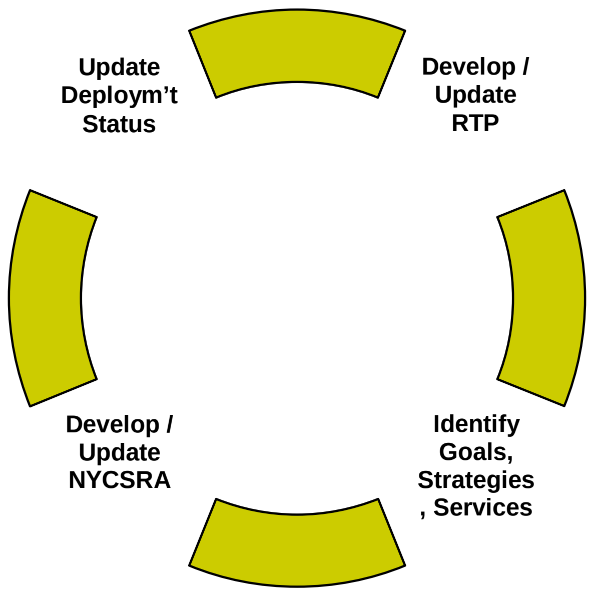

Figure 3-1. Regional Transportation Plan Process

The next section provides a discussion on how these goals, strategies and transportation services provide input to the regional ITS architecture. This is followed by a section discussing how the regional ITS architecture then provides input for updating the RTP.

3.2.2 Output from the RTP

The RTP provide important inputs to the regional ITS architecture. The outputs from the RTP include the goals for the region across the different transportation modes and what transportation services are required, both short- and long- term, to attain those goals. The RTP will also articulate the strategies and actions, as agreed upon by the participants and stakeholders, to attain those goals.

However, the RTP only provides a high level overview of the strategies, actions and transportation services. More specific details of the strategies and transportation services needed to satisfy the regional goals can be depicted in the regional ITS architecture. These details may include the interfaces, the operational concepts and agreements necessary to implement the strategies and transportation services. With these details, ITS projects can be more clearly defined, funded, and implemented to satisfy the regional goals.

As an RTP is refined and updated, new regional goals and strategies may have an effect on the priorities of the transportation services to be provided by the regional ITS architecture, including the possibility of adding new transportation services. As the changes in the priorities in transportation services are identified, as articulated in the RTP, these changes may require new or different interfaces between agencies and new operational concepts.

All these changes (priorities, operational concepts, etc.) may require an update to the regional ITS architecture. Updates to the regional ITS architecture are expected as the projects identified by the regional ITS architecture are deployed and implemented and as the RTP is updated. The process for updating the regional ITS architecture is detailed in the Maintenance Plan document.

3.2.3 Input to the RTP

The regional ITS architecture is also a major source of input to the RTP. First, the regional ITS architecture provides a short-term and long-term, multi-modal view of the ITS systems in the region. It provides the details of the transportation services and functions that can be provided by the stakeholders in a project, and indicates the priorities and needs (project sequencing), both short-term and long-term, for those services and functions. The regional ITS architecture also illustrates the interfaces necessary between transportation systems to meet the transportation needs of the region.

The regional ITS architecture also includes a complete inventory of the current and proposed ITS inventory (systems) across all modes in its region. The architecture not only indicates the transportation services and functions already provided by existing deployments, but also highlights areas where these systems may be deficient.

As the projects are implemented and completed, their deployment status should be updated in the regional ITS architecture. As the regional ITS architecture is updated, however, it may have an effect on the goals and action plans of the RTP. Updates to the regional ITS architecture provide feedback and information to the transportation planning process, including some necessary information to update to the Regional Transportation Plan, and indicating the progress of the region in meeting its transportation goals and objectives. The progress in deploying ITS systems defined in the architecture can be directly related to the progress in deploying the transportation services that are provided by those same ITS systems.

As the RTP is updated, goals that were satisfied with the successful deployment of the projects and transportation services should be noted in the RTP. The inventory of the existing ITS systems that have been deployed may also need to be updated. The goals and action plans in the RTP may also need updates to reflect new needs and requirements as previous goals and plans are attained. New goals can be established based on new transportation needs, or the next steps in satisfying existing goals can be identified. These continuous processes and steps form the transportation planning cycle.

3.2.4 Coordinating ITS Architectures in the NYMTC Region

The NYMTC Region consists of three New York State Department of Transportation regions, the New York City region (Region 11), the Lower Hudson Valley region (Region 8), and the

Long Island region (Region 10). Each region potentially has its own regional ITS architecture to reflect the needs and goals of its local transportation agencies.

The NYCSRA and the other 2 regional ITS architectures in the NYMTC region provide input during the development of the RTP and when the RTP is updated. Despite the different character and needs of each region, the NYCSRA, the Lower Hudson Valley Regional ITS Architecture and the Long Island Regional ITS Architecture, should all have a relationship to NYMTC's Regional Transportation Plan. Although many of the plans and goals of each Regional ITS Architecture will focus on transportation needs and services specific to each region, some of the plans and goals will cross jurisdictional and institutional boundaries, and have effects on adjoining regions.

For example, freight transportation and management in the Long Island region cannot be considered without also considering its effects on and coordinating with the New York City region, since nearly all freight on Long Island, whether by truck, rail, or sea, must pass through New York City.

Thus, although some transportation needs and services for each region can be localized, there will be certain areas of transportation which the three regions should reflect similar and coordinated goals, objectives, and strategies.

3.2.5 Other Roles in the RTP

In addition to its direct contribution to the transportation planning process described above, a regional ITS architecture can serve other roles and purposes. For example, a regional ITS architecture also can support the long range planning that goes into development of the RTP by promoting system and inter-agency integration, and by increased stakeholder participation.

Increased stakeholder participation in the planning process may be a result of stakeholder interest in the services and functions that result from the regional ITS architecture. The regional ITS architecture serves as a product and process whereby stakeholders can gain buy-in and make their needs known and accommodated. Because of their vested interests, identified stakeholders are generally eager to be involved with the regional ITS architecture development. To the extent that the architecture development encourages team building and dialogue, this stakeholder cooperation can be extended to address other, non-architecture related issues, such as the transportation planning process.

In addition to further motivating traditional planning participants, a regional ITS architecture can help identify and engage new participants.

3.2.6 Use Case – Contribution to the Regional Transportation Plan

One of the goals defined in the Regional Transportation Plan is to minimize the cost and improve the reliability of freight movement within the region. Improving freight movement in terms of ease, reliability, and transportation system-related cost was identified as important to the region. The high cost of transporting freight and delivering services contributes to a higher cost of doing business in the region. Higher business costs make the region less competitive in the global economy. Objectives include improving the physical infrastructure of the transportation system for freight-related transport between shipping and receiving points; and improving the transportation of freight by removing burdensome government regulation and restrictions.

In the regional ITS architecture, several transportation services were identified that will contribute to meeting these regional objectives. They include CVO01 – Fleet Administration; CVO02 – Freight Administration; CVO03 – Electronic Clearance; and CVO04 – CV Administrative Processes.

Table 3-1. Use Case – Transportation Services

Market Package	Description	Services Provided
CVO01	Fleet Administration	Provides the capabilities to manage a fleet of commercial vehicles. The fleet and freight management system provides the route for a commercial vehicle by either utilizing an in-house routing software package or an information service provider. A route would be electronically sent to the commercial vehicle with any appropriate dispatch instructions. The location of the commercial vehicle can be monitored by the fleet and freight management system and routing changes can be made depending on current road network conditions. Fleet and freight management systems can process and respond to requests for assistance and general information from the commercial vehicle. Fleet and freight management systems may also be provided with the capability of monitoring on-board vehicle data.
CVO02	Freight Administration	Tracks the movement of cargo and monitors the cargo condition. Interconnections are provided to intermodal freight shippers and intermodal freight depots for tracking of cargo from source to destination.
CVO03	Electronic Clearance	Provides for automated clearance at roadside check facilities. The roadside check facility communicates with the commercial vehicle administration systems to retrieve infrastructure snapshots of critical carrier, vehicle, and driver data to be used to sort passing vehicles. This allows a good driver/vehicle/carrier to pass roadside facilities at highway speeds using transponders and dedicated short range communications to the roadside. Results of roadside clearance activities will be passed on to the CV administration systems. The roadside check facility may be equipped with Automated Vehicle Identification (AVI), weighing sensors, transponder read/write devices and computer workstations.
CVO04	CV Administrative Process	Provides for electronic application, processing, fee collection, issuance, and distribution of CVO credential and tax filing. Through this process, carriers, drivers, and vehicles may be enrolled in the electronic clearance program provided by a separate market package which allows commercial vehicles to be screened at mainline speeds at roadside check facilities. Through this enrollment process, current profile databases are maintained in the commercial vehicle administration systems and snapshots of this database are made available to the roadside check facilities at the roadside to support the electronic clearance process.

Customized market package diagrams were developed in the NYCSRA to provide these transportation services. A customized market package diagram for each transportation service identified is provided in the following figures.

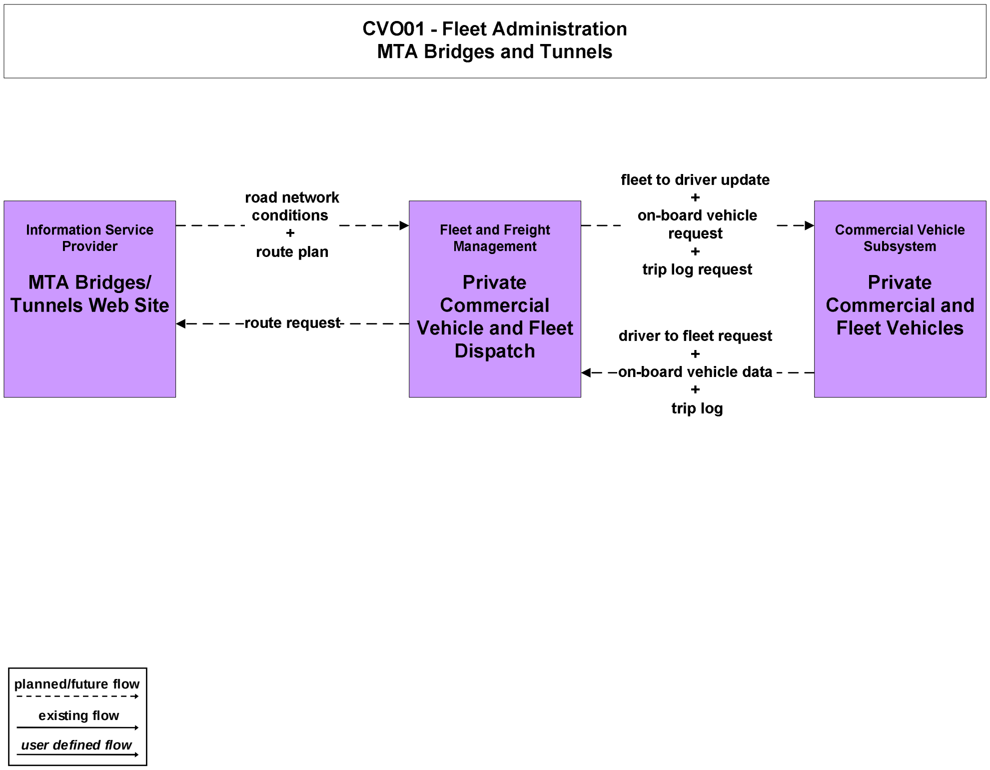

Figure 3-2. Use Case - Transportation Services - Fleet Administration

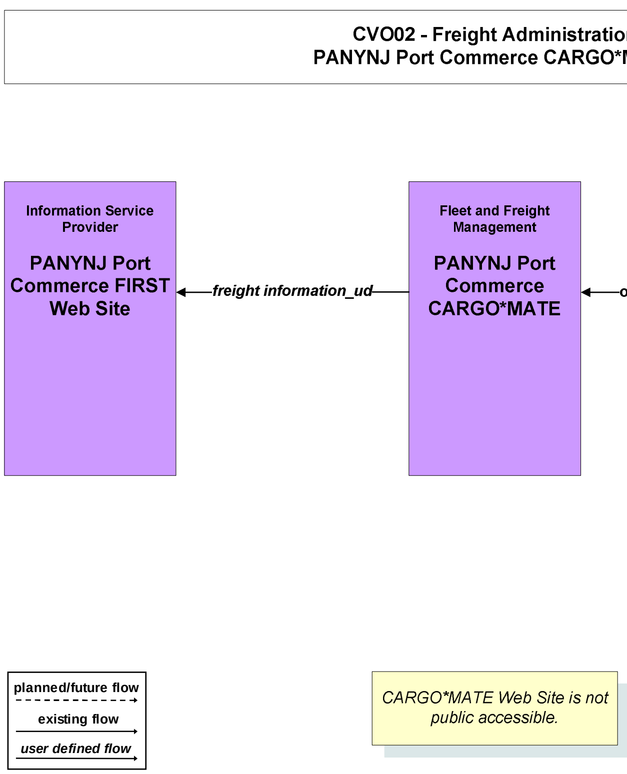

Figure 3-3. Use Case – Transportation Services – Freight Administration

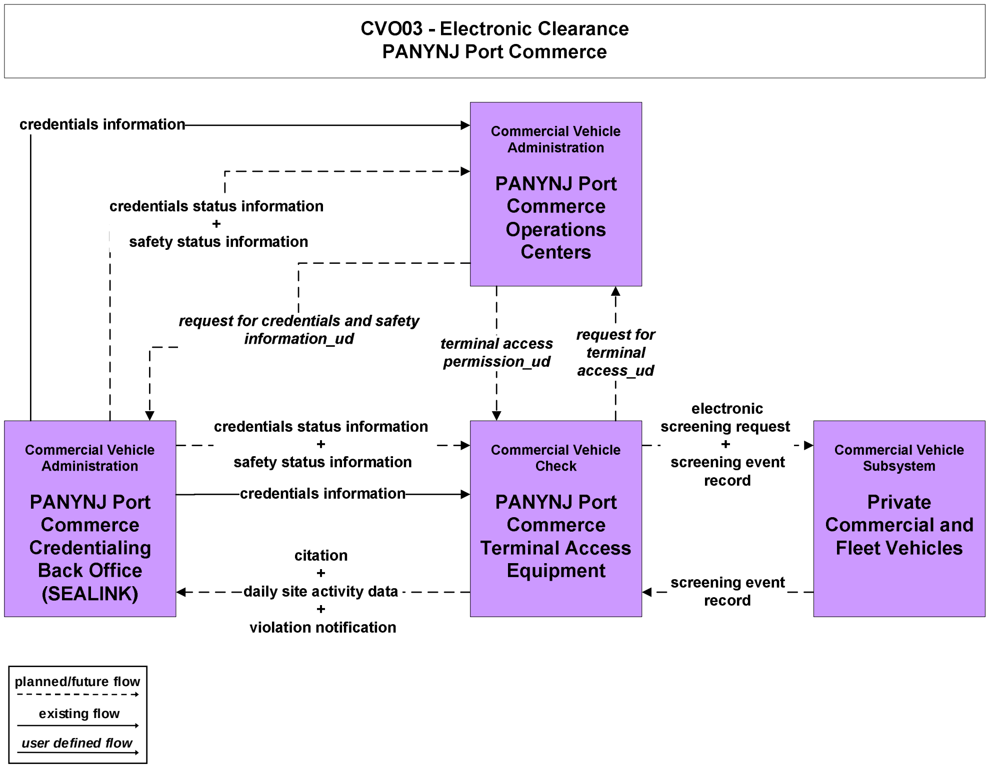

Figure 3-4. Use Case – Transportation Services – Electronic Clearance

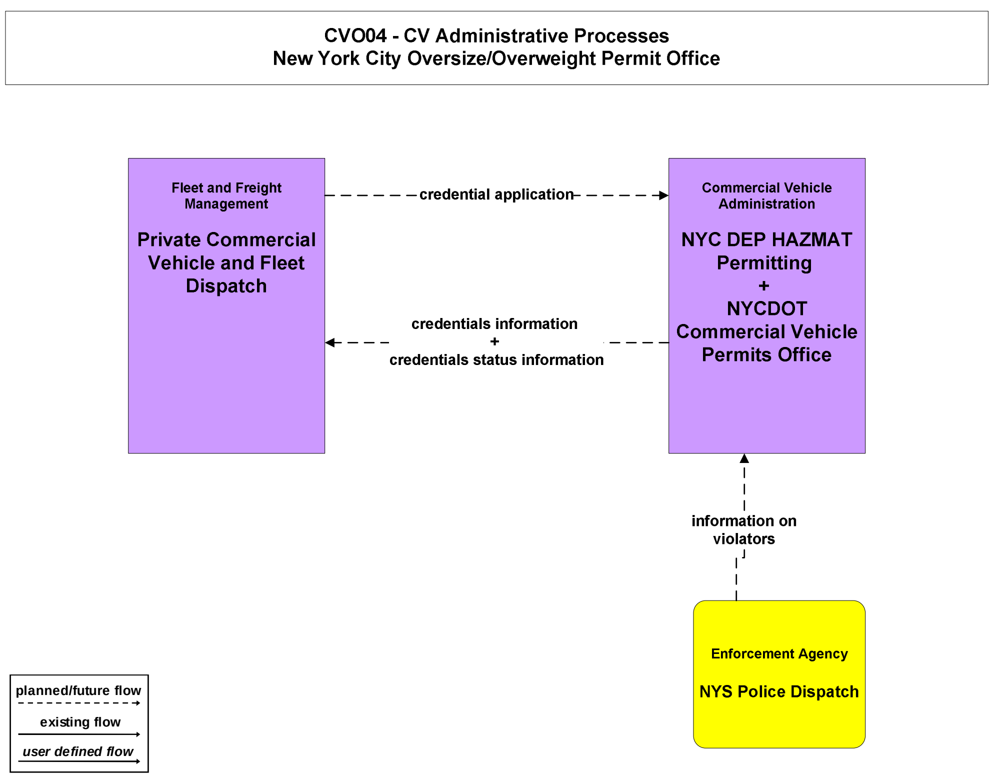

Figure 3-5. Use Case – Transportation Services – CV Administrative Process

3.2.7 Summary

The New York City Sub-Regional ITS Architecture:

- is a plan to deploy ITS projects, with a focus on integration of systems
- highlights existing and needed transportation services and functions in the region, while supporting the definition of the goals and objectives of the Regional Transportation Plan
- represents a consensus view of the regional transportation goals and objectives from the viewpoint of ITS systems and deployments
- is useful in understanding the complexities of the components necessary to realize the regional transportation goals and to gain insight into potential project costs and dependencies
- can be used to measure progress in attaining regional transportation goals

3.3 The Transportation Improvement Program (TIP)

3.3.1 Introduction

The Transportation Improvement Program (TIP) is a staged, multiyear, intermodal program of transportation improvements for a region, which is consistent with the region's Regional Transportation Plan (RTP). For NYMTC, the TIP is the capital program, normally over a 5-year period, which implements the goals and objectives identified in the region's Regional Transportation Plan, and is fiscally constrained within the reasonable cost estimates anticipated for those years. The TIP is a representation of how the region plans to attain the goals and objectives described in the Regional Transportation Plan. The adoption of the TIP serves an additional purpose in that it assures the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) that NYMTC's members have agreed on priorities for the region.

By federal mandate, the TIP must be periodically prepared by each metropolitan region and by each state requesting federal funding for transportation projects. The TIP describes specific transportation improvements that will be deployed and/or operated in the region for at least the next three years. The U.S. Department of Transportation does not approve use of Federal funds for a transportation improvement project unless the project is identified on the TIP. Inclusion on the TIP does not, however, guarantee Federal funding, but it does make that funding possible. For NYMTC, projects not funded by the Federal government are also included on the TIP to provide a more comprehensive picture of the proposed allocation of transportation funds in the region.

Federal regulations also specify several requirements on what information must be included in the TIP. These requirements include:

- Be updated at least biennially

- Be a product of the metropolitan planning process
- Identify transportation improvements consistent with concepts proposed in the RTP along with recommendations for Federal funding during the program period
- Include highway, transit and other intermodal projects
- Be fiscally constrained
- Create opportunities for public participation and comment
- Indicate the transportation priorities of the region
- Include realistic estimates of total costs that fiscal year

3.3.2 The TIP Process

As mandated by federal requirements, NYMTC updates its TIP every two years. The TIP update process for NYMTC begins with a review of the Regional Transportation Plan by each of the three Transportation Coordinating Committees (TCCs) in the region. These 3 committees, representing each of the three (3) NYSDOT Regions in the NYMTC region (New York City, the Lower Hudson Valley and Long Island), are charged with recommending transportation improvement priorities for inclusion in the TIP as well as providing opportunities for the government agencies, interested stakeholders and general public to become involved in the planning process on a more local level.

The recommendations from the TCCs are generally based on regional needs and/or improvement concepts that are first identified in the Regional Transportation Plan. It is through this mechanism that more specific needs and concepts are brought to the attention of NYMTC member agencies and a course of action for implementing the Regional Transportation Plan is established.

It is also during this updating process that new improvement projects are identified, individual plans and programs of the NYMTC agencies are considered, and the status of projects already in the TIP are updated. NYMTC members, local municipal officials and the public are also solicited for additional proposals for new transportation improvements. These improvement proposals are evaluated based on their relevance to the Regional Transportation Plan and on the criteria of the proposed funding source. The proposed improvements are studied in greater detail by each TCC with alternative solutions developed and analyzed along with other external factors (such as economic and environmental impacts) before improvement projects are defined.

Next, the TCCs select the transportation improvement projects to be included in the next update of the TIP. These improvements are organized by the priorities of the TCC into sub-regional project lists, and are then compiled into a regional TIP.

3.3.3 Project Definition

As capital or improvement projects, ITS projects must be included in the TIP to receive Federal funds. The regional ITS architecture development process not only defines ITS projects, but also establishes a preferred sequencing of these projects, which can form a part of the overall project prioritization effort required to complete a TIP.

Primarily, the regional ITS architecture identifies projects; projects are an output of a regional ITS architecture. The regional ITS architecture defines projects, and project descriptions, via the customized market packages that were created during the regional ITS architecture development process. Using these customized market packages, projects can now be derived to implement these customized market packages and provide the transportation services required to meet the region's transportation goals. Each identified project should clearly:

- Contribute to meeting the identified goals of the region
- Contribute to the seamless regional integration of ITS systems
- Support national interoperability by the use of standards, where applicable.

