NYSDOT Task 2.A.2

Best Practices for ITS Standards Specifications

(Draft Final)

December 7, 2005

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Prepared for

New York State Department of Transportation

D015186 PIN S148.00

Technical Support and Strategic Plan Development Services for

NYSDOT Statewide ITS Program

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Revision History

Filename	Version	Date	Author	Comment
NYSDOT ITS Standards Best Practices v0.01.doc	0.01	03/26/05	P. Chan / M. Insignares	First Draft
NYSDOT ITS Standards Best Practices v0.02.doc	0.02	03/30/05	P. Chan / M. Insignares	Added Appendix C - Example Center to Center Interface Specification.
NYSDOT ITS Standards Best Practices v1.00.doc	1.00	12/2/05	P. Chan / M. Insignares	Final draft. Incorporated user comments from Hawthorne and Syracuse, NY stakeholder meetings. Developed new section on Project Programming. Updated appendices.

Relation to Project Scope

In October 2003, Consensus Systems Technologies Corp. (ConSysTec), was sub-contracted by Gardner Engineering of New York, P.C., to provide technical support for New York State Department of Transportation's Statewide ITS Program. This work was performed under a contract between Gardner Engineering of New