Projects, when derived from the regional ITS architecture, do not have to be a separate, standalone projects in the traditional sense, that is, with a specific scope of work for a specific agency or agencies, and a defined budget. Rather, these projects can be characterized as packages, a set of scopes of work with a collection of requirements, interfaces and flows that provide specific transportation services. These packages can be combined with other non-ITS projects, such as highway repaving jobs, or other ITS scopes of works, to form projects.

The process of identifying these packages can originate from two sources.

First, potential packages can be identified from existing transportation plans, such as the existing TIP. Potential packages may be the completion or expansion of existing projects or projects previously identified but not completed.

Second, new packages, or projects, can be derived from the customized market package diagrams in the regional ITS architecture. These customized market packages describe the functional requirements, system interfaces and the information flows between the systems required to support the desired transportation services. The diagrams identify elements, system interfaces and information flows that do not exist or are already part of project scopes with identified funding sources. The architecture then defines high-level functional requirements for those elements. For those elements that do not already exist, the requirements, interfaces, and flows are packaged to develop new ITS projects, or added as a part of larger projects, such as major construction projects.

Once an ITS package has been selected for the TIP, the project description information for those components can be taken from the outputs of the regional ITS architecture effort. Project descriptions for the TIP are usually more extensive than those associated with the Regional Transportation Plan. Project descriptions typically include:

- Sufficient descriptive material to identify the project or phase, including type of work, expected length of project
- Identification of the agencies responsible for carrying out the project

These project descriptions can be derived from the market package diagrams. The descriptions may include the transportation services to be provided in support of the regional goals and action plans, the interfaces and information flows to other agencies, and the functions that are to be performed. Additional information may include standards that may be applicable to the project.

3.3.4 Project Sequencing

One of the principal goals for developing a regional ITS architecture is to create a plan to integrate ITS systems in a region. The integration of ITS in the region is “implemented” with many individual ITS projects and private sector initiatives that occur over years, or even decades. Together, these projects and initiatives will require a significant investment by the public agencies and private companies in the region. Unfortunately, funding is never available to support all these investments and the region’s transportation needs and goals.

Thus, it is important to prioritize the region’s transportation needs and the projects that will satisfy those needs. To most efficiently use the investments and to yield the most benefits to the public up front, it is important to define a sequence, or ordering, to implement ITS projects and systems that will contribute to the integrated regional transportation system. This sequencing will help agencies, and the TCC, determine which ITS projects or packages are to be included in the TIP.

All projects that go into the TIP are subject to some form of prioritization. Some of the factors that are considered in developing these priorities include:

- Urgency of need for the project
- Project effectiveness versus cost
- Sequencing as related to other ITS and non-ITS projects (e.g. Is it best if ITS implementation is done at the same time as a construction project?).

The “Sequencing of Projects” output from the regional ITS architecture effort can provide a major input to this aspect of prioritization. Using the list of projects, which are output from the regional ITS architecture, each ITS project is prioritized or sequenced through a consensus process. This consensus process reflects a sequence of projects intended to create a transportation network that best suits the regional transportation needs.

It is not a rigid requirement that projects are implemented in accordance with the sequence established in the regional ITS architecture. Opportunities may appear that allow projects to occur with less risk or cost; or priorities may change due to external factors, such as changes in the environment or political landscape. Each has effects that may change the project sequence. However, the projects sequence from the regional ITS architecture serves as a good starting point for determining which projects or packages should be included in the TIP, and with what priority.

The project sequence output from the regional ITS architecture is generally dependent on two things:

- Transportation planning factors that are used to prioritize projects (e.g., identify early winners)
- Project dependencies that require successive ITS projects to build on one another.

Transportation planning factors that may affect the project sequence include cost-benefit ratios, technical feasibility, institutional issues, financial constraints and the strategic priorities of the region. Much of this information can be derived from other transportation planning documents, such as Strategic Deployment Plans, existing TIPs, the Regional Transportation Plan, or Early Deployment Plans. Transportation planning factors also include institutional or policy decisions that support the projects. For example, the absence of an agreement between two different agencies to share data, how the data is to flow between the agencies, and on the allowable use of data are barriers to the immediate implementation of transportation services. An example of a policy barrier is the lack of a common database structure identifying street names, which may impede properly sharing road network information between agencies, since there is no agreement on how locations are established.

Other transportation planning factors include technical issues that may impede implementation. For example, technologies to support work zone monitoring and alarming are currently prohibitively expensive. Agency priorities and local priorities also will influence the actual sequencing of projects.

Project dependencies are also considered when developing the project sequence for the regional ITS architecture. Several factors can determine project dependencies. The most important factor is when deployment of certain transportation services “enables” other transportation services. That is, certain project packages and transportation services must be available and supported before other functions, capabilities or transportation services can be implemented.

For example, traffic signal priority for emergency vehicles cannot occur until the traffic signal systems are provided the capability to change signal timing plans, or until the location of the emergency vehicles can be determined. Another example is that incidents cannot be detected or verified until traffic detectors or CCTV cameras are deployed on the roadways. Simultaneously, a traffic agency cannot disseminate road network conditions to other traffic agencies, or to the general public, until its traffic detectors or CCTV cameras are deployed.

Another factor is the status of current and planned ITS deployments and the readiness of proposed projects. Specific ITS elements may be deployed simultaneously with other traditional construction and maintenance projects, or with other ITS projects. The decision on how to deploy the ITS elements likely will depend on which method will save money and deploy the ITS elements more quickly. For example, if the construction of a critical roadway link is being designed, the installation of ITS roadway devices should be considered in the design to take advantage of certain efficiencies.

Project dependencies also occur where information flows between different systems, or elements, are required to satisfy a regional need. In these cases, both systems (one to send the flow, one to receive the flow) must be deployed before the information can be exchanged. Without this flow, the regional need cannot be satisfied and the desired transportation services cannot be provided.

Based on the project sequencing in the regional ITS architecture, high priority projects and packages should be considered for inclusion in the TIP. Actual inclusion in the TIP will ultimately depend on the transportation factors and project dependencies identified above, financial constraints, and public support for the project. Financial considerations include the anticipated costs and benefits of each proposed project or package. As projects are added to the TIP, the finances of the project should be consistent with the proposed transportation investments and priorities. Documentation exists elsewhere on how to perform cost-benefits analysis of ITS projects and thus the analysis is not discussed here. One reference is the USDOT JPO website, http://www.benefitcost.its.dot.gov.

As each project is identified and included in the TIP, the description should identify other projects that its success is dependent on and describe the nature of the dependency. The dependency description could be a narrative description, a categorization (e.g., functional or information dependency), or both.

3.3.5 Use Case – Existing Construction Project – Project Definition

A highway agency has received funds to replace an existing portion of a major roadway. The construction project was part of the TIP. Reviewing the regional ITS architecture, the highway agency identified that for a potentially incremental cost in design services and construction, it may be able to add the Network Surveillance and Traffic Information Dissemination transportation services to the project. Reviewing its customized market package diagrams for those transportation services, the following ITS elements were identified:

- ATMS01 – Network Surveillance – Agency A Traffic Management System (TMS), Agency A CCTV Cameras, Agency A Vehicle Detectors
- ATMS06 – Traffic Information Dissemination – Agency A Traffic Management System, Agency A Variable Message Signs

An analysis was performed to determine if indeed the additional costs for including these ITS elements to the construction project was incremental. A financial analysis for the inclusion of the ATMS01 and ATMS06 market packages into the proposed construction project indicated that the benefits to cost ratio was high, and that the cost for implementing the market packages under a separate, standalone project would be much higher.

Next, the market packages were checked if they were a high or low-priority in satisfying the regional transportation goals. ATMS01 – Network Surveillance market package was identified in the regional ITS architecture as a high-priority project, while the ATMS06 – Traffic Information Dissemination market package was identified as a medium priority project. Thus, although

ATMS06 was deemed a medium priority project, the addition of this market package was also added to the project description in the TIP, along with the ATMS01 market package.

With the decision made to include the market packages in the construction project, a description was needed for inclusion in the TIP and the project description. The full descriptions for these market packages can be found on the National ITS Architecture website, but the relevant portions are repeated here:

- ATMS01 – Network Surveillance – This market package includes traffic detectors, other surveillance equipment, the supporting field equipment, and fixed-point to fixed-point communications to transmit the collected data back to the Traffic Management Subsystem. The derived data can be used locally such as when traffic detectors are connected directly to a variable message sign or remotely (e.g., when a CCTV system sends data back to the Traffic Management Subsystem). The data generated by this market package enables traffic managers to monitor traffic and road conditions, identify and verify incidents, detect faults in indicator operations, and collect census data for traffic strategy development and long range planning. The collected data can also be analyzed and made available to users and the Information Service Provider Subsystem.
- ATMS06 – Traffic Information Dissemination – This market package provides driver information using roadway equipment such as dynamic message signs. A wide range of information can be disseminated including traffic and road conditions, closure and detour information, incident information, and emergency alerts and driver advisories. This package provides information to drivers at specific equipped locations on the road network. Careful placement of the roadway equipment provides the information at points in the network where the drivers have recourse and can tailor their routes to account for the new information. A link to the Maintenance and Construction Management subsystem allows real time information on road/bridge closures due to maintenance and construction activities to be disseminated.

The above descriptions of the market package was added to the project description of the construction project. For ATMS01, since the market package includes a connection with another agency, the description of the project was further expanded to include a sentence that, "In addition, traffic images collected at the Traffic Management (Subsystem) will be shared with the Police Department to assist with identifying, verifying and managing traffic incidents."

3.3.6 Summary

The NYCSRA supports the TIP by:

- describe projects or ITS project packages consisting of project descriptions, requirements, interfaces and flows
- better defining the integration opportunities for each project
- more accurately estimate project budgets based on an understanding of the elements of interfaces included in a project

- identify the priorities by which projects needs to be deployed.

3.4 Stakeholder- and Agency- Specific Transportation Plans

3.4.1 Introduction

Similar to how the New York City metropolitan region maintains a regional transportation plan, each transportation agency in the region also maintains an agency-specific transportation plan. The level of detail and information that goes into each agency's transportation plan varies for each agency, however, each transportation plan describes its agency's transportation needs, goals and objectives for the next several years. The transportation plan defines the vision for the agency and guides the development of its transportation programs and projects, describing the agency's approach to constructing, operating, and maintaining its transportation systems. Each plan also assists with the agency with projections and budgeting.

3.4.2 The Role of the Regional ITS Architecture

In the area of ITS, an agency's transportation plan generally includes details for the long-term implementation of ITS elements for the agency. The agency's plan defines the ITS elements to be implemented over time, aimed at meeting the agency's needs and goals. The plan generally includes recommendations for funding, phasing, managing the ITS elements.

The regional ITS architecture can play a role in defining and providing detail to the agency's transportation plan involving ITS elements. Similar to how the regional ITS architecture is used to support the TIP, the regional ITS architecture can be used to support the agency-specific transportation plan. The regional ITS architecture identifies potential ITS project packages for specific agencies; it defines the ITS integration needs, including the transportation services provided, project descriptions, functional requirements and interfaces. While the projects identified by the regional ITS architecture was intended to reflect regional goals and needs, the architecture should also reflect each stakeholder's goals and needs in the regional view.

In addition, the regional ITS architecture provides other outputs that can go directly into the agency's transportation plan. This includes information supporting project sequencing and project dependencies and provides information such as functional requirements, applicable standards, and interfaces. The regional ITS architecture also highlights potential external constraints that may impede implementation of projects, including technical feasibility, institutional issues and policy barriers. Financial constraints and information can also be derived from the regional ITS architecture.

Because the regional ITS architecture is a consensus process and reflects the needs and goals of the region, the architecture can also be used to garner support for ITS projects or packages. The diagrams and outputs also provides administrators and management a vision of what services can be provided and what projects should be supported.

3.4.3 Summary

The NYCSRA can be used to support an agency-specific transportation plan by:

- showing what ITS projects are needed to support regional goals
- indicating what ITS projects are needed and where agreements are needed to support sharing information and coordinating with other agencies and stakeholders

4 Project Systems Engineering Analysis

4.1 Introduction

Another requirement of the Rule 940 (940.11) is the submission of a Project Systems Engineering Analysis (PSEA) when requesting approval for federal funding for projects with an ITS component. The PSEA is the document that defines a project scope and systems engineering approach for these ITS projects. There are seven (7) requirements to be included in the PSEA. The PSEA is to identify:

1. Portions of the Regional ITS Architecture Being Implemented
2. Participating Agencies Roles and Responsibilities
3. Requirements Definitions
4. Analysis of Alternative System Configuration and Technology Options
5. Procurement Options
6. Applicable ITS Standards and Testing Procedures
7. Procedures and Resources Necessary for Operations and Management of the System

This section of the Use Plan provides a discussion and examples on how to use the regional ITS architecture to satisfy the PSEA requirements and to help move project specific information forward in the project development process.

4.2 PSEA Requirements

Information used in a PSEA for the NewYork City region will be derived from a variety of sources including: the NYC Sub-Regional ITS Architecture, the National ITS Architecture, ITS standards documents, previous PS&E (Plans, Specifications, and Estimates) sections from similar projects, and discussions with public sector and private sector staff involved in development of other project related scoping or design documents (e.g., project managers, construction engineering consultants, etc.).

The following general process can be applied to develop much of the material for a PSEA.

1. **Portions of Regional ITS Architecture Being Implemented**. Assess portions of the regional ITS architecture that apply to the project. This can be done by conducting a preliminary review of the customized market package diagrams from the NYC Sub-Regional ITS Architecture, ITS Inventory, and the “sausage diagram.” Extract the relevant portions of the customized market package diagrams to reflect only the ITS elements and architecture flows that apply to the ITS project. As will be shown in the example in this section, ITS elements and architecture flows that do not apply are shown grayed out.

2. **Participating Agencies Roles and Responsibilities.** Based on the project specific customized market package diagrams and ITS elements, as well as the operational concept developed for the regional ITS architecture, identify participating agencies and roles.
3. **Requirements Definition**. Based on the ITS elements identified, a list of high level functional requirements will be developed. These high level requirements will be based on the equipment packages and functional requirements of the ITS elements as represented in the regional ITS architecture.
4. **Alternative System Configuration and Technology Options**. Based on the high level requirements, system configuration and technology options can be developed. In general, three major categories of "technology options" can be developed: a) ITS operations alternatives, b) technology alternatives for delivery of the required ITS functionality, and c) communications. The ITS operations alternatives should relate directly to the participating agencies roles and responsibilities. For example, will agencies operate from existing centers, will a new center to house all agencies involved be developed, etc.
5. **Procurement Options**. This section of the PSEA would be developed based on existing planning documents, such as the Transportation Improvement Program (TIP) or an agency's capital plan. The key point of this section is to show traceability to the Federal, State, or Local sources of funds, and to indicate what portions of the project are covered by those funds (e.g., capital costs, operations, maintenance, staff, etc.). Especially helpful is showing the "project identifiers" used in the existing planning documents, and cost estimates as they relate to the project/system life cycle. Note the Implementation Plan contains information regarding projects and their funding sources that might serve as a starting point for this section of the PSEA.
6. **Applicable ITS Standards and Testing Procedures**. Based on the project specific architecture flows, relevant ITS standards will be identified. In the case of center to field standards, the NTCIP document number will be sufficient. In the case of center to center standards, a preliminary list of messages should be developed. This would leave the process of selecting specific NTCIP objects (data elements), and data elements for messages to the detailed plan stages of the project development process. In a separate step, procedures to facilitate testing of conformance to the standards specifications will be developed. Also develop the section on testing requirements for factory and system acceptance test based on the previous PS&E documents for similar projects.
7. **Procedures and Resources Necessary for the Operations and Management of the System**. This section is part of a concept of operations for the project. A concept of operations is a document that discusses the overall environment in which the system(s) of the project will operate. It includes a description of

organizational procedures or practices appropriate to the system(s), which covers this aspect of the PSEA. A complete concept of operations is not a specific requirement of the PSEA (only the aspects described above are covered by PSEA requirements), but it is part of an overall system engineering development process and should be considered particularly for major projects.

Finally, while not stated explicitly in the rule, any general background information related to the project should be included: For example, the specific roadway sections, transit routes, or geographic areas being considered; and project objectives.

4.3 PSEA Example

In order to illustrate the key points of the PSEA development process, this section will make use of a fictitious project example called the NYC Freeway Expansion project. This example shows only one possible out of many means to satisfy the PSEA requirements.

4.3.1 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 4-1. Use Case - PSEA 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 New York City Sub-Regional ITS architecture are shown mapped to one or more subsystems or terminators of the National ITS Architecture. The applicable ITS project elements for this example project are highlighted in italic, bold, blue text.

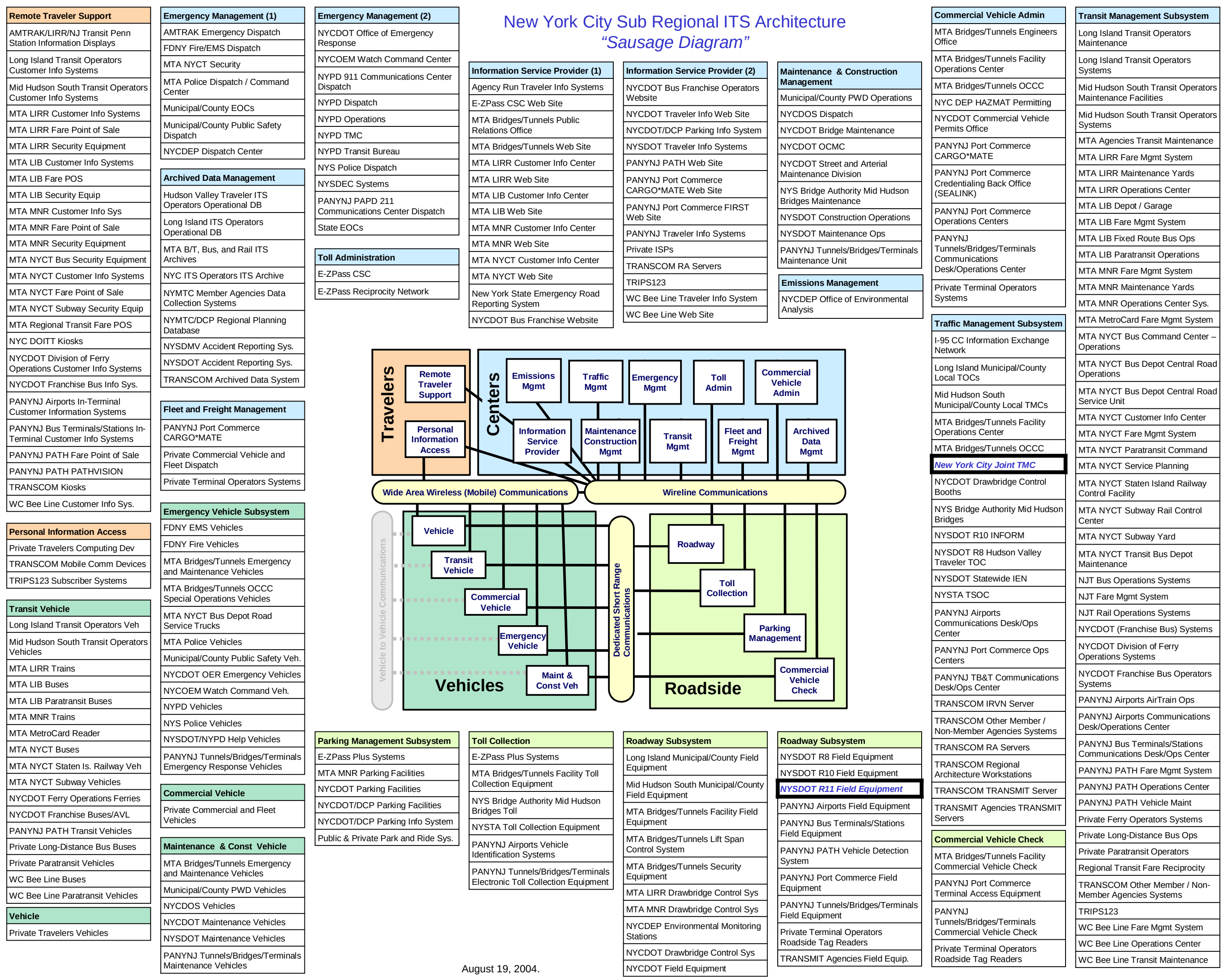

Figure 4-1. Use Case - Portion of the Regional ITS Architecture Covered by NYC Freeway Expansion Project

4.3.1.1 Customized Market Package Analysis

The table below lists which customized market packages from the ITS architecture apply. Specifically, the table contains all of the relevant market packages that contain the ITS project elements.

Table 4-2. Use Case - 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.

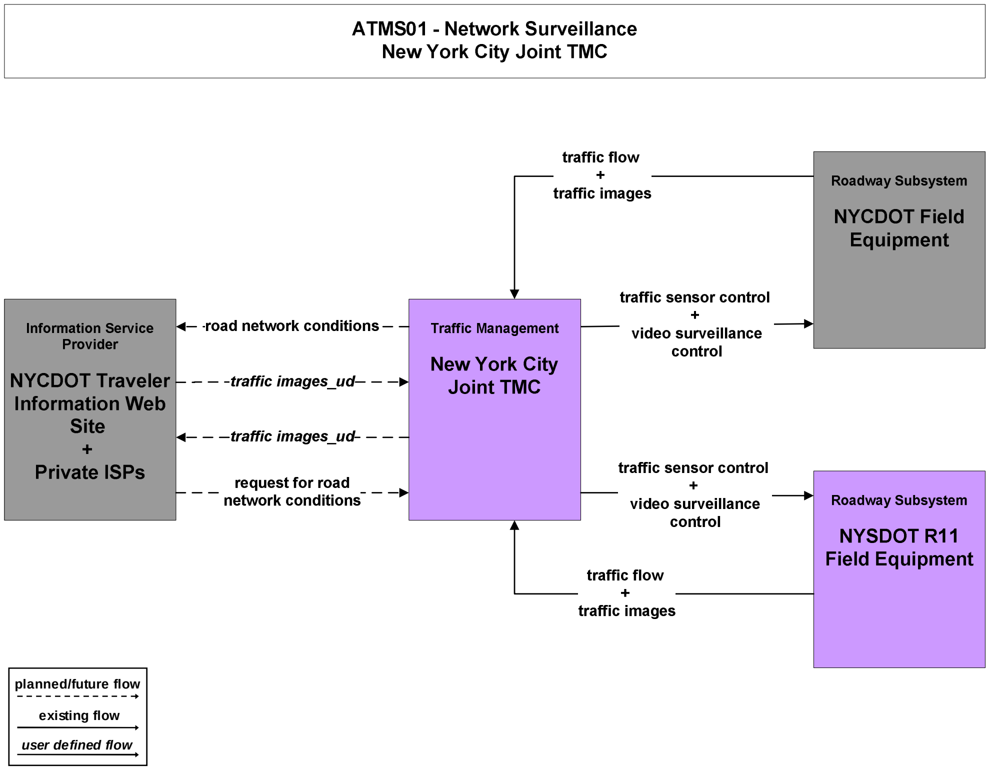

Figure 4-2. Use Case - ATMS01 - Network Surveillance Customized Market Package

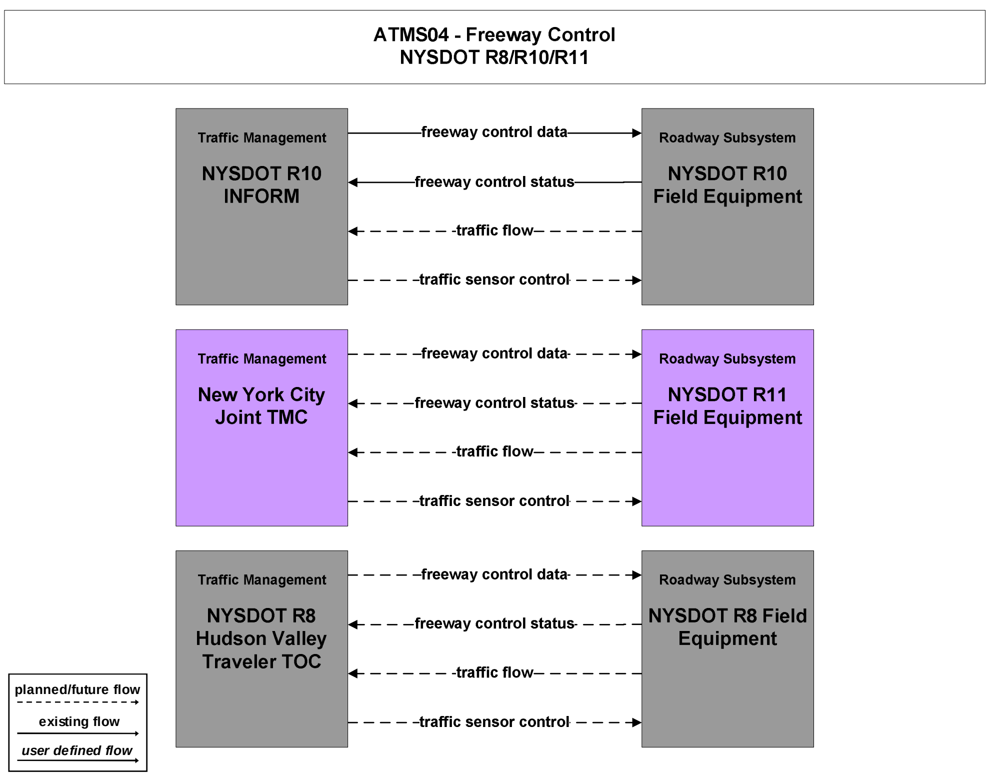

Figure 4-3. Use Case - ATMS04 – Freeway Control Customized Market Package

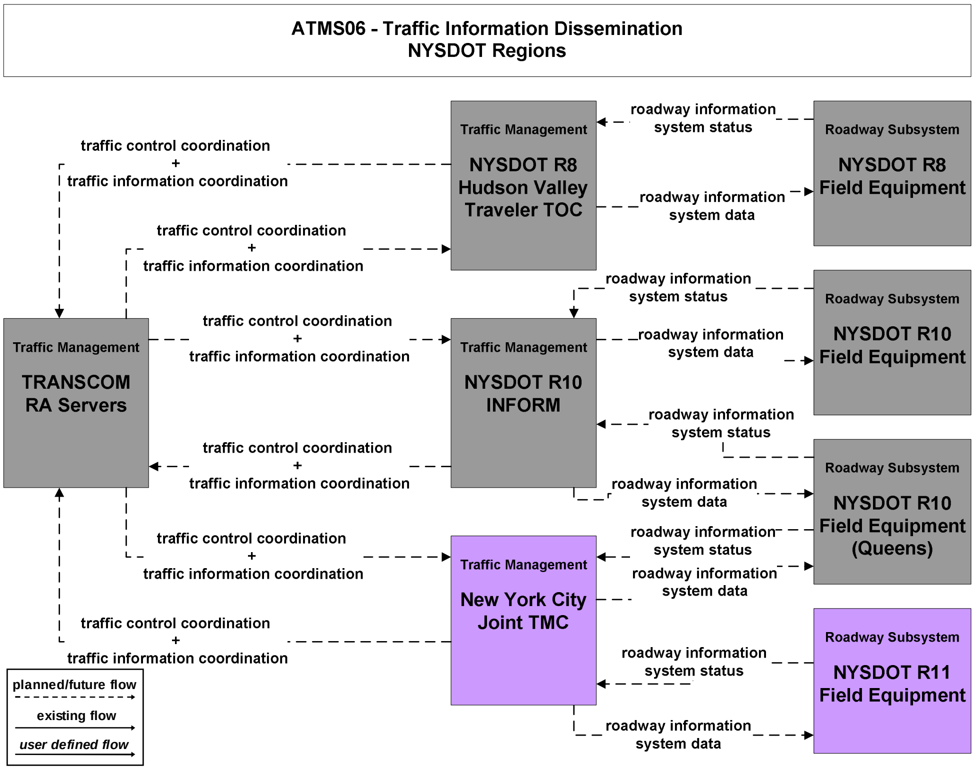

Figure 4-4. Use Case - ATMS06 – Traffic Information Dissemination Customized Market Package

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

Table 4-3. Use Case - 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.
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.

Project Element	Direction of Flow	Flow and Definition
	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).

4.3.2 Participating Agencies Roles and Responsibilities

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

Table 4-4. Use Case - 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 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)

4.3.3 Requirements Definition

This section of the PSEA includes high level functional requirements that may be derived directly from the New York City Sub-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 can also be found on the NYCSRA website. 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:

(a) 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.

(b) 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 4-5. Use Case - 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.
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.

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 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.
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.

4.3.4 Analysis of Alternate System Configurations and Technology Options

This section of the PSEA 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 three categories:

(a) Operational alternatives

(b) Technology alternatives for delivery of the required ITS functionality

(c) Communications alternatives

Each is reviewed briefly below:

- **Operational Alternatives**. For the purposes of a PSEA, this section would reflect which centers that house operational staff are involved. In the case of this example, all staff will be housed in the New York City Joint TMC and will be staffed 24 hours a day/7 days a week. However, another project may include the construction of a new, separate management center. How the field equipment will be maintained (in-house or contractor) might also be included.
- **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).

4.3.5 Procurement Options

This section of the PSEA 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 4-6. Use Case - Procurement Options

Project Document	Project ID	Funding
NYSDOT State TIP	NYS-	$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

4.3.5.1 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:

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

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

4.3.5.2 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

4.3.5.3 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.

4.3.6 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.

4.3.6.1 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 PSEA will identify applicable ITS standards and test procedures. The table below shows the applicable NTCIP center to field communications standards, as derived from the New York City Regional ITS Architecture.

Table 4-7. Use Case - 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

4.3.6.2 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:

(a) Adding NTCIP communications may require modification to the central software. The previously developed central software may be based on non-standard or 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.

(b) It may be possible that a State 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:

1. Develop an operational concept and requirements for the devices.
2. 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.
3. Develop performance requirements for communications between the central system and devices

(c) 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.

4.3.6.3 System Testing

The section of the PSEA 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:

(a) Design Verification Tests

(b) Power-On Tests

(c) Stand-alone Tests

(d) Final Acceptance Test

1. System Interface Tests
2. System Performance Tests, and
3. 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.

4.3.6.4 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 PSEA 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-Ban 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.

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

This section of the PSEA 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.

5 Project Implementation

5.1 Introduction

The "ITS Project Life Cycle" , as shown in Figure 5-1, consists of three phases, Project Planning and Funding Request; Funding Allocation; and the Procurement phase. The Project Planning and Funding Request phase encompasses the development or update of the regional ITS architecture, the Regional Transportation Plan and the Transportation Improvement Program. The Funding Allocation phase involves the evaluation of funding requests and the allocation of funding for proposed projects, and is not discussed in this document. In the Procurement phase, the Project Systems Engineering Analysis is performed, and the Local Fed "Approves Projects" (Step 9), so now, the Agency must "Procure Projects".

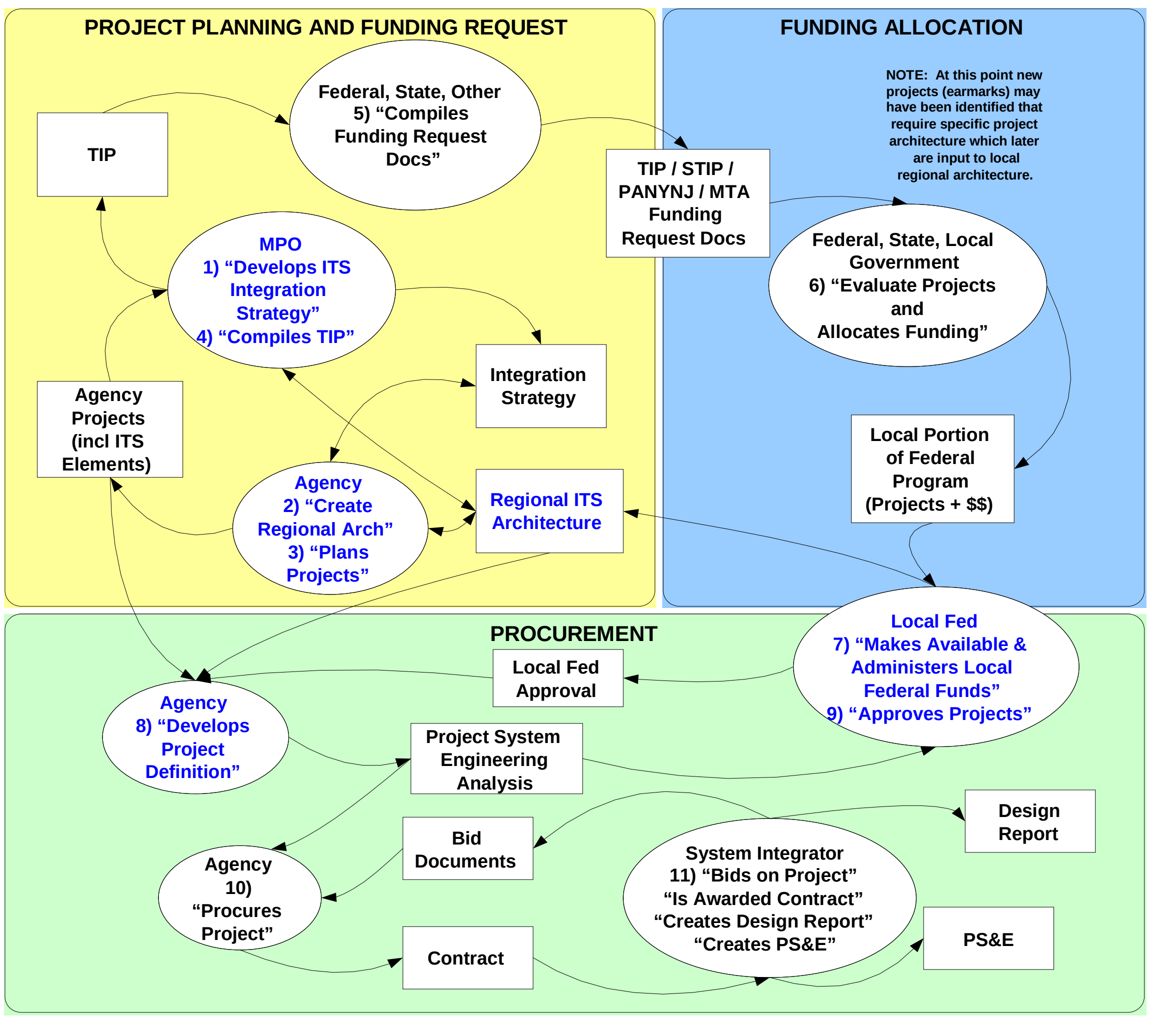

Figure 5-1. ITS Procurement Process

The discussion in this chapter focuses on this step of the ITS Procurement Process. The chapter discusses how the regional ITS architecture is used to define the project, including:

- Defining functional requirements, system interfaces, interconnects
- Determining agency roles and responsibilities, and
- Identifying applicable standards

Note that all three topics have already been discussed at a high-level to perform the Project Systems Engineering Analysis in Chapter 4. However, a greater level of detail is needed to develop a good specification that can be published in a request for bids. A good specification will provide a clear documentation of the requirements for the project and will minimize misunderstandings by the bidder/contractor, which ultimately leads to cost overruns and disputes.

All discussions in this chapter consider projects from a software point-of-view, that is, what functions, processes, and information flows are required for the project. The discussions do not consider hardware equipment or technologies, especially since the regional ITS architecture is technology-independent. In this way, the regional ITS architecture provides the flexibility needed so the architecture can be useful for many years (up to 20-30 years), as opposed to requiring changes every 3-5 years because of changes in technology.

Following the sections on project definition, a brief discussion is also provided on communications architecture and concepts.

5.2 Project Detail

The level of detail required for Project Definition will vary based on what point in the ITS Project Life Cycle the project is in. In the first and second phase, the “Project Planning and Funding Request” and “Funding Allocation”, a project can be defined in terms of the transportation services it will provide and by the major system pieces it contains.

However, once a project enters the third phase, the “Procurement Phase”, the details of the project must be developed. The regional ITS architecture can be used to support in developing the project details. Information provided by the regional ITS architecture includes:

- Project Scope
- Project Requirements
- Project Interfaces

5.2.1 Project Scope

The first project detail is defining the project scope. This includes defining:

1. what transportation services the project will provide, and
2. with what constraints.

Each ITS project is likely derived from one or more of the customized market packages resulting from the development of the regional ITS architecture. Each of these market packages provides a transportation service. Descriptions of the transportation services can be derived from the market package definitions. Through these market package definitions, specification writers can clearly identify and include in the project descriptions what transportation services the project provides. Although the transportation services provided by the project may seem intuitive, a good project description and understanding of the transportation services that the project is to provide will assist in a more focused project specification and avoid vague requirements.

Types of constraints indicated in a project scope include geographical (e.g., a specific freeway corridor, transit line or geographical area), functional (general descriptions of the functional requirements, and perhaps what functional requirements are not required), and financial.

5.2.2 Project Requirements

The second project detail is a description of the project functions and system specifications. This includes defining what systems or parts of systems will make up the project and what functions must the system(s) perform. High-level functional requirements can be derived directly from the New York City Sub-Regional ITS Architecture. Deriving high-level requirements was already discussed in this document to perform the Project Systems Engineering Analysis (See Section 4.3.3). However, more detail is necessary for writing the project specifications.

In the regional ITS architecture, each element in the customized market packages perform specific functions and processes to provide the transportation services defined by the market package. Functions and processes that are similar in scope have been broken down and packaged by the National ITS Architecture into groups called Equipment Packages. Equipment packages break up the subsystems into deployment-sized pieces. Equipment Packages group similar processes of a particular subsystem together into an “implementable” package. This grouping takes into account the actual transportation services provided and the need to accommodate various levels of functionality.

For example, the National ITS Architecture has an equipment package called Roadway Basic Surveillance. This equipment package is intended for Roadway Subsystems and is used to “monitor traffic conditions using fixed equipment such as loop detectors and CCTV cameras.” This equipment package includes several architecture flows that may be output from this roadway subsystem, including “traffic flow” and “traffic images”, and may receive several architecture flows, including “traffic sensor control” and “video surveillance control.”

Equipment packages are further broken down in the National ITS Architecture into process specifications, or P-Specs. P-specs are software processes that perform specific functions. Each process specification defined by the National ITS Architecture includes an overview, a set of functional requirements, and a complete set of inputs and outputs.

Using the same “Roadway Basic Surveillance” equipment package example, this equipment package includes two (2) p-specs, “Process Traffic Sensor Data”, and “Process Traffic Images”. Looking at the “Process Traffic Sensor Data” p-spec, this p-spec is defined as:

- This process shall be responsible for collecting traffic sensor data. This data shall include traffic parameters such as speed, volume, and occupancy, as well as video images of the traffic. The process shall collect pedestrian images and pedestrian sensor data. The process shall collect multimodal crossing and high occupancy vehicle (HOV) lane sensor data. 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.

Further analysis and review of the p-specs can lead to further details, including descriptions of the data flows that may be associated with this p-spec, and suggestions for the data elements that may be involved.

Requirements definition can be completely or partly defined by using the regional ITS architecture functional requirements applicable to the project. However, by no means is the National ITS Architecture complete, nor are the process specifications applicable for all regions. Rather, the process specifications in the National ITS Architecture only provides a starting point for writing the project requirements. Each region and each agency may have functional requirements or needs that are different from those defined in the National ITS Architecture. Or, it is also possible that project has functional requirements that were not considered or included in the National ITS Architecture. However, in the majority of the projects, the process specifications from the National ITS Architecture may be applicable and can be used as a check so that something is not neglected.

From the p-specs, the National ITS Architecture also provides descriptions of User Service Requirements that these equipment satisfies. The User Service Requirements are functional requirements statements that were used by the National ITS Architecture team to guide the development of the National ITS Architecture. However, these User Service requirements can be used as a basis for deriving the functional requirements in the Request For Proposals. Again, this does not imply that the User Service Requirements provided in the National ITS Architecture for that transportation service are complete or correct. Rather, it should be reviewed by the specifications writer as a guide to ensure that its project requirements are complete. These User Service Requirements can also be used as a basis for other requirements.

The level of detail for the functional requirements in the actual Request For Proposals will vary by agency. If an agency knows, in detail, what functions are desired and how those functions should be implemented, these detailed functional requirements should be included in the RFP. If an agency is interested in hearing different alternatives (or technologies) in the proposals, a more general level of detail for functional requirements may be desired.

For the NYCSRA, all the information discussed above, equipment packages, p-specs, and user service requirements can be found on the NYCSRA web site, under the Elements Details page for each ITS element.

5.2.3 Project Interfaces

The third project detail is the interface definitions. Interface definitions include what interconnections do the project entails. By interconnections, it is meant what systems, or parts of systems, will information be shared across. This may include systems owned by other agencies or private companies. Interface definitions should include what information needs to flow across the system interconnections, the format of the information, the data elements, and how the interfaces communicate with each other.

Interconnects between elements can be derived directly from the customized market package diagrams developed for the regional ITS architecture. For each transportation service identified, the customized market package diagrams indicate what interconnects are existing or planned between ITS elements in support of the transportation service. Interconnects can also be derived from the operational concepts developed as part of the regional ITS architecture.

The interconnects also define what architecture flows, or information, is exchanged or planned between the ITS elements in support of the transportation services. In the National ITS Architecture, descriptions are given for each architecture flow, including what information is being exchanged and under what conditions do the information exchange occurs. The National ITS Architecture also provides more details for some architecture flows, which may consist of several different data flows or specific data elements.

Although the regional ITS architecture can provide significant amounts of information towards the generation of an RFP, by no means can the regional ITS architecture or the National ITS Architecture provide all the information necessary for a good specification. Rather, the architectures provide a starting point for defining the interface requirements, it describes what interfaces between systems are necessary and what information is exchanged between those interfaces. However, the details of how these interfaces are to be implemented and other user needs and requirements will be agency- and region-specific and are not provided by the architectures.

5.2.4 Use Case - Existing Construction Project – Project Implementation

Expanding on the example from Section 4.3, the NYC Freeway Expansion project has been funded, and it is now necessary to write the specifications for the three ITS market packages added to the construction project.

To review, the following ITS elements were identified as components of the example project:

- New York City Joint TMC
- NYSDOT R11 Field Equipment

The following information flows were identified between these ITS elements, and are

- ATMS01 – Network Surveillance:
  - From New York City Joint TMC to NYSDOT R11 Field Equipment (CCTV Cameras) – video surveillance control
  - From New York City Joint TMC to NYSDOT R11 Field Equipment (Vehicle Sensors) – traffic sensor control
  - From NYSDOT R11 Field Equipment (Vehicle Sensors) to New York City Joint TMC – traffic flow
  - From NYSDOT R11 Field Equipment (CCTV Cameras) to New York City Joint TMC – traffic images
- ATMS06 – Traffic Information Dissemination
  - From New York City Joint TMC to NYSDOT R11 Field Equipment (Dynamic Message Signs) – roadway information system data
  - From NYSDOT R11 Field Equipment (Dynamic Message Signs) to New York City Joint TMC – roadway information system status

The definitions for the above information flows can be found on the NYCSRA website, the National ITS Architecture website, but are repeated in Table 4-3.

Based on the above information flows, the NYCSRA website and the National ITS Architecture website identify ITS standards that may be applicable to each of the above information flows. The relevant ITS standards can be found in Table 4-7.

- Based on the market packages defined, the NYCSRA website and the National ITS Architecture website identify equipment packages that may be applicable to each of the ITS elements. The descriptions for these equipment packages can be found on the NYCSRA website or the National ITS Architecture website, but the relevant portions are repeated in Table 4-5.

For each equipment package, user service requirements and process specifications can be defined.

For example, for the Roadway Basic Surveillance equipment package, two process specifications (P-specs) are defined on the NYCSRA website and the National ITS Architecture website. The relevant portions of the descriptions are repeated here:

- 1.1.1.1-Process Traffic Sensor Data - This process shall be responsible for collecting traffic sensor data. This data shall include traffic parameters such as speed, volume, and 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.
- 1.3.1.3-Process Traffic Images - This process shall process raw traffic image data received from sensors located on the road (surface street) and freeway network served by the Manage Traffic function. The process shall transform the raw data into images that can be sent to another process for incident or work zone intrusion detection. It shall also act as the control interface through which the images of traffic conditions can be changed by the traffic operations personnel and maintenance and construction center personnel, who shall also be supplied with images for viewing. This process shall also provide sensor equipment fault information to other processes in the Manage Traffic and Manage Maintenance and Construction functions that are monitoring the health of field equipment so that repairs can be scheduled by those other processes if deemed necessary.

For each p-spec, more detailed data flows and data elements can be extracted to support the p-spec.

For the Roadway Basic Surveillance equipment package, several user service requirements are also defined on the NYCSRA website and the National ITS Architecture website. The relevant portions of the descriptions are repeated here:

1.0 - TRAVEL AND TRAFFIC MANAGEMENT
1.6 - TRAFFIC CONTROL
1.6.2 - TC shall include a Traffic Surveillance function.
1.6.2.1 - Traffic Surveillance shall include a vehicle detection function with the capability of accurately detecting vehicles in a real-time fashion.
1.6.2.1.1 - Vehicle detection shall include the capability to determine those

vehicles that are HOVs.
1.6.2.2 - Traffic Surveillance shall include a data collect function to provide the capability to collect data for determining traffic flow and prediction.
1.6.2.2.1 - The data collect function shall provide the capability to quickly feedback traffic data to the control processes.
1.6.2.3 - Traffic Surveillance shall include a wide-area surveillance capability to include several jurisdictions.
1.6.2.3.1 - The wide-area surveillance shall gather speed and flow information.
1.6.2.4 - TC shall provide the capability to acquire detailed traffic measurements at specific locations.
1.7 - INCIDENT MANAGEMENT
1.7.1 - Incident Management shall provide an Incident Identification function to identify incidents.
1.7.1.1 - The Incident Identification function shall include the capability to identify predicted incidents.
1.7.1.1.1 - The Incident Identification function shall use information from the following types of sources, where available, to identify predicted incidents:
1.7.1.1.1(a) - Traffic flow sensors.
1.7.1.2 - The Incident Identification function shall include the capability to identify existing (both planned and unplanned) incidents.
1.7.1.2.2 - The Incident Identification function shall determine and continuously monitor at least the following characteristics of each existing incident:
1.7.1.2.2(a) - Type (including Terrain Hazards).

5.2.5 Summary

The NYCSRA provides detailed information for project implementers. This information includes:

- Project scope, including goals and constraints of the project
- Project requirements, including functional requirements and user requirements.
- Project interfaces, including interfaces and data flows between different ITS systems.

5.3 Agency Roles and Responsibilities

5.3.1 Discussion

Many of the interconnects identified in the regional ITS architecture occurs between systems of different agencies, or between different divisions or departments of the same agency. The identification of agency roles and responsibilities (including any inter-agency cooperation) can come from the operational concept developed as part of the regional ITS architecture. This operational concept can either serve as a starting point for a more detailed definition, or possibly provide all the needed information.

More detailed identification of agency roles and responsibilities can be derived by reviewing the project interface definitions. Although the interface definitions indicate what information is exchanged, it does not dictate the conditions when information is passed, the details on how the information is passed between the ITS systems, nor the details on how the information exchanged may be used by the systems.

Many of these details should be agreed upon between the agencies before the project can be fully implemented. Although it may not be necessary to have the exact details and an agreement before the project specifications is released for bidding, it is advantageous, from a scope of work and pricing point of view, to have the major principles agreed upon before the it is released.

Some agency roles and responsibilities that should be agreed upon before implementation include:

- Data format – Describes the communications protocol to be used, the data structure, and the data format, ideally through ITS Standards
- Communications characteristics – Describes the conditions when the information is exchanged, how often is the information exchanged, and how is the information transported.

Note that the emphasis on agency roles and responsibilities here is on and between ITS systems, and not on people doing things. The latter is discussed in detail as part of the operational and institutional agreements between agencies, and is reviewed in Chapter 6. Defining agency roles and responsibilities was also discussed in brief to perform the Project Systems Engineering Analysis (See Section 4.3.2). In addition, Section 5.4 provides a discussion on standards that may be applicable to the interconnects in the areas of communications protocols and data element structures, while Section 5.5 provides a brief overview on communications architectures.

Although these topics are discussed in other sections, these subjects are mentioned here because it is important that these details be addressed, or at least considered when writing the scope of work for the project.

5.3.2 Use Case – Agency Roles and Responsibilities

Agency A is a transportation agency that has CCTV cameras in the field. Agency A has pan/tilt/zoom control over the CCTV cameras. The images from the CCTV cameras all return to Agency A's traffic management center and goes through a video switcher. Agency B is another transportation agency in the region. Agency B would like to receive the traffic images collected by Agency A.

The ITS project is funded, and the transportation service is shown in the regional ITS architecture as ATMS07 – Regional Traffic Control, which would show Agency A providing traffic information coordination and traffic control coordination with Agency B.

Agency A and Agency B establishes an agreement with their roles and responsibilities defined as follows:

Agency A agrees to provide Agency B with their video images. Rather than Agency A selecting which video images to provide Agency B, Agency B is provided with the capability to control the video switcher so Agency B can select which video images it would like to receive. Control of the video switcher will use the appropriate NTCIP suite of standards (NTCIP 1201: Global Object Definitions; NTCIP 1208: Object Definitions for Video Switches).

Agency B will not have the right to control the video images (pan/tilt/zoom), thus, no information flow is necessary for p/t/z control. However, a procedure is established whereby Agency B can request Agency A to move the CCTV camera, so an information flow may be necessary to forward the request(s) from Agency B to Agency A.

5.3.3 Summary

The NYCSRA provides information for determining agency roles and responsibilities. This information includes:

- Information flows to be exchanged between agency systems
- ITS standards that may be applicable

5.4 Applicable ITS Standards

5.4.1 Introduction

What are ITS standards? Standards specify how to do things consistently. They may specify how things should work, or they may describe certain physical attributes. ITS standards are industry-consensus standards that define how ITS system components operate within a consistent framework, the National ITS Architecture. ITS standards establish a common way in which systems and devices connect and communicate with one another. By specifying how systems and components interconnect, the standards promote interoperability, allowing transportation agencies to implement systems that cost-effectively exchange pertinent data and accommodate equipment replacement, system upgrades, and system expansion.

Standards benefit the traveling public by providing products that will function consistently and reliably throughout the region. ITS standards contribute to a safer and more efficient transportation system, facilitate regional interoperability, and promote an innovative and competitive market for transportation products and services.

The U.S. DOT ITS Standards Program is working toward the widespread use of national ITS standards to encourage the interoperability of ITS systems. Through cooperative agreements with six standards development organizations (SDOs), the Standards Program is accelerating development of about 100 non-proprietary, industry-based, consensus ITS standards, and is encouraging public-sector participation in the development process.

In addition to adopting national standards, a region may wish to adopt regional standards that would facilitate interoperability and the integration of ITS systems in the region. For example, standard base maps, naming conventions, measurement & location standards, and organizational structure identifiers can all facilitate the meaningful exchange of information between systems in the region. Specific examples of regional standards include the Inter-Agency Group (IAG) standard for the New York City region's electronic toll collection system (E-ZPass), the Universal Smartcard for electronic payment systems, and the New York City Department of City Planning's ITS database for archiving transportation data for the region. These types of regional standards should also be considered and can be included in the standards documentation at the discretion of the region.

Standards are an important tool that will allow efficient implementation of the regional ITS architecture over time. Establishing regional and national standards for exchanging information among ITS systems is important not only from an interoperability point of view; it also reduces risk and cost since a region can select among multiple vendors for deployment products. Standards facilitate deployment of interoperable systems at local, regional, and national levels without impeding innovation as technology advances and new approaches evolve.

In general, each information flow has up to three types of standards that are relevant: a data element standard, a message set standard, and one or more communications protocol standards. Data elements are the smallest entity of data. Sometimes labeled as data objects or object definitions, they are the building blocks for transferring bits of information. Message sets are strings of data elements put together to provide related, relevant information. A group of pre-defined messages can accomplish a function. Communications protocols are the rules to move information. The protocol may consist of rules regarding data formats, control information coordination, error handling, or timing.

An analogy to better understand the three types of standards is the english language: the data elements are the words, the message sets are the sentences, and the communications protocols is the english grammar that defines the rules for creating sentences.

A report identifying potential ITS Standards supporting regional and national interoperability is a required component of the regional ITS architecture as identified in FHWA Final Rule/FTA Final Policy, and is included as an output of the NYCSRA. The Rule/Policy requires, where appropriate, that federally funded ITS projects use ITS standards that are adopted by the USDOT. No ITS standard have been formally adopted by the USDOT as of April 2005 but development of ITS standards continues.

As an SDO-approved standard matures and its market expands, USDOT may decide to adopt it through a formal rulemaking process.

Unfortunately, the regional ITS architecture does not provide guidance on how to use the standard, or more importantly, how to test the standards. However, the USDOT web site on ITS standards (http://www.standards.its.dot.gov/standards.htm) and ITS architecture and standards conformity (http://www.ops.fhwa.dot.gov/its_arch_imp/index.htm) site, provide a listing of resources on where more information about the standards development can be found, including the current status on the development of the various ITS standards.

As mentioned, a report identifying applicable ITS standards is a required component of the regional ITS architecture according to FHWA Final Rule/FTA Final Policy. ITS standards address the interfaces between ITS systems. These interfaces, and the information flows between the interfaces were 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 NYCSRA web site includes a map for each interface and each information flow in the regional ITS architecture to applicable ITS standards (or interim standards) for that interface or flow, if one exists. A set of standards can be identified for many of these interfaces and information flows. This may include message sets, data elements, and communications protocols. From this mapping, a project specifications writer can extract the applicable ITS standards for the project.

The Turbo Architecture database that is generally generated with regional ITS architectures also provides an ITS Standards Report based on all of the architecture flows selected in the region. This report lists all standards associated with each architecture flow, either sorted by standard or by interface.

However, this does not suggest that the standards listed will support all the functions desired and needed. Many of the ITS Standards are still in development and only a handful of ITS Standards can be considered mature at this time. By mature, it is meant that the standard has been deployed and tested by numerous agencies, and has industry-wide support. Also, regions, or agencies, may have functional requirements or needs that may not be supported by the standards. Although the standards development process attempts to support a majority of the user requirements and needs, it cannot always do so, or may satisfy those requirements and needs in a different manner.

5.4.2 Using the Standards

Although the report identifies the applicable national standards, it is up to the region and the individual projects to determine which standards to use, and how to specify those standards. The stakeholders in the region should convene to evaluate the interfaces between systems and the ITS Standards identified in the regional ITS architecture. By evaluating interfaces rather than individual information flows, the amount of work required is reduced considerably.

Using the information provided by the regional ITS architecture, the stakeholders should agree what standards, if any, should be adopted for each interface. There are several factors to consider before a region adopts a standard. These factors include:

- What standards are currently used in the region?
- Is the standard mature and widely-adopted?
- Does the standard support the regional needs and requirements?

The first step is to review any national or regional standards that have been adopted by the region and currently used by the stakeholders. It's possible that many industry standards are already in use in the region. Examples of regional standards that have been adopted by the New York City region include the E-ZPass IAG interfaces or the TRANSMIT data interfaces. Examine these existing interfaces and determine if these adopted interfaces support the region's current and future needs. If a regional standard exists, examine if a national ITS standard exists may provide greater benefits, and which standard other agencies in the region are using or are considering. If applicable, consider options for migrating from regional standards to national ITS standards over time.

The second step is to evaluate the relative maturity of the standards. When evaluating the maturity of each ITS Standard, consider the following:

- Will the ITS standard be mature or available in the deployment timeframe?
- Has the ITS standard been approved or published by the SDOs?
- Is the ITS standard supported by multiple vendors?
- Has the ITS standard been deployed by other agencies?
- Has the ITS standard been tested or are standard testing procedures been developed?
- Is an update to the ITS standard expected in the near future?

The third step is to evaluate whether the applicable standard supports the region's needs and requirements. Although ITS Standards generally support most common user requirements and needs, it may not support the less common functions or needs that the region or agency may require. Although the ITS Standards allow for the support of some customization to meet a region's unique requirements, it is a concern if the region has too many unique requirements that the ITS Standards cannot support.

Adoption of an ITS Standard may also depend on the available communications infrastructure in the region, especially in the area of communications protocols. Some standards require high bandwidth, constant communications, such as the collection of video images for recording purposes. Other standards can support low bandwidth, infrequent communications, such as polling roadway devices on occasion to check its status.

Even if the region decides not to deploy an ITS Standard immediately, stakeholders in the region should reach consensus on a plan to migrate toward eventual adoption of the ITS Standard once they are available or mature, if it is still a consideration.

Recall that it is currently not a federal requirement to use the ITS standards, however, it is a requirement to consider using them. Justification should be provided by the region, or agency, if an ITS standard is available but is not used. Justification may include the use of a regional standard that is already adopted and deployed by the region, or previous and significant investments into a specific interface definition. The justification may also include interim adoption of another interface definition with a migration path towards the use of ITS Standards. The immaturity of the appropriate ITS Standard may also be a justification.

Once a standard has been adopted by the region, it is important to understand how to use the standard. The first use case, Developing A DMS Project, provides an example on how to use the center-to-field standards. Unfortunately, the information flows of the regional ITS architecture (not the National ITS Architecture) currently do not have a one-to-one correlation between the message sets, data elements, or communications protocols of the ITS Standards. However, the second use case, which is an example of a center-to-center ITS standard, is an example on how to use the information flows from the regional ITS architecture and map those flows to the ITS Standards.

5.4.3 Use Case – Developing A DMS Project

Agency A has a project to furnish and install dynamic message signs. The dynamic message signs will require communications between the traffic management center and the roadside field equipment. From the NYCSRA, the following ITS standards are applicable to the information flow, roadway information systems data and roadway information systems status:

- NTCIP 1101 – Simple Transportation Management Framework (STMF)
- NTCIP 1102 – Base Standard: Octet Encoding Rules
- NTCIP 1103 – Simple Transportation Management Protocol (STMP)
- NTCIP 1201 – Global Objects Definition – NTCIP 1201:1996, version 01.10, including Amendment 1.
- NTCIP 1203 – Object Definitions for DMS – Version 1, with Amendment 1
- NTCIP 2001 – Class B Profile
- NTCIP 2101 - Point-to-Multi-Point Protocol over RS–232 Subnetwork Profile (SP-PMPP) – Version 2101:2001, dated November 26, 2001.

- NTCIP 2102 – Subnet Profile for PMPP over FSK modems
- NTCIP 2103 – Subnet Profile for Point-to-Point Protocol using RS-232
- NTCIP 2104 – Subnet Profile for Ethernet
- NTCIP 2201 – NTCIP TP - Transportation Transport Profile (formerly TP-Null)
- NTCIP 2202 – NTCIP TP - Internet (TCP/IP and UDP/IP) Transport Profile (formerly TP-INTERNET)
- NTCIP 2301- Simple Transportation Management Framework (STMF) Application Profile
- NTCIP 2302 – Application Provide for Trivial File Transfer Protocol
- NTCIP 2303 – Application Profile for File Transfer Protocol (FTP)

To support basic communications using NTCIP, NTCIP 1102 and NTCIP 2301 profiles are needed and are specified. The project specifications will include NTCIP 1201 and NTCIP 1203 to support communications and management of the DMS. Initially, the communications infrastructure for this project is to be dial-up telephone lines. However, in the future, communications with the DMS field equipment is expected to be via a fiber optic network, using IP-addressing and ethernet. Based on this information, support for NTCIP 2201 and NTCIP 2103, is necessary for the existing communications infrastructure, and support for NTCIP 2104 and NTCIP 2202 is necessary for the future communications infrastructure.

To develop the detailed requirements of the NTCIP standards, a Concept of Operations (ConOps) document is created. The ConOps defines the relationship between the system and the organization. Or, put in different words, the ConOps describes how the ITS "system" will be used (its operational characteristics) and what transportation problem is being solved through the implementation of the system. It should clearly define the user needs and operational context for the functions that the ITS system will support, using easy-to-use understand terms and with participation from the various stakeholders and users of the ITS System.

From an ITS Standards point of view, the Concept of Operations for an ITS system using center-to-field communications should include discussion of the following:

- **Introduction.** The introduction will contain a general overview of the project elements and locations of field equipment.
- **Physical Features.** This section will contain an overview of the type or types of equipment being considered, and the physical characteristics of the field and central system.
- **Normal Operations.** This section contains a narrative of how the field and central control system should operate under normal conditions. The focus will be on what functions the ITS system should support. Ideally, a description of what

detailed information is required for the function to be completed, paving the way for an analysis of NTCIP object requirements.

- **Exception Operations.** This section will contain a narrative of how the field and central control system should operate under abnormal conditions, such as during equipment or power failures.
- **Control Modes.** The section will focus on control modes, functions, and which operations are available during which control modes.
- **Monitoring.** The section will outline the behavior of the system during status monitoring, event logging, and diagnostics.
- **Installation/Testing.** This section will outline what testing is required under various times/conditions. For example, during installation, routine maintenance, and failure.

A sample ConOps with key portions of the document filled in for a DMS (dynamic message sign) system is included in Appendix A.

Based on the ConOps, it was determined that Agency A does not need all the functions and messages that NTCIP 1203 supports, thus the project specifications should specify the required data objects (center-to-field) for the project. Conversely, there is also a possibility that an ITS standard does not support all the user and functional requirements that have been defined. However, for this example project, no agency-specific objects are needed.

The proposed NTCIP 1203, Version 2, will have a Protocol Requirements List (PRL) that maps user requirements to functional requirements to solutions that are defined in the ITS standards. This makes it easy to review the PRL and determine what sections of the ITS standards need to be included in the agency's specifications. In essence, the PRL allows an agency to "customize" the standard, including only the relevant sections that apply to the project's requirements.

In the case of center-to-field ITS standard, the solutions are usually described in the form of data objects that must be supported by a field device. A specification for center to field communications should include the following:

- **General NTCIP Requirements**. This section of the specification should cover general information related to the NTCIP such as definitions, references, conformance clause, and property/ownership rights.
- **Functional Requirements / Physical Features**. This section of the specification should cover any physical features of the device and be written in the form of 'shall' statements.
- **Protocol Implementation Conformance Specification (PICS)**. This section of the specification should contain the Protocol Requirements List (PRL) from the NTCIP standard modified to meet the project requirements. Tailoring the PRL for

use in a specification makes it a Protocol Implementation Conformance Specification (PICS).

- **Software and Integration Support**. This section should include any information and assumption made about the behavior or performance of the central software, and what the device vendor's responsibilities are related to software and integration.
- **Testing**. This section should include a discussion of the roles and responsibilities of the agency, manufacturer/vendor, and contractor through the various testing phases: factory acceptance test, visual inspection test, startup tests, stand-alone tests, operational test, and integration test.
- **Example MIB**. Optionally, the agency may desire to include a sample or example MIB, depending on whether the new equipment will need to support the objects defined in an existing MIB.
- **Documentation**. The specification should stipulate that the vendor provide NTCIP and MIB documentation in electronic form.

A partial specification with key portions of the document filled in for a DMS (dynamic message sign) system is included in Appendix B.

5.4.4 Use Case – Developing a Center-To-Center Communications Project

A project is approved to develop an information exchange network between three agencies in the region. The connections to the information exchange network is to be established at the management center for each of the three agencies, located at different locations. Since the connections are all management centers, a review of the proposed interfaces in the regional ITS architecture indicate that all communications fall under the realm of center-to-center communication standards. Several center-to-center communications standards are listed.

To assist in the development of the detailed requirements, a Concept of Operations (ConOps) document is created. The ConOps defines the relationship between the three organizations and also, between the three systems. Or, put in different words, the ConOps describes how the ITS "system" will be used (its operational characteristics) and what transportation problem is being solved through the implementation of the system. It should clearly define the user needs and operational context for the functions that the ITS system will support, using easy-to-use understand terms and with participation from the various stakeholders and users of the ITS System.

From an ITS Standards point of view, the Concept of Operations for Center to Center Communications should include the following:

- **Introduction.** The introduction will contain a general overview of the project elements and physical locations of major centers involved in the project.

- **Candidate Message Set Standards.** This section of the ConOps would include a brief discussion of the candidate message set standards and list of messages. Message set standards that may be considered for center-to-center communications include:
    - **ITS/AASHTO MS/ETMCC.** The Message Set for External Traffic Management Center Communications.
    - **IEEE1512.** The Incident Management Message Set, which includes public safety and emergency management center communications and HAZMAT.
    - **SAE ATIS.** The Advanced Traveler Information Systems Message Set.
    - **APTA TCIP.** The Transit Communications Interface Profiles.
- **Messaging Dialogs.** This section of the ConOps will contain a list of dialogs that fulfill the functional requirements of the center(s) to be specified. . The dialogs will show which input and output messages are related to center system functions. This section would be divided into 2 subsections:
    - Normal Operations and Messages
    - Exception Operations and Messages
- **Monitoring.** The section will outline the behavior of the system during status monitoring, event logging, and diagnostics.
- **Installation/Testing.** This section will outline what testing is required under various times/conditions. For example, during installation, routine maintenance, and failure.

Based on the ConOps, it was determined that several center-to-center standards can supports the requirements for the project. Also, the agencies do not need all the messages that are supported by these standards, thus the project specifications should specify which messages are required by the project. Conversely, there is also a possibility that the ITS standards do not support all the user and functional requirements that have been defined. Thus, an analysis must be performed to select which ITS Standard(s) should be selected and required for this project.

In the case of center-to-center ITS standard, the solutions are usually described in the form of message sets that must be supported by the central systems. A specification for center to center communications should cover the following:

- **General Requirements**. This section of the specification should cover general information related to the standards such as definitions, references, conformance clause(s), and property/ownership rights.

- **Applications Profile for Center to Center Communications**. The specification should state which of the two application profiles for center to center communications the vendor shall provide. The two application profiles are:
  - **NTCIP 2306 (NTCIP C2CXML).** Application Profile for XML in ITS Center to Center Communications.
  - **NTCIP 2304 AP-DATEX.** Application Profile for Data Exchange.

  It is important to note that the Application Profiles cover only message transport and message encoding options. The content of the messages themselves have been developed by the message set standards working groups.

  If neither of the two application profiles is being specified, then the agency should reference: 1) the standards that will be used in message encoding, and 2) the standards that will be used in message transport. [By "standards", the authors mean a document developed by a standards development organization.] Based on discussions and knowledge of projects being developed in New York, the rest of this section will focus on the XML-based standards for center to center communications.

- **NTCIP C2CXML Profile Implementation Conformance Specification (PICS)**. The NTCIP C2CXML standard covers 3 major topics: 1) interface definition, 2) message encoding, and 3) transport for XML. The following describes what elements would be modified in the standards (based on the project requirements) to form a PICS.
  - **Interface Definition.** The NTCIP C2CXML specifies the format of a Web Services Description Language (WSDL) document to describe a systems interface (message inputs and outputs, message encoding mechanism, and transport).
  - **Message Encoding.** The NTCIP C2CXML provides for 2 message encoding mechanisms.
    - SOAP (Simple Object Access Protocol)
    - XML
  - **Message Transport.** The NTCIP C2CXML provides for 3 message transport "bundles":
    - SOAP Encoded Messages over HTTP
    - XML Encoded Messages over HTTP
    - XML Encoded Messages over FTP

- **XML Schemas, Messages, and Data Elements**. The section should reference the message set standard(s) and version that will be used in the project, and contain a list of messages (from the message set) that will be used in the project.

For each message, this section should specify which optional data element will be made mandatory for the project or deleted, and for data elements that may be repeated in the message a number of times, the maximum number of occurrences.

- **Center Interface Definitions**. This section will define the center's interface to external systems including: operations (functions) supported, message inputs and outputs, and message transport. This section of the specification should contain the following:
    - **Message Exchange Diagram.** Optionally, the specification may include graphical depictions of the information exchanges.
    - **Center Interface Definition Worksheet.** This worksheet lists the system interface elements (operations, message encoding, message inputs, message outputs, and transport) in table form. This table provides the information necessary to develop the WSDL.
    - **WSDL.** The formal Web Services Description Language document. This must be provided for a center system to be in conformance with the NTCIP NTCIP C2CXML. The agency may select to include only the System Interface Worksheet in the specification and let the vendors provide the WSDL in their bid.
- **Software and Integration Support**. This section should include any information and assumptions made about the behavior or performance of the central software, and what the device vendor's responsibilities are related to software and integration.
- **Testing**. This section should include a discussion of the roles and responsibilities of the agency, manufacturer/vendor, and contractor through the various testing phases: factory acceptance test, visual inspection test, startup tests, stand-alone tests, operational test, and integration test.
- **Example XML Schemas and Messages**. It may be helpful to provide an example project specific XML Schema and messages that meet the project requirements.
- **Documentation**. The specification should stipulate that the vendor provide XML Schema and WSDL documentation in electronic form.

A partial specification with key portions of the document filled in for center to center communications is included in Appendix C.

5.4.5 Summary

- For each information flow that appear, the NYCSRA indicates what ITS Standards may be applicable for that information flow.
- The use of ITS standards is not currently a federal requirement, but the consideration of any applicable ITS standard is a requirement.
- The use of regional standards should also be consideration.

5.5 Communications Architecture Concepts

Since ITS Standards involve interfaces and information flows, it is important to understand some basic concepts of a communications architecture, which will affect the selection of the appropriate ITS Standards, and assist the design and specification of ITS systems. This section reviews some of the concepts of a communications architecture, but is by no means complete.

Bandwidth considerations – How much bandwidth is needed or required to support the communications needs? Monitoring the status of a simple roadway device may appear to require very little bandwidth, the roadway device operating status is either good or bad. However, it is important to consider what actions are required to remedy the situation if the operating status is poor. For example if a dynamic message sign fails, does the system need to update the entire DMS database, and how long would it take? Some devices always require high bandwidth, even when the device is operating correctly. For example, transferring video images from a CCTV roadway camera is the most obvious example, but another example may be transferring toll transactions from the toll plazas.

Always On Environment – An Always On environment is one where a communications “link” between devices is always available. In this environment, one device can always “communicate” with the other device without interference or delay. Unfortunately, in a communications system with many devices, this type of environment can be prohibitively expensive since this usually requires a dedicated link between the two devices. However, for communications with critical devices, the additional expense may be warranted. Examples of critical devices might include a traffic signal controller and a CCTV camera at a critical intersection, where constant monitoring of the traffic signal controller and the traffic images from that CCTV camera are needed.

An alternative to an “Always On” environment is multiplexing. In a multiplexing environment, multiple devices are placed on the same communications channel, eliminating the need for direct communications lines with every device. A “window” for communicating with each device is available on that communications channel at regular, fixed intervals. Thus, a central system may allot 5 seconds to communicate with Device 1, during which time it cannot communicate with any other device on that communications channel. Then, during the next 5 seconds, it will communicate with

Device 2, then Device 3, etc., before communicating with Device 1 again. In a multiplexing environment, the capital costs may be much lower than the always-on environment. For example, ITS devices such as dynamic message sign, which do not require constant monitoring are polled at regular intervals for operational status.

A “dial-up” is a form of multiplexing. In a dial-up IThe device can also be “dialed-up” when the operation of the device needs to be changed (e.g., a new message). With dialup, the operational costs for the communications service is much lower than the always-on environment.

Initiating Information Exchanges - “Push versus pull” – How will the information be transferred between the systems? Will System A send the information to System B (“push”), or will System B request the information from System A (“pull”)? In a “push” condition, System A will determine when to send the information to System B, generally when agreed upon conditions are met, such as set intervals (e.g., every 5 minutes), or alarm conditions (e.g., when an incident is detected). When System A sends out the information, it may or may not confirm that System B received the information. In a “pull” condition, System B determines when to request the information from System A. System A will generally have the information available for System B at all times, however, System B will request the information from System A when agreed upon conditions are met. These conditions may be at set intervals or when System B needs the information.

Request/Reply (Polling) – Periodic versus event-driven – When should information be exchanged between two interfaces? Usually, that is determined by the type of information is being exchanged and if the information is critical. For example, the exchange of normal traffic information can be periodic, meaning they occur at regular fixed intervals. The intervals between when the information is exchanged will depend on the type of information. If the data is used to maintain control of critical equipment for safety reasons, such as traffic signals, the interval may be very short, such as once every second. For exchanging archive data, such as passenger or traffic counts for planning purposes, once every 24 hours may be sufficient. On the other hand, the transfer of data may be event-driven, that is, the information is sent only when pre-determined conditions are met. This may be an alarm condition, a fault condition, or upon the detection of a traffic or transit incident. It is also possible that both methods are used. Status information from equipment may occur on a regular interval, unless an alarm condition is detected, when the status information is sent immediately with an alarm flag.

Fire and Forget (Broadcast) – This concept is when information is “pushed” to another system. The question is does the sender expect a confirmation that the receiver has actually received the information. For critical systems, which depend on receiving every bit of information, and possibly in order, it may be desirable for a receiver to send a confirmation to the information sender that it has properly received the information. The sender may handle confirmations, or non-confirmations, differently. If it does not receive confirmation, it may wish to resend that piece of information constantly until a confirmation is finally received, or it may continue to resend that piece of information for a fixed period of time, before sending the next piece of information.

For non-critical systems, or for systems where precise timing is important (e.g., real-time video monitoring), the sender can send the information and hope that the information gets there without verification (“send and forget”).

6 Use Plan in Institutional Agreements

6.1 Introduction

One of the clearest benefits of ITS is the ability to support information sharing between ITS systems, agencies, and stakeholders for mutual benefit. A regional ITS architecture provides the framework for analyzing how ITS elements are related and thereby, identify the areas for potential cooperation. Since opportunities for system integration and operational coordination extend beyond jurisdictional boundaries, development of a regional ITS architecture can serve to promote both system and inter-jurisdictional integration.

Integrating ITS across jurisdictional boundaries to provide transportation services requires agencies to share a common set of goals and perspectives on the purpose of implementing integrated ITS. Once those goals and perspectives are identified, data flows are identified between the agencies and systems in support of those goals and to provide the transportation services required. However, when sharing information between different agencies or systems are necessary, agreements or some sort of understanding between the participating agencies and systems is necessary before the information sharing can take place. Agreements may also include discussions on operational concepts when providing these transportation services which involve multiple jurisdictions.

The discussion in this section concentrates on the different forms of agreements or understanding required between agencies and other stakeholders to support the integration of ITS elements in the region to provide transportation services. The section discusses how the regional ITS architecture is used to determine the details of the agreements, including:

- Areas where agreements are needed
- Levels of detail required in the agreements, including operational concepts and the use of ITS Standards
- Roles and responsibilities of the respective agencies and stakeholders

Although FHWA Rule 940 and the FTA National ITS Architecture Policy do not explicitly require the development of agreements between agencies, these agreements are implicitly required to support the ultimate goals and objectives of this Rule and Policy.

6.2 Identification of Agreements

The regional ITS architecture identifies areas where cooperation between different agencies, ITS systems and stakeholders are needed to provide transportation services for a region. To provide these transportation services, agreements are generally needed between these stakeholders.

Unfortunately, it may require a long period of time, sometimes years, from the time the need for an agreement is identified to the time the agreement is executed. It takes time for agencies to agree on what information should be included in the agreement, develop the contract, agree on the language and to execute the agreement. Thus, one of the benefits of the regional ITS architecture is to indicate early on where agreements may be needed to support the integration of ITS systems. Once a need for some type of agreement is identified between stakeholders, the stakeholders should begin drafting the basic principles of an agreement. The different types of agreements and the level of detail needed is discussed later, but by agreeing the basic principles of an agreement early on, it will save significant time once the integration of systems begin and a formal agreement is needed.

A documented agreement also will aid agencies in planning their operational costs, understanding their respective roles and responsibilities, and build trust for future projects. Formal agreements also are necessary where funding or financial arrangements are defined or participation in large regionally significant projects is required.

There are three areas of a regional ITS architecture that an agency can look at to determine where agreements may be needed, both now and in the future.

- Interconnects
- Market packages
- Systems (ITS Elements)

Each area is discussed in further detail below.

6.2.1 Interconnects

Each interconnect between systems identified in a regional ITS architecture represents cooperation between the owners of those systems. The owner of a system may be an agency itself, or different departments or divisions within an agency. The owner of a system may also be a company in the private sector.

Each interconnect represents a potential requirement for an agreement between each owner. The agreement involves the owner of one system agreeing to provide the owner of the other system with the information described in the regional ITS architecture; and the owner of the other system agreeing to accept the information. This information can be directly derived from the regional ITS architecture. The details of the data to be exchanged, which includes the conditions when the data will be exchanged, the communications protocol, the data format and the allowable uses, should also be included in the agreement.

Although a regional ITS architecture may have hundreds of interconnects between owners, a separate agreement may not be required for each interconnect. A single agreement between two owners, which includes all the relevant flows between those owners in the regional ITS architecture, may suffice.

6.2.2 Market Package

Each market package is also a potential area for an agreement. Each market package indicates the data flows and the cooperation needed between the stakeholders required to provide a transportation service. As opposed to the interconnects, which focuses on the exchange of data between two stakeholders or owners, the market package provides a more general overview of the transportation service, bringing to focus the operational concepts, and the policies required to support the transportation service desired for the region.

Some examples of agreements that can be derived from market packages identified from the regional ITS architecture include:

- Operational Concept - Regional Coordination during Incidents and Emergencies (ATMS08 – Incident Management System, EM2 – Emergency Routing)
- Policy for Sharing Video Images (ATMS07 – Regional Traffic Control)
- Policy for Sharing Transportation Data (AD2 – ITS Data Warehouse)
- Agreement on Transit Coordination (APTS7 – Multi-modal Coordination)
- Agreement for a Regional 511 System (ATIS1 – Broadcast Traveler Information)
- Memorandum of Understanding for Sharing ITS Infrastructure and the Coordination of Maintenance and Construction Activities (MC10 – Maintenance and Construction Activity Coordination)
- Agreement for the Coordination of HAZMAT Response (CVO10 – HAZMAT Management)

6.2.3 ITS Elements

A review of existing and planned ITS Elements (systems) in the region can lead to the identification of potential synergies between stakeholders. The identification of these synergies can lead to potential cost savings for the region and the agency. Jurisdictional boundaries are generally one of the major barriers to the development of a seamless transportation network.

For example, Agency A may decide to deploy dynamic message signs to inform travelers of construction work on its facilities. However, the most advantageous location to deploy these dynamic message signs will be on the approaches towards the construction area, which may be in Agency B's jurisdiction. Deploying the dynamic message signs once the traveler is on the Agency A's jurisdiction may be of no value to the traveler, there may no alternate routes available to the traveler. However, if this conundrum is identified early, there may be an agreement between Agency A and Agency B to allow Agency A to deploy dynamic message signs on Agency's B right-of-way, or for Agency B to procure the dynamic message signs and deploy the signs at locations which will benefit Agency A and regional travelers.

Another example of potential synergy is if multiple agencies are planning to deploy similar ITS systems. Transit Agency A and Transit Agency B may both identify the need for Automated Vehicle Location (AVL) systems for their transit vehicles. The two transit agencies may agree to have one of the agencies procure the AVL system for both agencies. This approach may result in immediate cost savings in procuring the systems, and future cost savings for regional coordination and maintenance costs.

Agencies should also review what agreements currently exist that supports the sharing of information, funding or specific ITS projects. These existing agreements can be used as a basis for future agreements, or be amended to support new requirements or areas of cooperation between the stakeholders, as identified in the regional ITS architecture.

6.2.4 Next Steps

From the previous steps, an agency and stakeholder can compile a list of potential agreements that may be needed to support the integration of ITS systems in the region. Each entry should minimally identify the stakeholders involved, a detailed, concise description of the purpose of the agreement, and a priority for executing the agreement. The priority of the market package that the agreement is based on, the project sequencing identified by the regional ITS architecture, and the TIP for the region are good starting points for determining the priority for developing agreements.

Other information that may be described for each entry includes a draft agreement title, the type of agreement that is anticipated, and an identification of what ITS standards are being considered for the interface(s).

Referencing the market package, the functional requirements, and the projects as defined by the regional ITS architecture is also helpful. The exact nature of the reference to the regional ITS architecture is highly dependent on the nature and scope of the agreement, but this reference will help identify the services and requirements to be provided by the agreement and serve as a guide to ensure that the agreement is of sufficient detail to be complete and avoid any vagueness that may come up.

6.2.5 Summary

There are three areas of a regional ITS architecture that an agency can look at to determine where agreements may be needed, both now and in the future.

- Interconnects
- Market packages
- Systems (ITS Elements)

6.3 Agreement Details

Once the need for a potential agreement is identified, the next step is to determine the type of agreement needed and the level of detail required for the agreement. The level of formality and detail of each agreement between owners will vary according to several factors, including the importance and sensitivity of the information, prior agreements, and the working relationship between the two owners. Other factors may include the institutional structure of the owners, the attitudes of the agency at the executive level and what types of contracts each agency is familiar with.

These factors also affect the number of agreements between the two owners. In some cases, multiple agreements may be necessary to address different needs or types of data exchanges (information data, data requests, device control, etc…). Agreements may already exist between the owners that can be extended and used to support the cooperative implementation and operation of ITS systems in the region.

6.3.1 Types of Agreements

The owners or operators of the systems that will be integrated should determine the types of agreements that are needed. Most organizations have a legal department or contracts division that already has approved operational agreements, funding agreements, etc. When possible, try to use an approved process to reduce the time needed to develop, review, and execute agreements. If not, perhaps a handshake agreement or a simple Memorandum of Understanding (MOU) will suffice in the interim.

There is considerable variation between regions and among stakeholders regarding the types of agreements that are created to support ITS integration. Some common types of agreements include:

- Memorandum of Understanding – An agreement between two or more entities demonstrating a general consensus towards a common, stated goal. The agreement may be broad in scope and with minimal detail.
- Operational Agreement – An agreement between two or more operating agencies regarding funding, operating, maintaining or using the right-of-way of one of the public or private agency. Identifies respective responsibilities for all activities associated with shared systems being operated and/or maintained.
- Funding Agreement - Documents the funding arrangements for ITS projects (and other projects). Includes at a minimum standard funding clauses, detailed scope, services to be performed, detailed project budgets, etc.

6.3.2 Details of an Agreement

Information that goes into an agreement can be categorized into four sections. The level of detail for each area can vary, depending on the purpose of the agreement and if the information is available:

The four sections are:

- Operational Concept
- Roles and Responsibilities
- Interfaces
- Technology

The operational concept section defines the conditions for which the agreement is valid for. For operational agreements, this section may include the conditions when coordination between the stakeholders is “activated” or in effect, such as regional emergencies. If applicable, it should also reference any other agreements, such as agreements on emergency plans. This section should include the transportation services to be provided and shared by the stakeholders.

The roles and responsibilities section defines the functions of the stakeholders during the conditions as described in the operational concept section. This section should detail the specific agency responsibilities for various components of the transportation service to be provided. This section also may include the liaisons for each stakeholder and their responsibilities. Other information in this section may include the conditions the information is exchanged, the allowable uses of the information.

The interfaces section describes the nature of the information to be exchanged. Minimally, this section should describe the high-level information that each agency needs to exchange in order to meet the goals and expectations of the other rather than defining how the delivery of that information will occur. If ITS standards are to be used, this section should state the standards.

Stakeholders may prefer that the description of the interface in the agreement be detailed to avoid vagueness or any misunderstanding. This detail may include the exact data elements, the allowable formats, and the communications protocol. However, this information may be better suited in an appendix section of the agreement, as opposed to the main body of the document.

In the technology section, it is generally recommended to avoid being too specific regarding the technology to be used. Technology changes very rapidly and specifying the exact technology may limit the flexibility of a design if the agreement is for a design project, or may require numerous changes over the life of the agreement for other types of agreements, such as operational agreements. There are times when it is necessary to provide detailed descriptions of the technology, such as for funding agreements or for projects that require interagency cooperation. Examples of interagency cooperation includes joint procurements of regional traveler payment cards, support for legacy systems, or where a region has already made significant investments in a technology.

6.3.3 Use Case – Transportation Archive Data Policy

A regional ITS architecture has identified the need for a regional transportation archive data to collect, store, and distribute transportation data collected by multiple transportation agencies in the region. State Department of Transportation B, City Department of Transportation C, and Highway Agency D, each maintain its own traffic and roadside archive data but will provide that archive data to the regional transportation archive. Transit Agencies E and F each maintain its own transit archive data, but also will provide that archive data to the regional transportation archive. Each agency's own data archive supports the internal needs of its own agency.

However, each agency also recognizes the need and value of sharing their archive with the other agencies, and having access to other agencies' archives. Other agencies may have traffic or transit data that supplements an agency's own data for planning and operational purposes. Some benefits of establishing a regional transportation archive include reduced data collection costs, faster and easier access to other transportation archive data, reduced costs for operating and maintaining different methods of access and archive data sharing with multiple agencies.

In the regional ITS architecture, the need for this transportation service is reflected by market package AD-2, ITS Data Warehouse. The transportation service includes the following data flows:

- Archive requests
- Archive status
- Traffic archive data
- Roadside archive data
- Transit archive data

Regional Transportation Planning Agency A offers to be the "owner" of the regional transportation archive, and thus, the "customized" market package in the regional ITS architecture reflects "ownership" by Regional Transportation Planning Agency A.

After approval of the regional ITS architecture, Regional Transportation Planning Agency A, State DOT B, City DOT C, Highway Agency D, Transit Agency E, and Transit Agency F come together and agree to develop a Transportation Archive Data Policy for the region. Although no funds have been allocated to develop and maintain the regional transportation archive, some of the agencies are planning to upgrade their own archives. The agencies agree to develop a policy to coordinate the development of the individual archives so the individual archives can be merged at a future date to form the regional transportation archive.

The agencies agreed that the draft Policy will include the following:

- Establish a policy working group to identify what archive data will be shared between each agency, including the allowable uses of that archive data. Archive data may be sensitive in certain formats and agencies may wish to restrict how shared archive data is used or shown. For example, the working group may determine that each traffic agency will share its traffic counts with other traffic agencies and use the information as the agency sees fit, but the vehicle classification data may not be shared with the general public without the expressed written permission of the originating agency.

- Establish a technical working group to identify standards and protocols that will support the functional requirements and needs of the regional transportation archive. If no national standards and protocols are available to support those requirements or needs, the working group will be responsible for establishing a regional standard and/or protocol. These standards and protocols include the communications protocol for accessing the archive and transmitting the archive data, the data format and the structure of the data dictionary. Establish the rules for which the agency is to provide its archive data to the regional transportation archive, including when, how often (i.e., how often is the archive data updated), and in what manner (push/pull).
- Determine which agency is responsible for implementing the regional transportation archive, and agree on the responsibility of Regional Transportation Planning Agency A for operating and maintaining the regional transportation archive, including monitoring the integrity of the transportation data and performing backups. Also agree on the responsibility of the other agencies for ensuring that the archive data is available and providing resources (i.e., funding) to Regional Transportation Planning Agency A to support the regional transportation archive.

Some of the early functional requirements and needs determined by the region include:

- The (regional transportation) archive shall collect archive data from the agencies and archive databases identified.
- The archive shall support the creation of user groups. Each user group shall have access only to those archives and information agreed upon.
- The archive shall provide on-line analysis and data mining capabilities.
- City DOT C already established a data dictionary structure, with input from State DOT B and Highway Agency D. It was agreed by the technical working group to use this data dictionary structure for the regional transportation archive. For any new data elements not already identified, national standards shall be used.

6.3.4 Summary

Agreements may be necessary to support the exchange of information between agencies. Agreements may be formal in nature, or informal. Information to be included in an agreement should include:

- Operational Concepts
- Roles and Responsibilities
- Interfaces
- Technology

Appendix A – Example Concept of Operations - DMS

Introduction

The document is a Concept of Operations for the Dynamic Message Sign (DMS) to be installed as part of Freeway Expansion Project.

The intent of this document is to present:

- the functions and capabilities available by the DMS to be procured by this project
- a discussion on how the DMS is envisioned to be controlled and monitored from the ATMS software, and
- the functions and capabilities accessible from the manufacturer-provided software

The document describes the behavior of the DMS under the various modes and conditions that the signs may experience. This concepts described in this document will be used to develop the Technical Specification for the DMS, to define the objects and ranges for the NTCIP standard, and to determine the test procedures for the DMS.

Variables that can be changed are provided in *italics*. These variables were selected based on the consultant's understanding from the Standards workshop conducted on *MM/DD/YYYY,* or are the consultant's recommendation. These values can be changed prior to completion of the Technical Specification. Variables are that require further discussion or a decision by the agency(ies) are in ***bold italics***. When reviewing this Concept of Operations, ASSUME that if the capability is NOT explicitly mentioned in this document, that the feature is not a requirement.

Physical Features

Type of Sign

The Dynamic Message Sign for this project will be a *line matrix sign*, capable of displaying *3* lines of *460-mm* (18-inch) character text. Each line is a minimum of *7 pixels* high and *165* pixels wide. The horizontal pitch between pixels shall be *2.6* ± *.15* mm, and the vertical pitch between pixels shall be at *2.6* ±*.15* mm.

The DMS will be *x* ± *y* mm high by *x* ± *y* mm in width, with borders at least *1 foot* high and *1 foot* wide.

The address of the DMS will be assigned by the ATMS system manager.

The DMS will be a walk-in sign. It shall be possible for a maintainer to perform all maintenance on the sign, such as replacement of LEDs, display boards, environmental controls, etc…, within the walk-in enclosure.

LEDs

The DMS will be a single color sign, *amber*, with a peak wavelength of *590* mm ± *2* mm. All LEDs shall have a viewing angle of at least *23*˚ from the center axis or greater on the horizontal axis, but no greater than *30*˚.

Communications Port
The DMS sign has 2 communications port, one labeled *CENTRAL* port and one labeled *LAPTOP* port. The CENTRAL port is *a **9-pin, RS-232 serial*** port. The LAPTOP port is a ***9-pin, RS-232*** port.

Fonts
All fonts for the DMS will be *single stroke* fonts, and *5x7* characters. Two permanent fonts will be provided with the DMS, a Standard font, as defined in Section 5.6 in the draft NEMA Standards Publication TS 4-2004, Draft –V1.30b, dated February 9. 2004; and another font, to be supplied by AGENCY. The DMS is capable of supporting two additional downloadable fonts. These fonts can be created and downloaded to the DMS through the manufacturer-provided software. The *default* font will be the font supplied by the AGENCY.

Brightness
The DMS sign contains 3 photosensors to determine ambient lighting around the DMS sign. The photosensors will be used to automatically set the brightness of the LEDs on the face of the DMS sign. The histeresis (algorithm) for determining the brightness values will be provided by the manufacturer and can be adjusted if necessary.

Other
This DMS does not support the following:

- External beacons – beacons which flash to get a traveler's attention for critical messages
- Auxiliary (external) devices – outputs to control other devices, such as gates
- External triggers – inputs from other external devices to trigger a message (e.g., radar speed detector).
- Scheduling messages

Normal Operations

Default Messages

Several default messages will be stored on the DMS Controller. These messages will be stored in non-volatile memory. These default messages can be changed using the manufacturer-provided software.

Sign Display Behavior After Bootup
When the DMS is first powered on, the DMS face shall remain blank during the power-up and boot-up cycle. Once the boot-up cycle is complete, the DMS will display a default message until a message is commanded.

The default message to be displayed can be a blank message, a specific defined message, or the last message commanded before the DMS was shut down. Note that a different default message may be displayed if the DMS controller was shut down due to a controller software reset command or a momentary power loss (see below). The duration of time which constitutes a momentary power loss is user-defined.

The default message to be displayed after a DMS Bootup is currently a ***blank*** message.

Sign Display After a Momentary Power Loss
If the elapsed time is less than the defined time duration, for example, one second, the DMS can be configured to display a default message. The default message to be displayed can be a blank message, a specific defined message, or the last message commanded before the DMS momentarily lost power.

The current default message to be displayed after a Momentary Power Loss shall remain the ***current*** message, and the defined time duration shall be ***1 second***. The assumption is that if the DMS momentarily loses electrical power for less than 1 second, the message should not change from what is currently displayed before the momentary power loss.

Sign Display Behavior During Communications Loss
This parameter defines what message should be displayed on the DMS if the DMS controller has not received a valid poll from any source for a defined time period. The message to be displayed can be a blank message, the current message, or a specific defined message. This parameter does not apply if the DMS is in Local Mode.

A determinant of the defined time period will be how often the ATMS software polls the DMS. If the polling period is one hour (dialup modem), the defined time period should be longer than 1 hour, say, 121 minutes (2 hours, or 2 polling periods, + 1 minute). If the polling period is 15 minutes (direct-connect), the defined time period may be 46 minutes (45 minutes, or 3 polling periods, + 1 minute).

Assuming a ***direct connection***, the DMS will be set to display ***a blank message*** is no valid communications with the AGENCY STATEWIDE TOC is detected within ***46 minutes***. Once valid communications is received, the DMS will display the same message (in this case, the ***blank message)*** until a new message is commanded.

Sign Display After End Duration
Messages on the DMS can be activated for a fixed duration, either from a scheduler or manually (e.g., Display Message X for 30 minutes). If a message ends, and no other message has been assigned to replace the message, the DMS will display ***a blank message***. The DMS will continue to display this message until a valid message is commanded.

Sign Display After Controller Reset
If the controller is reset (software), the DMS can be set to display a specific message after the reset. *This parameter is optional* and assumes that the DMS controller can differentiate between a power loss and controller reset. The default message to be

displayed can be a blank message, a specific defined message, the last message commanded before the DMS was reset. The current default message to be displayed after a Controller Reset should be a ***blank message***. The DMS will continue to display this message until a valid message is commanded.

ATMS Software

Under normal conditions, the DMS will be monitored and controlled from the AGENCY Operations Center, using the ATMS software.

The ATMS software provides the following functions:

- polls the DMS for operational status (errors) and checks the current message on a periodic basis (currently once per hour)
- selects a message to display from the center's library on the DMS based on current traffic conditions and incidents (subject to operator approval)
- once a message has been selected for display, the software downloads the message to the DMS and activates the message.

Polling

The ATMS software polls each DMS on a periodic basis for operational status and verifies the message currently displayed. The periodic basis is adjustable (by communications channel) and is currently set for once per hour. The one-hour period was selected because the communications media for a majority of the DMSs operated and monitored by AGENCY is on dial-up telephone lines. For DMSs that uses direct-connect serial lines for communications, such as optical fiber, a shorter polling period may be programmed, such as 15 minutes.

The ATMS software will poll each DMS for operational status, such as pixel failures, photocell failures, message failures, fan failures, module failures and communications failures. Certain types of failures are deemed to be severe, such as module failures and communication failures. If a severe failure is detected, the GUI will turn that DMS icon red.

The ATMS software cannot diagnose the severity, number, or exact location of any failure. For example, the ATMS software will note a pixel failure in its event logs, but cannot determine how many pixels or which pixels have failed.

The ATMS software will also verify the message being displayed. If the message currently displayed on the DMS does not match what the ATMS software believes it should be, the GUI will turn that DMS icon red.

Selecting Messages

The ATMS software suggests a message for display on each DMS from its central library based on current traffic conditions and any detected incidents. Operators must approve the suggested message before the command to display that message is sent to the DMS. Operators may also manually select a message from the central library to display on a DMS. The ATMS software assigns priorities to operators, so messages sent by an operator with a higher priority will "override" messages commanded by an operator with a lower priority.

The ATMS software provides tools for adding and editing messages in the central library. Users may create new messages that are to be displayed on the sign from the workstation. Messages may be text only and will support the basic ASCII character set (ASCII 30-126, inclusive), which includes all the characters on the full keyboard set. All messages are checked by the ATMS software for allowable words and that the message will fit on the DMS display (e.g., a 21-character line message on a DMS display that can only fit 20 characters per line).

Only one font is currently available for each DMS. The ATMS software can support multiple fonts for a DMS, but requires configuring the software.

The ATMS software currently limits all messages to two phases, but the limit can be adjusted. Each phase can be programmed with a different page duration (amount of time the phase appears before displaying the next phase). Each phase will be displayed for the user-defined duration before the next phase is displayed. Once all the phase has been displayed, phase 1 will be displayed again. The default page duration is ***2.0 seconds.***

The ATMS software also defaults all messages to be center justified, both horizontal (left, center, right justify) and vertical (top, center, bottom).

Activate Messages
Upon an operator commanding a message to be displayed on a DMS, the ATMS software will download the message to the DMS controller, followed by a command to activate that message. The ATMS software downloads every commanded message to the exact same message table slot in the DMS controller and with the same priority. No other messages other than the commanded message are downloaded to the DMS controller. Thus, the "old" commanded message is always overwritten with the "new" commanded message.

Exception Operations

ATMS Software
Normally, the DMS will be monitored and controlled from the ATMS software at the AGENCY STATEWIDE TOC. On occasion, situations may occur that requires control of the DMS be transferred to some other party or software. These situations may include:

- For maintenance purposes – use of the manufacturer-provided software at the AGENCY STATEWIDE TOC or a laptop at DMS controller
- For emergency use, such as communications loss from AGENCY STATEWIDE TOC – use of the manufacturer-provided software at some other location, e.g., AGENCY, and through a dialup modem

It is expected that when control of the DMS is transferred from the ATMS software at the AGENCY STATEWIDE TOC to some other party or software, that proper operating procedures will be followed. This includes properly informing the AGENCY STATEWIDE TOC that the transfer of control is about to take effect, and when transfer of control is to be returned.

Control Modes

The DMS has three (3) modes of operation, Central, Local and Central Override. The mode of operation determines the source that the sign will accept commands from.

Central Mode

In Central mode, the DMS sign will display only those messages that originate through the CENTRAL communications port at the DMS controller. Commands through the CENTRAL communications port will normally be from the ATMS software. However, it may also originate from the manufacturer-supplied software installed at the AGENCY STATEWIDE TOC. The DMS will normally operate in Central mode.

Local Mode

In Local mode, the DMS will display only those messages that are commanded through the LAPTOP communications port at the DMS controller. For maintenance purposes, the LAPTOP port may instead be connected to a laptop computer for monitoring, testing or maintenance purposes.

With the manufacturer-supplied software through the LAPTOP port, the laptop computer or AGENCY can perform diagnostics and monitor the operations of the DMS while the DMS is still in Central Mode.

However, the laptop computer or AGENCY can command the DMS into Local Mode, therefore taking control of the DMS, including commanding new messages and locking out control of the DMS from the AGENCY STATEWIDE TOC. This may be beneficial for testing the DMS on-site, if communications with the AGENCY STATEWIDE TOC is lost, or if the local user is aware of a field condition that may be temporary or the TMC is unaware of.

Central Override Mode

When a DMS is in Local mode, whether via a dialup modem or a local user, the user will normally release control of the DMS back to Central mode either by operating a switch or button at the DMS Controller, or by sending a command from the manufacturer-provided software. **While the DMS is in Local Mode, the Central (TMC) cannot control the DMS Sign!** The computer controlling the DMS via the LAPTOP port **MUST** release the computer back to Central Mode.

Unfortunately, the user may forget to release the sign from Local Mode when their work is complete. Thus, it may be necessary to send a Central Override command from the ATMS software or the manufacturer-provided software at the AGENCY STATEWIDE TOC. The DMS will then transition from Local Mode, temporarily to Central Override

Mode, then back to Central Mode. (Note: verify that the ATMS software supports Central Override).

Monitoring

Monitoring Status

Regardless of which control mode the DMS sign is in, any computer connected to the CENTRAL communications port or the LAPTOP communications port, will be able to monitor the status of the DMS, whether using the ATMS software, or the manufacturer-provided software.

Monitoring the status of the DMS includes determining what message is currently displayed, and the source of the message. Monitoring also includes reporting error status of the DMS sign. Errors reported include communications error, power error, photocell error, pixel error, message error, and controller error.

Event History

The DMS controller maintains an event history file. The event history file contains entries to indicate dates and times of any events or failures that occur. These events and failures include communications loss, sign doors opening, changes (and source) in the sign display. The Event History file can maintain a minimum of 256 entries. The Event History can be accessed using the manufacturer-provided software.

Diagnostics

There are several diagnostics and monitoring tools that will be provided with the DMS sign and can be accessed with the manufacturer-provided software. Diagnostic tools include:

- Specifically indicate what pixels are working and what pixels are not. Pixel testing of each pixel can also be commanded using the manufacturer-provided software. *Note: pixel exercises or pixel testing can be scheduled on a daily basis, but will require the scheduler functions*
- Controller resets (soft). This command will only restart the operating system and controller software.
- *Manually control brightness* of the DMS or to change the histeresis (algorithm for determining brightness based on the photocells).
- Fan tests

Monitoring tools include determining the temperature (control cabinet, sign housing, ambient temperature), and the status of the power supplies, communications, fans, photocells, and other equipment at the sign.

Installation/Testing

Testing

Upon the installation of the DMS, the functionality of the DMS will be exercised locally at the DMS control cabinet. This demonstration and exercising of the DMS locally will be called the Startup Tests. The purpose of the Startup Test is to demonstrate that the basic capabilities of the DMS are functioning properly (LEDs, climate controls, uploading/downloading), and that the proper default values have been properly set up (fonts, default messages, device address). A laptop computer will be connected to the DMS's LAPTOP port. Basic control and monitoring of the DMS will be demonstrated using the DMS manufacturer-supplied software, which will be loaded on the laptop computer.

Upon satisfactory completion of the Startup tests, the functionality of the DMS will be exercised at the local workstation provided by the manufacturer, using the manufacturer-supplied software; and using the ATMS software. This demonstration and exercising of the DMS from the AGENCY STATEWIDE TOC will be called the Operational Tests. The purpose of the Operational Test is to demonstrate proper monitoring, control, and exercising of all the DMS's functionality, as required in the Technical Specifications. The Operational Test will be a 60-day test, 30-days of which will be using the manufacturer-supplied software and 30-days using the ATMS software. *Note: we are assuming that the initial and final location of the workstation will be at AGENCY.*

Upon satisfactory completion of the initial 30-day Operational Test using the manufacturer-supplied software, the monitoring and control of the DMS will be transferred from the local workstation to the ATMS software. The transfer and verification of monitoring and control of the DMS using the ATMS software will be called the Integration Tests. The Integration Test will be performed by the AGENCY and other contractors, however, a qualified representative of the DMS manufacturer will be present to assist the AGENCY and its contractors on any issues that may occur during the integration test.

Workstation

Under the project, a workstation will be supplied with the DMS manufacturer's software to allow users to monitor the status of and control the signs on the facility. The purpose of the workstation is to test the DMS upon initial installation of the DMS sign, and to serve as a backup in the event of a failure of the main ATMS software.

Each workstation will be provided with a *Microsoft Windows 2000* or *Microsoft Windows XP* operating system, and an archival media, such as a *CD-ROM burner* or *tape backup* for storing log files and event messages. *An Uninterruptible Power Supply* will be provided with each workstation to protect the workstation in the event of a power failure for at least *15* minutes. *A laser printer* will be provided with each workstation to allow printing of reports and logs.

A *technician's laptop computer* will be provided with the sign. The technician's laptop computer will be used to maintain or control the DMS sign at the DMS cabinet for maintenance purposes or in the event there is no communications between the traffic management center and the DMS sign. The technician's laptop computer shall be environmentally hardened. The laptop computer shall be provided with the manufacturer's software, *Microsoft Windows* operating system, and the necessary cables to connect to the DMS sign's laptop *RS-232* port.

Appendix B – Example DMS Specification

This portion of the specification defines the functional requirements and the detailed NTCIP requirements for the Dynamic Message Sign.

General NTCIP Requirements

Definitions

The following terms shall apply within the scope of this procurement specifications.

Full, Standardized Object Range – Support for, and proper implementation of, all valid values of an object as defined within the object's OBJECT-TYPE macro in the subject NTCIP standard.

Management System – A management system used to control a DMS. This includes any laptop software used for field control as well as the central control software.

Dynamic Message Sign System – A Dynamic Message Sign, including the sign housing, the DMS controller, and the Management System.

References

The Dynamic Message Sign (DMS) System shall use NTCIP as its means of communications. The implementation of NTCIP for this DMS System shall conform to the following standards and versions:

- NTCIP 1201 – Global Objects Definition – NTCIP 1201:1996, version 01.10, including Amendment 1.
- NTCIP 1203 – Object Definitions for DMS – Version 1, with Amendment 1
- NTCIP 2101 - Point-to-Multi-Point Protocol over RS–232 Subnetwork Profile (SP-PMPP) – Version 2101:2001, dated November 26, 2001.
- NTCIP 2201 – NTCIP TP - Transportation Transport Profile (formerly TP-Null)
- NTCIP 2202 – NTCIP TP - Internet (TCP/IP and UDP/IP) Transport Profile (formerly TP-INTERNET)
- NTCIP 2301- Simple Transportation Management Framework (STMF) Application Profile

Conformance

To claim conformance with the above referenced standards, the implementation of NTCIP for the DMS System shall satisfy the mandatory requirements and objects as identified in the referenced standards.

Optional objects and requirements in the referenced standard(s) needed to satisfy a functional requirement in the Technical Specification, shall be conformant with the appropriate standard, and any standards it references (e.g., NTCIP 1201 and 1203).

Property Rights

If additional objects beyond the referenced standards are needed to support functionality required by this specification, the vendor shall inform the AGENCY, in writing and before factory acceptance testing, and clearly document the proposed object(s) including how the object is used, and all variables. The AGENCY must approval, in writing, each proposed additional object(s) prior to the Factory Acceptance Test. For any additional object(s) approved by the AGENCY, the AGENCY and its authorized parties shall have unlimited use of the object and all related documentation, at the time initially or in the future. This use of these objects and documentation shall extend to any systems integration purposes, regardless of what parties are involved.

Physical and Functional Requirements

Type of Sign

The Dynamic Message Sign shall be capable of displaying 3 lines of *460-mm* (18-inch) character text, and shall use LED technology. Each line shall be capable of displaying a minimum of 21 characters, 5-pixels wide per character, with 3 pixel spacing between characters.

The DMS will be a walk-in sign. It shall be possible for a maintainer to perform all maintenance on the sign, such as replacement of LEDs, display boards, environmental controls, etc…, within the walk-in enclosure.

LEDs

The DMS will be a single color sign, *amber*, with a peak wavelength of *590* mm ± *2* mm. All LEDs shall have a viewing angle of at least *23*˚ from the center axis or greater on the horizontal axis, but no greater than *30*˚. All LEDs shall have a half-angle of ±*y*˚ from the center axis or greater on the vertical axis. The currents through an LED shall be limited to the manufacturer’s recommendation under any condition.

Communications Ports

The DMS shall have a minimum of 2 ports for communications at the DMS controller.

One communications port shall be a serial EIA-232C port, labeled *CENTRAL,* and shall have a DB-9 connector configured as a DCE for communications with the AGENCY STATEWIDE TOC. It is the intent of the AGENCY to install an optical fiber network from the DMS for communications to the AGENCY STATEWIDE TOC.

A second communications port shall be a serial EIA-232C port, labeled *LAPTOP,* and shall have a DB-9 connector configured for communications with a portable maintenance computer, or to a dialup telephone modem.

Both communications port shall be capable NTCIP 2103 over a null-modem connection. Each port shall be able to communicate at the NTCIP 2103 mandatory bit rates as well as the optional bit rates of 28800, 38400, 57600, and 115200 bps. Each port shall minimally support NTCIP 2101 bit rates of 1200, 2400, 4800, and 9600 bps.

The physical layer shall conform to the EIA 232 interface defined in NEMA 3.2.1.1 and support the following command sets:

- Hayes AT - command set
- MNP5
- MNP10
- V.42bis

Fonts

All fonts for the DMS will be single stroke fonts, and 5x7 characters. Two permanent fonts will be provided with the DMS.

Font 1 shall a font to be supplied by the AGENCY. This shall be the default font.

Font 2 shall be a Standard font, as defined in Section 5.6 in the draft NEMA Standards Publication TS 4-2004, Draft –V1.30b, dated February 9. 2004.

The DMS shall be capable of supporting two additional downloadable fonts. These fonts can be created and downloaded to the DMS through the manufacturer-provided software.

Photosensors

The DMS sign contains 3 photosensors to measure ambient lighting around the DMS sign. The DMS controller will utilize stored tables or curves combine the readings into a single ‘suggested light level’. The photosensors will be used to automatically set the brightness of the LEDs on the face of the DMS sign. The histeresis for determining the brightness values will be documented by the manufacturer and provided to the AGENCY.

Protocol Implementation Conformance Specification

This Specification uses a modified Protocol Performance List (PRL) table to identify the required features for the DMS System for this project. The DMS System shall support all of the functional requirements listed in this table. The column, Project Requirement, indicates the default value for the appropriate NTCIP object(s) supported by the functional requirement, or the minimum range that the NTCIP object(s) are required to support.

The appropriate NTCIP object(s) to support these functional requirements shall be required. Unless it is stated otherwise, each appropriate, required object shall support the Full Standardized Object Range (FSOR) as defined by the standard.

Requirements ID	Functional Requirement	Project Requirement
1.0	Manage the DMS Configuration	
1.1	Identify DMS	

Requirements ID	Functional Requirement	Project Requirement
1.1.1	Determine Sign Type and Technology - The DMS shall allow a management station to determine its type (such as DMS, CMS, BOS, portable) and technology (such as LED, Fiber optic, bulb, hybrid).	dmsSignType(5 - vmsLine) dmsSignTechnology(1 - LED)
1.2	Determine Message Display Capabilities	
1.2.1	Determine Basic Message Display Capabilities	
1.2.1.1	Determine the Size of the Sign Face - The DMS shall allow a management station to determine the height and width of the sign face.	
1.2.1.2	Determine the Size of the Sign Border - The DMS shall allow a management station to determine the size of the horizontal and vertical border around the sign face.	
1.2.1.3	Determine Beacon Type - The DMS shall allow a management station to determine the configuration of any beacons attached to the DMS, which may be 'none'.	*Not required.*
1.2.1.4	Determine Sign Access and Legend - The DMS shall allow a management station to determine the access mechanism to the sign internal components and the text of any legend on the sign.	dmsSignAccess(1 - Walk-In)
1.2.2	Determine Matrix Capabilities - Requirements for determining the detailed matrix capabilities of the sign are provided in the following subclauses.	
1.2.2.1	Determine Sign Face Size in Pixels - The DMS shall allow a management station to determine the height and width of the sign face in pixels.	
1.2.2.2	Determine Character Size in Pixels - The DMS shall allow a management station to determine the height and width of a character, in pixels, when displayed on the sign face.	
1.2.2.3	Determine Pixel Spacing - The DMS shall allow a management station to determine the spacing of pixels (pitch).	
1.3	Manage Fonts - Requirements for managing the font information are provided in the following subclauses.	
1.3.1	Determine Number of Fonts - The DMS shall allow a management station to determine the maximum number of fonts that can be defined and the number that are defined within the sign controller.	The DMS shall support a minimum of 4 fonts.
1.3.2	Determine Maximum Character Size - The DMS shall allow a management station to determine the maximum size (in bytes) that the DMS allows for each character bitmap.	
1.3.3	Determine Supported Characters - The DMS shall allow a management station to determine which characters are supported by each font within the DMS.	The DMS shall minimally support the basic ASCII character set (ASCII 30-126, inclusive)
1.3.4	Retrieve a Font Definition - The DMS shall allow a management station to upload the fonts defined in the sign controller.	
1.3.5	Configure a Font - The DMS shall allow a management station to modify or create a font definition in the sign controller.	
1.3.6	Delete a Font - The DMS shall allow a management station to delete a font definition in the sign controller.	
1.3.7	Validate a Font - The DMS shall allow a management station to validate any font stored within the controller in order to ensure that the font specification is as expected and has not been corrupted during download or changed since last use.	

Requirements ID	Functional Requirement	Project Requirement
1.5	Configure Brightness of Sign - Requirements for configuring the sign controller's internal algorithm to set sign brightness are provided in the following subclauses.	
1.5.1	Determine Maximum Number of Light Sensor Levels - The DMS shall allow a management station to determine the number of ambient light detection levels supported by the light sensors.	
1.5.2	Configure Light Output Algorithm - The DMS shall allow a management station to configure the relationships between the detection of ambient light (light sensor input reading) and the brightness level of the sign (light output).	
1.5.3	Determine Current Light Output Algorithm - The DMS shall allow a management station to determine the relationships between the detection of ambient light (light sensor input reading) and the brightness level of the sign (light output).	
2.0	Control the DMS - Requirements for controlling the DMS operation are provided in the following subclauses.	
2.1	Manage Control Source – The DMS shall allow the user to switch between the local and central control modes	
2.2	Reset the Sign Controller - The DMS shall allow a management station to reset the sign controller.	
2.3	Control the Sign Face - Requirements for controlling the sign face are provided in the following subclauses.	
2.3.1	Activate a Message - The DMS shall allow a management station to display a message on the sign face, including: 1. Any permanent message supported by the sign 2. Any previously defined message 3. A blank message of any run-time priority *4. A message based on the scheduling logic, if a scheduler is supported by the sign.*	
2.3.2	Manage Default Message Display Parameters - Requirements for managing default settings for certain message display parameters are provided in the following subclauses.	
2.3.2.1	Determine Default Message Display Parameters - The DMS shall allow a management station to determine the current settings for the following message display defaults: 1. Default background and foreground colors 2. Default font 3. Default flash-on and flash-off times 4. Default line justification 5. Default page justification 6. Default page-on and page-off times 7. Default character set	
2.3.2.2	Configure Default Background and Foreground Color - The DMS shall allow a management station to configure the default background and default foreground colors for a message on the sign face to any color supported by the sign.	defaultBackgroundColor(0 - black); defaultForegroundColor(9 – amber);

Requirements ID	Functional Requirement	Project Requirement
2.3.2.3	Configure Default Flash-On and Flash-Off Times - The DMS shall allow a management station to configure the default on-time and default off-time for flashing text or graphics.	The DMS shall minimally support all on and off values ranging from 0.0 seconds to 10.0 seconds, inclusive. defaultFlashOn(5 – 0.5 seconds) defaultFlashOff(5 – 0.5 seconds)
2.3.2.4	Configure Default Font - The DMS shall allow a management station to configure the default font for displaying text.	defaultFont(1);
2.3.2.5	Configure Default Line Justification - The DMS shall allow a management station to configure the default justification for a line.	The DMS shall support left, center, and right justification. defaultJustificationLine(3 – center);
2.3.2.6	Configure Default Page Justification - The DMS shall allow a management station to configure the default vertical justification for displaying a page of text on the sign face (e.g., at the top of the sign, in the middle, or at the bottom).	The DMS shall support top, center, and bottom justification. defaultJustificationPage(3 – middle);
2.3.2.7	Configure Default Page On-Time and Page Off-Time - The DMS shall allow a management station to configure the default time to display each page of a multipage message and the default time to blank the sign face between the display of each page of the message.	The DMS shall minimally support all page-on and page-off values ranging from 0.0 seconds to 10.0 seconds in 0.5 second increments, inclusive. defaultPageOnTime(20 – 2.0 seconds); defaultPageOffTime(20 – 2.0 seconds);
2.3.2.8	Configure Default Character Set - The DMS shall allow a management station to configure the default character set to be used when displaying a message (e.g., ASCII versus UNICODE).	defaultCharacterSet(2 – eightbit)
2.3.3	Manage Message Library - Requirements for managing the contents of a message library are provided in the following subclauses.	
2.3.3.1	Determine Available Message Types - The DMS shall allow a management station to determine information about the different message storage memory types available within the sign controller. The different types are: a.) Permanent memory (content cannot be edited and will not be lost upon power failure) b.) Volatile memory (content is editable but will be lost upon power failure) c.) Changeable memory (content is editable but will not be lost upon power failure)	*Amount of memory to be completed.*
2.3.3.2	Determine Available Message Space - The DMS shall allow a management station to determine the number of messages that are currently stored and remaining space within the controller's message library.	
2.3.3.3	Define a Message - The DMS shall allow a management station to download a message for storage in the sign controller's message library.	

Requirements ID	Functional Requirement	Project Requirement
2.3.3.4	Verify Message Contents - The DMS shall allow a management station to quickly verify that the contents of a message are as expected through the use of a relatively unique code.	
2.3.3.5	Retrieve Message - The DMS shall allow a management station to upload any message definition from the sign controller.	
2.3.4	Schedule Messages for Display - Requirements for managing the contents of a schedule to display one or more permanent or previously defined messages are provided in the following subclauses.	*Not required.*
2.3.4.1	Retrieve a Schedule - The DMS shall allow a management station to retrieve the schedule as stored within the sign controller.	*Not required.*
2.3.4.2	Define a Schedule - The DMS shall allow a management station to define daily schedules of actions with a time resolution of one minute; the rules for selecting a daily schedule to run shall allow schedule configuration up to a year in advance. NOTE: One may specify the minute at which a scheduled action becomes active, but this standard does not require a one-second resolution.	*Not required.*
2.3.5	Configure Event-Based Message Activation - Requirements for configuring the controller to activate a message (including blank or schedule) in response to certain internal events are provided in the following subclauses.	
2.3.5.1	Configure Messages Activated by Standardized Events - Requirements for configuring the message to be activated in response to various standardized internal events are provided in the following subclauses.	
2.3.5.1.1	Configure Message for Short Power Loss Recovery Event - The DMS shall allow a management station to define which message to display upon recovery from a short power loss.	*dmsShortPowerRecoveryMessage(currentBuffer).* *dmsShortPowerLossTime(1 – 1 second)*
2.3.5.1.2	Configure Message for Long Power Loss Recovery Event - The DMS shall allow a management station to define which message to display upon recovery from a long power loss. This message will remain until a new valid message is commanded.	*dmsLongPowerRecoveryMessage(to be determined)*
2.3.5.1.4	Configure Message for Controller Reset Event - The DMS shall allow a management station to define which message to display upon the DMS controller being reset. This message will remain until a new valid message is commanded.	*Value to be Determined*
2.3.5.1.5	Configure Message for Communications Loss Event - The DMS shall allow a management station to define which message to display upon the detection of a loss of communications to the management station. Loss of communications is defined as no detection of a valid NTCIP message. This message will remain until a new valid message is commanded.	*dmsTimeCommLoss (To be Determined)* *dmsCommunicationsLossMessage(to be determined).*
2.3.5.1.6	Configure Message for End Message Display Duration Event - The DMS shall allow a management station to define which message to display upon the expiration of the message display duration. NOTE: Every message is associated with a duration when it is activated, which may be infinite. If the duration expires, the message referenced by this configuration parameter defines the message to display next.	*Value to be determined*
2.5	Control Sign Brightness - Requirements for controlling the brightness of the message on the sign face are provided in the following subclauses.	

Requirements ID	Functional Requirement	Project Requirement
2.5.1	Determine Number of Brightness Levels - The DMS shall allow a management station to determine the maximum number of (settable) brightness levels. The DMS shall support the number of brightness levels as specified in the specification. If the specification does not define the number of brightness levels, the DMS shall support at least 3 brightness levels.	The DMS shall be capable of supporting 9 brightness levels, each level equivalent to 1/8 of the maximum allowable output of the LEDs (0, 12.5%, 25%, 37.5%, 50%, 62.5%, 75%, 87.5%, and 100%).
2.5.2	Determine Current Photocell Readings - The DMS shall allow a management station to determine the current photocell readings.	
2.5.3	Manually Control Brightness - The DMS shall allow a management station to manually control the light output of the display.	
2.5.4	Switch Brightness Control Modes - The DMS shall allow a management station to switch between the defined brightness control modes. NOTE: See Requirement ID 3.4.2 for Supplemental Requirements related to brightness control modes.	
2.6	Manage the Exercise of Pixels - The DMS shall allow a management station to manage frequency and duration of the exercise of each pixel's physical actuation mechanism.	
3.0	Monitor the Status of the DMS - Requirements for monitoring the status of the DMS are provided in the following subclauses.	
3.1	Perform Diagnostics - Requirements for performing diagnostic functions on the DMS are provided in the following subclauses.	
3.1.1	Test Operational Status of DMS Components - Requirements for activating tests are provided in the following subclauses.	
3.1.1.2	Execute Pixel Testing - The DMS shall allow a management station to initiate a pixel test.	Default values: vmsPixelServiceFrequency(1440) vmsPixelServiceTime(181)
3.1.1.3	Execute Fan Equipment Testing - The DMS shall allow a management station to initiate an equipment test of the fan system.	
3.1.2	Provide General DMS Error Status Information - The DMS shall allow a management station to retrieve a high-level overview of the operational status of the DMS that includes an indication of the following error and warning conditions: 1. Communications Error 2. Power Error 3. Pixel Error 4. Light Sensor Error 5. Message Error 6. Controller Error 7. Temperature Warning 8. Fan Error	
3.1.3	Identify Problem Subsystem - Requirements for identifying the component within a subsystem that is causing an error or warning are provided in the following subclauses.	
3.1.3.1	Monitor Power Errors - The DMS shall allow a management system to determine the status of the power supply and the power source.	

Requirements ID	Functional Requirement	Project Requirement
3.1.3.3	Monitor Pixel Errors - The DMS shall allow a management system to determine the status of each pixel (not failed/failed). The DMS shall be accompanied with documentation that maps each individual bit to a specific pixel.	
3.1.3.4	Monitor Light Sensor Errors - The DMS shall allow a management system to determine the status of any light sensor (not failed/failed).	
3.1.3.5	Monitor Controller Software Operations - The DMS shall allow a management system to determine the status of the DMS controller hardware and software. The following error conditions shall be reported: 1. PROM integrity error 2. RAM integrity error 3. Program/processor error 4. Watchdog failure	
3.1.3.6	Monitor Fan Errors - The DMS shall allow a management system to determine the status of any fan (not failed/failed).	
3.1.3.7	Monitor Temperature Warnings - The DMS shall allow a management system to determine whether each temperature sensor is reporting either a temperature warning or a critical temperature alarm. The DMS shall be accompanied with documentation that maps each individual bit to a specific temperature sensor.	
3.1.3.10	Monitor Door Status - The DMS shall allow a management system to determine if the door of the DMS enclosure is open/closed. *Which door? Controller cabinet or the enclosure?*	
3.1.4.3	Monitor Pixel Error Details - The DMS shall allow a management system to determine the detailed information for any pixels that are not operational, including: 1. Horizontal location of the pixel 2. Vertical location of the pixel 3. The type of failure (electrical error, mechanical error)	
3.1.4.4	Monitor Light Sensor Error Details - The DMS shall allow a management system to determine the detailed information for light sensors.	*dmsIllumPhotocellLevelStatus shall indicate the value calculated by the histeresis.*
3.1.4.5	Monitor Message Activation Error Details - The DMS shall allow a management system to obtain detailed information regarding the success or failure of the last message activation, including details related to any message content errors. This information may be overwritten by other actions in the device, but there shall be a way to verify that the error details still apply to the last activation command.	
3.1.4.6	Monitor Fan System Error Details - The DMS shall allow a management system to determine the detailed information for fans.	*If any fan is failed, the fanFailures bit shall be set to one (1).*
3.1.4.7	Monitor Sign Housing Temperatures - The DMS shall allow a management system to determine the minimum and maximum temperature of the sign housing.	
3.1.4.9	Monitor Control Cabinet Temperatures - The DMS shall allow a management system to determine the minimum and maximum temperature of the control cabinet. If the controller is located in the sign housing without its own distinct cabinet, the values reported by the DMS shall be the same as for the sign housing.	

Requirements ID	Functional Requirement	Project Requirement
3.1.5	Monitor the Sign's Control Source - The DMS shall allow a management station to determine the current control source for the DMS. See Supplemental Requirements for Control Modes for a description of the possible control modes.	
3.1.6	Monitor Power Information - The DMS shall allow a management station to determine current source of power. The possible sources include: 1. Shutdown Power 2. AC Line 3. Generator 4. Solar 5. Battery - UPS 6. Other power source	
3.1.7	Monitor Ambient Environment - The DMS shall allow a management system to determine the minimum and maximum temperature of the ambient environment (i.e., outside of sign housing and control cabinet).	
3.2	Monitor the Current Message - The DMS shall allow a management station to monitor details about the current message, including: 1. The message content 2. The stored message number used to activate the current message 3. The message display time remaining 4. The process or management station that activated the message 5. The current brightness level of the message *6. The status of the beacons* 7. The status of pixel service	
3.2.1	Monitor Information about the Currently Displayed Message - The DMS shall allow a management station to monitor details about the current message, including: 1. The message content 2. The stored message number used to activate the current message 3. The message display time remaining 4. The process or management station that activated the message 5. The current brightness level of the message *6. The status of the beacons* 7. The status of pixel service	
3.2.2	Monitor Dynamic Field Values - The DMS shall allow a management station to monitor the value(s) currently being displayed within the dynamic fields of the current message.	
3.3	Monitor Status of DMS Control Functions - Requirements for monitoring the status of the various control functions are provided in the following subclauses.	
3.3.2	Monitor Short Power Recovery Message - The DMS shall allow a management station to determine which message is currently configured to be displayed in response to a power recovery event after a short power loss.	

Requirements ID	Functional Requirement	Project Requirement
3.3.3	Monitor Long Power Recovery Message - The DMS shall allow a management station to determine which message is currently configured to be displayed in response to a power recovery event after a long power loss.	
3.3.4	Monitor Power Loss Message - The DMS shall allow a management station to determine which message is currently configured to be displayed during a power loss.	
3.3.5	Monitor Reset Message - The DMS shall allow a management station to determine which message is currently configured to be displayed in response to software or hardware reset event.	
3.3.6	Monitor Communications Loss Message - The DMS shall allow a management station to determine which message is currently configured to be displayed if communications with the management station are lost for a user-defined period of time. Detection of loss of communications shall be is disabled when the DMS is in 'local' control mode.	
3.3.7	Monitor End Duration Message - The DMS shall allow a management station to determine which message is currently configured to be displayed upon the termination of the current message duration.	

Supplemental Requirements

Supplemental requirements for the DMS are provided in the following subclauses. These requirements do not directly involve communications between the management station and the DMS, but, if the supplemental requirement is selected in the PRL, the DMS must perform the stated functionality in order to claim conformance to this standard.

Requirements ID	Functional Requirement	Project Requirement
3.4.1	Supplemental Requirements for Fonts - Supplemental requirements for character set support are provided in the following subclauses.	
3.4.1.1	Support for a Number of Fonts - The DMS shall support the number of fonts as defined by the specification.	The DMS shall support a minimum of two (2) permanent fonts, and a minimum of two (2) non-volatile fonts.
3.4.3	Supplemental Requirements for Automatic Brightness Control - Supplemental requirements for automatically adjusting the brightness of a message are provided in the following subclauses.	
3.4.3.1	Automatically Control Brightness - The DMS shall automatically manage the light sensor-driven light output of the display when this mode is enabled.	
3.4.3.2	Inhibit Flickering of Message Brightness - The DMS shall allow the Light Output Algorithm to include overlapping values, which shall enable the Light Output Algorithm to avoid flickering of the light output due to small changes in the measured ambient light conditions.	
3.4.4	Supplemental Requirements for Control Modes - Supplemental requirements for allowing different entities to control the DMS are provided in the following subclauses.	
3.4.4.1	Support Central Control Mode A DMS shall allow an operator to control the sign from a remote location (e.g., from central).	

3.4.4.2	Support Local Control Mode - The DMS shall allow an operator to control the sign through a local interface. NOTE: A 'local' interface may include any of the following: a touch panel on the sign controller, a laptop connected directly to a 'local' port on the sign controller, any other mounted or unmounted panel that can be used to select a message for display.	
3.4.4.3	Support Central Override Control Mode - The DMS shall allow the central system to override the local control mode.	
3.4.4.4	Processing Requests from Multiple Sources - The DMS shall only allow a single source to control the sign at any one time.	
3.4.5	Supplemental Requirements for Message Activation Request - Supplemental requirements for activating a message for display on the sign face based on an external request are provided in the following subclauses.	
3.4.5.1	Supplemental Requirements for Internal or External Message Activation - Supplemental requirements for activating a message for display on the sign face (whether generated by an internal or external request) are provided in the following subclauses.	
3.4.5.1.1	Activate Any Message - The DMS shall allow the activation of any valid message that is stored in the sign controller.	
3.4.5.1.2	Preserve Message Integrity - The DMS shall prohibit the display of a message that uses memory objects such as fonts or graphics that were altered after the message was composed and saved within the sign's local message library.	
3.4.5.1.3	Ensure Proper Message Content - The DMS shall ensure that the contents of the message are the same as what the requester requests.	
3.4.5.2	Indicate Message Display Duration - Each message activation shall be associated with a duration for the sign controller to display the message. If the request is validated, the DMS shall display the associated message for the indicated duration.	
3.4.5.3	Indicate Message Display Requester ID - Each message activation shall be associated with an indication of the entity that requested the display. The DMS shall store this information while the message is displayed.	
3.4.5.4	Supplemental Requirements for Message Activation Priority - The DMS shall only activate the newly requested message if the activation priority is higher than the runtime priority of the currently displayed message.	
3.4.6	Supplemental Requirements for Message Definition - Supplemental requirements for defining user-defined messages (i.e., volatile and changeable messages) are provided in the following subclauses.	
3.4.6.1	Identify Message to Define - Each message stored in the sign controller shall be associated with a unique identifier.	
3.4.6.2	Define Message Content - Supplemental requirements for defining the message content are provided in the following subclauses.	
3.4.6.2.1	Support Multi-Page Messages - The DMS shall allow the message to contain the number of distinct page displays as defined by the specification. If the specification does not define the number of distinct page displays that must be supported, the DMS shall support at least one page per message.	
3.4.6.2.2	Support Page Justification - Supplemental requirements for supporting vertical justification of the message on the display are provided in the specification text related to Requirement ID 2.3.2.6 and the following subclauses.	

3.4.6.2.2.1	Support for One Page Justification within a Message - The DMS shall allow the message content to specify a single vertical (page) justification, which shall apply to all pages of the message.	
3.4.6.2.2.2	Support for Multiple Page Justifications within a Message - The DMS shall allow the message content to specify vertical (page) justification on a page-by-page basis.	
3.4.6.2.3	Support Multiple Line Messages - The DMS shall allow each page of the message to contain up to the number of lines as defined by the specification. If the specification does not define the number of lines that must be supported, the DMS shall support at least one line per page.	
3.4.6.2.4	Support Line Justification - Supplemental requirements for horizontal (line) justification are provided in the specifications related to Clause 3.4.2.3.2.5 and the following subclauses.	
3.4.6.2.4.1	Support for a Single Line Justification within a Message - The DMS shall allow the message content to specify a single line justification, which shall be used for each line within the message.	
3.4.6.2.4.2	Support Line Justification on a Page-by-Page Basis - The DMS shall allow the message content to specify the line justification on a page-by-page basis.	
3.4.6.2.4.3	Support Line Justification on a Line-by-Line Basis - The DMS shall allow the message content to specify the line justification on a line-by-line basis.	
3.4.6.2.6	Support Font Commands - Supplemental requirements for supporting font commands within a message are provided in the specification related to Clause 3.4.2.3.2.4 and the following subclauses.	
3.4.6.2.6.1	Support One Font within a Message - The DMS shall allow the message content to specify a single font, which shall apply to the entire message.	
3.4.6.2.7	Support Moving Text - The DMS shall allow the message content to include a 'window' that contains moving text at a defined speed and direction.	*Not required.*
3.4.6.2.8	Support Character Spacing - The DMS shall allow the message content to specify the spacing between characters in a text string or between text and a graphic on a character-by-character basis.	
3.4.6.2.9	Support Customizable Page Display Times in a Message - The DMS shall allow the message content to specify the time to display each page and the time to blank the sign face between each page when displaying a multi-page message. The allowed range for the display time and the blank time shall be identical to the range identified in the specification for Requirement ID 2.3.2.7.	
3.4.6.2.10	Support Customizable Flashing Times within a Message - The DMS shall allow the message content to specify the time to display and the time to blank each section of flashing text. The allowed range for the display time and the blank time shall be identical to the range identified in the specification for Requirement ID 2.3.2.3.	
3.4.6.2.11	Support Flashing - Supplemental requirements for flashing text are provided in the following subclauses.	
3.4.6.2.11.1	Support Character-by-Character Flashing - The DMS shall allow the message content to identify portions of text (and/or graphics) to be flashed on a character-by-character basis.	
3.4.6.2.11.2	Support Line-by-Line Flashing - The DMS shall allow the message content to identify portions of text (and/or graphics) to be flashed on a line-by-line basis.	
3.4.6.2.11.3	Support Page-by-Page Flashing - The DMS shall allow the message content to identify portions of text (and/or graphics) to be flashed on a page-by-page basis.	

3.4.6.2.13	Support Message Data Fields - Supplemental requirements for defining a message that includes fields that display dynamic data are provided in the following subclauses.	
3.4.6.2.13.1	Support Current Time Field - The DMS shall allow the message content to include field(s) indicating the current time.	*Not required.*
3.4.6.2.13.2	Support Current Date Field - The DMS shall allow the message content to include field(s) indicating the current date.	*Not required.*
3.4.6.2.13.3	Support Current Temperature Field - A DMS shall allow the message content to include field(s) indicating the current ambient air temperature.	*Not required.*
3.4.6.2.13.4	Support Detected Vehicle Speed Field - The DMS shall allow the message content to include field(s) indicating the current reading from the attached speed detector.	*Not required.*
3.4.6.2.13.5	Support Current Day of Week Field - The DMS shall allow the message content to include field(s) indicating the current day of the week.	*Not required.*
3.4.6.2.13.6	Support Current Day of Month Field - The DMS shall allow the message content to include field(s) indicating the current date of the month.	*Not required.*
3.4.6.2.13.7	Support Current Month of Year Field - The DMS shall allow the message content to include field(s) indicating the current month of the year.	*Not required.*
3.4.6.2.13.8	Support Current Year Field - The DMS shall allow the message content to include field(s) indicating the current year.	*Not required.*
3.4.6.2.13.9	Support Current Time with uppercase AM/PM Field - The DMS shall allow the message content to include field(s) indicating the current time with uppercase AM/PM after.	*Not required.*
3.4.6.2.13.10	Support Current Time with lowercase am/pm - The DMS shall allow the message content to include field(s) indicating the current time with lowercase am/pm after.	*Not required.*
3.4.6.2.13.12	Data Field Refresh Rate - Each field shall be updated at least once every 60 seconds.	
3.4.6.2.15	Specify Location of Message Display - A DMS shall allow the message content to specify the starting position of text *and graphics* on the sign face at a one-pixel resolution.	
3.4.6.2.16	Support of Text - Supplemental requirements for including text characters in a message are provided in the following subclauses.	
3.4.6.2.16.1	Support of Textual Content - The DMS shall allow the message content to include any character supported by the DMS in any order.	
3.4.6.2.16.2	Support of Message Lengths Compatible with Sign Face - The DMS shall allow the message to contain any number of characters per page for each page, up to the physical limits of the sign face.	
3.4.6.3	Identify Message Owner - Each message stored in the sign controller shall be associated with an owner name.	
3.4.6.4	Priority to Maintain a Message - Each message stored in the sign controller shall be associated with a run-time priority.	
3.4.6.5	Beacon Activation Flag - Each message stored in a sign controller library shall indicate whether any existing attached beacons are to flash while this message is displayed.	*Not required.*
3.4.6.6	Pixel Service Flag - Each message stored in a sign controller library shall indicate whether a pixel service can be executed while the message is displayed.	
3.4.6.7	Message Status - Each message stored in the sign controller shall be associated with a status to indicate if it is valid for display, being modified, etc.	

3.4.6.8	Identify Message Name - Each message stored in the sign controller shall be associated with a message name.	
3.4.7	Supplemental Requirements for Locally Stored Messages Supplemental requirements for storing local messages are provided in the following subclauses.	
3.4.7.1	Support Permanent Messages	The DMS shall minimally support one permanent message, blank message.
3.4.7.2	Support Changeable Messages	The DMS shall minimally support x changeable messages.
3.4.7.3	Support Volatile Messages - The DMS may fulfill the requirements of this clause by providing additional changeable messages and additional changeable memory. If the DMS implements this option, the total number of changeable messages supported by the DMS shall be at least the sum of the required changeable messages and the required volatile messages; likewise, the total changeable memory supported by the DMS shall be at least the sum of the required changeable memory and the required volatile memory.	The DMS shall minimally support 1 volatile messages. The DMS shall support an amount of volatile memory that is at least the product of the number of volatile messages multiplied by 100 bytes.
3.4.8	Supplemental Requirements for Color Scheme Supplemental requirements for supporting color are provided in the following subclauses.	
3.4.8.1	Support Single Color - The sign face shall support black (or off) and at least one other color.	
3.4.9	Supplemental Requirements for Monitoring Subsystems - The DMS shall automatically test and update the internally stored values for the status of the following subsystems without any input from the user at a frequency specified by the specification: 1. Communications 2. Power Supply 3. Photocell (See Requirement ID 2.5) 4. Message 5. Controller 6. Temperature (See Requirement ID 3.1.4.7 and 3.1.4.9) 7. Door, if door-open sensors are present (See Requirement ID 3.1.3.10)	The DMS shall perform these tests at least once every minute.
3.4.10	Supplemental Requirements for Scheduling Supplemental requirements for defining a time-based schedule are provided in the following subclauses.	*Not required.*
3.4.10.1	Support a Number of Actions - The DMS shall support the number of actions as defined in the specification. If the specification does not define the number of actions, the DMS shall support at least two actions. NOTE: An action is defined as being a unique command that might be called by a day plan event. For example, displaying changeable message number 1 would be one action, displaying changeable message number 2 would be a second action and blanking the sign would be a third action.	*Not required.*
3.4.10.2	Support the Activate Message Action for the Scheduler - The DMS shall allow the scheduler to be configured to activate any message supported by the DMS and currently valid within the message table.	*Not required.*

3.4.10.3	Perform Actions at Scheduled Times - The DMS shall perform the actions configured in the scheduler at the times identified. The Activate Message action shall change the state of the scheduled message buffer and shall only cause the display of the message if the current message is the Scheduler.	*Not required.*
3.4.12	Supplemental Requirements for Page Justification - Supplemental requirements for page justification are provided in the following subclauses.	
3.4.12.1	Support top Page Justification - The DMS shall support top page justification.	
3.4.12.2	Support middle Page Justification The DMS shall support middle page justification.	
3.4.12.3	Support bottom Page Justification - The DMS shall support bottom page justification.	
3.4.13	Supplemental Requirements for Line Justification	
3.4.13.1	Support left Line Justification - The DMS shall support left line justification.	
3.4.13.2	Support center Line Justification - The DMS shall support center line justification.	
3.4.13.3	Support right Line Justification - The DMS shall support right line justification.	
3.4.13.4	Support full Line Justification - The DMS shall support full line justification.	

Software and Integration Support

It is expected that the DMS will be controlled and monitored from the ATMS software, provided by another Systems Integrator, under normal conditions. However, the functions and capabilities from the ATMS is limited to basic operations and monitoring, and supports only a subset of the NTCIP Standards.

Software

The manufacturer is to provide software supporting all the functional requirements listed above. The software will be used to support maintenance activities and to configure the DMS. The software shall be installed on the workstations and maintenance laptop computers to be provided.

Integration Support

The manufacturer shall support the AGENCY's systems integrator in troubleshooting and verifying proper monitoring and operations of the DMS using the ATMS software.

During the Factory Acceptance Tests (see Section xxx), the manufacturer shall assist the Systems Integrator with testing the implementation of DMS with the ATMS software. The Systems Integrator will use its software or its NTCIP exerciser to perform basic communications and control of the DMS. *Note: This part is vague in terms of the manufacturer's responsibilities.*

During the Integration Test (see Section xxx), the Systems Integrator will transfer monitoring and control of the DMS to the ATMS software for a 30-day demonstration period. During this period, the manufacturer shall assist the Systems Integrator with troubleshooting any problems or events that may occur.

The ATMS software is expected to exercise the following NTCIP 1203 objects when monitoring and controlling the DMS. These are the most common objects expected to be exercised by ATMS software, and is by no means limited to these objects.

- dmsMessageTable
  - dmsMessageNumber
  - dmsMessageMultiString
  - dmsMessageOwner
  - dmsMessageCRC
  - dmsMessageBeacon
  - dmsMessagePixelService
  - dmsMessageRunTimePriority
  - dmsMessageStatus
- dmsValidateMessageError
- dmsControlMode
- dmsActivateMessage
- dmsActivateMsgError
- shortErrorStatus

Testing

Perform the Factory Acceptance Tests, Visual Inspection Test, Startup Tests, Stand-alone Tests, Operational Tests, and Integration Tests on the Dynamic Message Sign (DMS) System.

- The Factory Acceptance Test (FAT) shall include all labor and material necessary to verify conformance of the field equipment with the performance, mechanical, electrical and environmental requirements specified.
- The Visual Inspection Test shall include all labor and material necessary to perform a visual inspection after the complete installation of the DMS equipment to check for manufacturing and installation defects.
- The Startup Tests shall include all labor and material necessary to verify the setup and configuration of the DMS.

- The Stand-alone Tests shall include all labor and material necessary to demonstrate that the required functionality and capabilities of the DMS are functioning properly, including subsystem check tests on all installed equipment and operation and monitoring of the DMS.
- The Operational Tests shall include all labor and material necessary to support the AGENCY over a 60-day period during which the DMS System will be utilized by the AGENCY in daily operations.
- The Integration Tests shall include all labor and material necessary to transfer control and monitoring of the DMS from the manufacturer-supplied software to the ATMS software.

The Visual Inspection, Startup and Stand-alone Test may be performed on the same day, subject to AGENCY approval. However, the tests must be performed and completed in the proper sequence, as defined in the technical specifications.

For each test, the CONTRACTOR shall provide written notice of the proposed test date to the AGENCY at least two (2) weeks in advance to allow the AGENCY to make arrangements to be present during the tests. All tests shall be performed as specified in the presence of the AGENCY, or its representative. The CONTRACTOR, and a qualified representative from the DMS manufacturer shall be designated to be present as well.

The AGENCY will review the test results for conformance with the requirements of the CONTRACT DOCUMENTS. If the DMS System fails any part of the test, at the option of the AGENCY, the entire test shall be repeated, and/or the AGENCY will consider other contractual options.

Factory Tests

Prior to delivery, the DMS System shall be subject to a Factory Acceptance Test. This test shall verify that the field equipment properly meets or exceeds the performance, electrical and environmental requirements specified. The Contractor shall provide all test equipment, test facilities, and personnel required for the performance of the Factory Acceptance Test. All costs incurred for the conduct of the laboratory tests shall be paid for by the Contractor.

The Factory Acceptance Tests shall be performed at the manufacturer's facilities or at an independent testing laboratory.

The CONTRACTOR shall submit a Factory Acceptance Test procedure for AGENCY review and approval, no less than eight (8) weeks prior to the proposed Factory Acceptance Test date. The AGENCY shall have no less than three (3) weeks to review the proposed Test procedure and provide comments back to the CONTRACTOR. The Factory Test Procedure must be approved, in writing, by the AGENCY before the Factory Tests are performed.

At a minimum, the Factory Acceptance Tests shall include the following:

- space on the checklist for each item for the AGENCY's or its representative's initials
- Environmental Testing – The environmental tests shall use the environmental test procedures (Chapter 2) outlined in the draft NEMA Standards Publication TS 4-2004, Hardware Standards for Dynamic Message Signs (DMS) with NTCIP Requirements, Draft –V1.30b, dated February 9. 2004. Environmental tests may include the temperature, transient, voltage, humidity, power interruption, shock (impact) and vibration tests, as required by the Technical Specifications.
- NTCIP Testing – The NTCIP tests shall demonstrate proper use and conformance of the appropriate referenced standards. The test shall include verification that any manufacturer-specific objects used have been properly documented. Tools that may be used by the AGENCY for the performance of the NTCIP tests include the FHWA NTCIP Exerciser software, Version 3.3b7a; and DeviceTester for NTCIP from Intelligent Devices, Inc.
- Display Testing – The display tests shall use the display test procedures (Chapter 5) outlined in the draft NEMA Standards Publication TS 4-2004, Hardware Standards for Dynamic Message Signs (DMS) with NTCIP Requirements, Draft –V1.30b, dated February 9. 2004. Display tests may include contrast ratio, cone of vision, and luminance intensity.
- Compatibility Testing – The compatibility tests shall demonstrate proper control and monitoring of the DMS with the ATMS software or systems integrator exerciser. The test procedures for the compatibility test shall be provided by others, and will be provided to the CONTRACTOR prior to the Factory Acceptance Test.

The Factory Acceptance Test Plans must be completed, dated, and signed by the CONTRACTOR and the AGENCY or its representative. The completed test plans are to be submitted to the Engineer, or his appointed representative, no less than 10 business days after completing the Factory Acceptance Test, regardless of pass or fail.

Visual Inspection Test

Upon the installation of the DMS, a visual inspection of the DMS will be performed, and shall be called the Visual Inspection Test. The purpose of the Visual Inspection is to verify that the DMS has been properly installed according to Contract Documents and to check for manufacturing and installation defects.

The CONTRACTOR shall submit a visual inspection checklist for AGENCY review and approval, no less than six (6) weeks prior to the proposed Visual Inspection Test date. The AGENCY shall have no less than three (3) weeks to review the proposed visual inspection checklist and provide comments back to the CONTRACTOR. The visual inspection checklist must be approved, in writing, by the AGENCY before the Visual Inspection Test is performed.

The visual inspection checklist shall include, at a minimum:

- space on the checklist for each item for the AGENCY's or its representative's initials
- check for manufacturing and installation defects prior to connecting the DMS System to the power feed. Any deficiencies found during this inspection must be corrected prior to the Startup Test.
- check the wiring diagrams from the manufacturer and compare to the actual wiring at the DMS site. Ensure that the wiring diagrams are on-site during the Visual Inspection Tests.
- proper grounding
- correct wiring of sensors and alarms to the controller's inputs.

A visual inspection checklist must be completed, dated, and signed by the CONTRACTOR and the AGENCY or its representative. Checklists are to be submitted to the Engineer, or his appointed representative, no less than 5 business days after completing the Visual Inspection Test, regardless of pass or fail.

Startup Tests

Upon satisfactory completion of the Visual Inspection Test of the DMS, the setup and configuration of the DMS will be verified locally at the DMS control cabinet. This verification of the DMS locally will be called the Startup Tests. The purpose of the Startup Test is to demonstrate that the proper default values have been properly set up (sign configuration, fonts, default messages, device address).

During the Startup Tests, a laptop computer will be connected to the DMS's LAPTOP port. Basic control and monitoring of the DMS will be demonstrated using the DMS manufacturer-supplied software, which will be loaded on the laptop computer.

The CONTRACTOR shall submit a Startup Test Plan for AGENCY review and approval, no less than six (6) weeks prior to the proposed Startup Test date. The AGENCY shall have no less than three (3) weeks to review the proposed Startup Test Plan and provide comments back to the CONTRACTOR. The Startup Test Plan must be approved, in writing, by the AGENCY before the Startup Test is performed.

The Startup Test plan shall include the following tests, at a minimum:

- space on the checklist for each item for the AGENCY's or its representative's initials

- verify that all global objects values have been properly set (Configuration, Database Management, Time Management, Report, STMF, and PMPP Conformance Groups), and record the information.
- verify that all dmsSignCfg and vmsCfg values have been properly set (Sign Configuration, GUI Appearance, and DMS Sign Configuration Conformance Groups) and record the information.
- verify that the MULTI default values have been properly set (MULTI Configuration Conformance Group) and record the information.
- verify that all default messages have been properly set (Default Message Conformance Group) and record the information.
- verify that the required fonts have been properly loaded and set (Font Definition Conformance Group).

Note that the Startup Tests do not require the display of a message on the DMS.

The Startup Test Plan must be completed, dated, and signed by the CONTRACTOR and the AGENCY or its representative. Checklists are to be submitted to the Engineer, or his appointed representative, no less than 5 business days after completing the Startup Tests, regardless of pass or fail.

Stand-alone Tests

Upon satisfactory completion of the Stand-Alone Test of the DMS, the functionality of the DMS will be demonstrated locally at the DMS control cabinet. This exercise will be called the Stand-alone Tests. The purpose of the Stand-alone Test is to demonstrate that the basic capabilities of the DMS are functioning properly, including subsystem check tests on all installed equipment (communications equipment, LEDs, climate controls), and activating, uploading and downloading messages.

The CONTRACTOR shall submit a Stand-alone Test Plan for AGENCY review and approval, no less than six (6) weeks prior to the proposed Stand-alone Test date. The AGENCY shall have no less than three (3) weeks to review the proposed Stand-alone Test and provide comments back to the CONTRACTOR. The Stand-alone Test must be approved, in writing, by the AGENCY before the Stand-alone Test is performed.

The hardware portion of the Stand-alone Test plan shall include the following tests, at a minimum:

- space on the checklist for each item for the AGENCY’s or its representative’s initials
- conduct of subsystem check tests on all installed equipment, including communications equipment. Include equipment checkout tests for each system component, including provisions for testing all internal and external system interfaces.

- Proper operation of every pixel, including uniform brightness at all brightness levels and proper current consumption.
- Proper wiring of the display modules, checked by displaying a test message that identifies the modules' proper row and column positions.
- Appropriate brightness of the DMS for day and night conditions, including when the sun is directly in front of or behind DMS.
- Test for absence of leaks. This can be demonstrated by operating the blowers with the doors and exhaust vents closed to pressurize the sign enclosure, and checking for air bypassing the door and window gaskets.
- Proper aiming of the display modules.
- Proper operation of the temperature sensors, blowers, defogging system, and lights.

Using these hardware tests, demonstrate that the equipment installed at each location is installed properly and that all functions are in conformance with the Contract Documents. The field equipment tests include non-central functional tests of the locally installed equipment. Any deficiencies found during Stand-alone Tests must be corrected prior to conducting the Operational Test.

The software portion of the Stand-alone Test plan shall include the following tests, at a minimum:

- space on the checklist for each item for the AGENCY's or its representative's initials
- connect a laptop computer loaded with the manufacturer's software to the LAPTOP port located on the VSLS controller. Proper control and monitoring of the DMS, as will be demonstrated using the DMS manufacturer-supplied software.
- upload, download and activate a message.
- use of all required and supported MULT tags.
- Proper reporting of the sign status reporting objects, such as shortErrorStatus (Sign Status Conformance Group, and all applicable subconformance groups).
- perform all diagnostic routines provided by the manufacturer and as required by the Contract Documents. This includes exercising the pixel service functions
- verify and record the histeresis for determining the brightness of the LEDs.

The Stand-alone Test Plan must be completed, dated, and signed by the CONTRACTOR and the AGENCY or its representative. Checklists are to be submitted to the Engineer, or his appointed representative, no less than 5 business days after completing the Stand-alone Tests, regardless of pass or fail.

Operational Tests

After all equipment and software provided under this Contract has successfully completed the Stand-alone Tests and system training has been completed, an Operational Test period will begin. The purpose of the Operational Test is to demonstrate that the system has been properly installed and integrated, performs properly, and complies with the Contract Documents. The Operational Test shall consist of a 60-day demonstration period and will serve to evaluate full-scale operation of the system under normal conditions. The AGENCY STATEWIDE TOC will be responsible for operating the system during this period. For the Operational Test, the functionality of the DMS will be exercised at the AGENCY STATEWIDE TOC, and will communicate with the DMS through the DMS's CENTRAL port.

The first 30 days of the 60-day demonstration period, monitoring and control of the DMS will be from the local workstation provided by the manufacturer using the manufacturer-supplied software. The last 30 days of the 60-day demonstration period, monitoring and control of the DMS will be from the ATMS software currently in use at the AGENCY STATEWIDE TOC, after completion of the Integration Tests.

Submit the following procedures and documentation to the AGENCY for review and approval before the start of the Operational Tests:

- procedures for notification and failure reporting to the CONTRACTOR and/or the DMS System manufacturer. Procedures shall include a log for recording failures or comments, and a 24-hour, either a toll-free or local telephone number, to contact the CONTRACTOR for maintenance or assistance.
- a preventative maintenance schedule for the DMS System. The schedule shall indicate maintenance procedures and a list of tools required to perform the maintenance.

The following conditions apply to the observation period:

- During the entire period, the system will monitor and control the signs, and perform all the other functions described in these Specifications.
- If any hardware item that is part of the DMS System fails (with the exception of expendable items such as printer cartridges), the items will repaired at no addition cost to AGENCY. The observation period for the failed item will restart for the full 60-day duration.
- Any system problems discovered during this demonstration period, will result in the suspension of the observation period until the problem is resolved. Once the problem has been eliminated, the observation period will resume. The

CONTRACTOR shall carefully record the problem and report to the AGENCY how the problem was resolved. The CONTRACTOR may be required to demonstrate that any corrections or modifications made are valid, that the problems which restricted system operation have been corrected, and no new problems have resulted from the changes.

- Total system "down time" may not exceed 36 hours during the entire period. Down time is a condition caused by failure of the central equipment, central software, which causes the system to cease normal operation. If total system "down time" exceeds 36 hours, a full 60-day observation period will begin again.
- Intermittent communications problems shall not count towards the total system “down time” if the CONTRACTOR shows that the communications problem is caused by problems unrelated to the DMS System. It is incumbent on the CONTRACTOR to provide proof to the agency.
- If 10 percent of the total quantity of a particular hardware item fails during the observation period, that item or unit will be replaced at no additional cost to AGENCY. The replacement units shall be new and unused. The observation period will start over after that item has been completely replaced.

Within five (5) business days of the completion of the 60-day demonstration period, the CONTRACTOR submit a final maintenance report summarizing the nature and time of all maintenance or repairs performed during the demonstration period and list the equipment and spare parts used in this effort. The report shall contain the following information as a minimum:

- tasks performed and man-hours required to perform them
- numbers and types of components repaired and the extent of repairs needed
- number and types of components replaced by new equipment
- numbers and types of components recommended as additional spare parts

Upon successful completion of the observation period, the AGENCY will accept the DMS System, in writing, providing that all corrections in documentation have been rendered and all other requirements of the Contract Documents have been met.

Integration Tests

Upon satisfactory completion of the initial 30 days of the 60-day Operational Tests, the monitoring and control of the DMS will be transferred from the local workstation to the ATMS software. The initial demonstration and exercising of monitoring and control of the DMS using the ATMS software will be called the Integration Tests. The Integration Test will be performed by the AGENCY and other contractors, however, a qualified representative of the DMS manufacturer will be available to assist the AGENCY and its contractors on any issues that may occur during the integration test.

If an integration issue arises, the DMS manufacturer may be asked to analyze the issue and shall submit a proposed solution in writing. *Note: Implementation of proposed solution is not discussed.*

Documentation

The component shall be supplied with full documentation, including 3.5" floppy disk(s) and a CD-ROM containing 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 Module 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 macro 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 (or agency-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.

Warranties

In addition, the developer shall provide free software upgrades for a period of 12 months from successful acceptance of the DMS System.

Interpretation Resolution

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 NTCIP Working Group for resolution. If the Working Group fails to respond within 90 days, the project shall develop an interpretation of the specification.

Workstation

Under the project, a workstation will be supplied with the DMS manufacturer's software to allow users to monitor the status of and control the signs on the facility. The purpose of the workstation is to test the DMS upon initial installation of the DMS sign, and to serve as a backup in the event of a failure of the main ATMS software.

Each workstation will be provided with a *Microsoft Windows 2000* or *Microsoft Windows XP* operating system, and an archival media, such as a *CD-ROM burner* or *tape backup* for storing log files and event messages. *An Uninterruptible Power Supply* will be provided with each workstation to protect the workstation in the event of a power failure for at least *15* minutes. *A laser printer* will be provided with each workstation to allow printing of reports and logs.

A *technician's laptop computer* will be provided with the sign. The technician's laptop computer will be used to maintain or control the DMS sign at the DMS cabinet for maintenance purposes or in the event there is no communications between the traffic management center and the DMS sign. The technician's laptop computer shall be environmentally hardened. The laptop computer shall be provided with the manufacturer's software, *Microsoft Windows* operating system, and the necessary cables to connect to the DMS sign's laptop *RS-232* port.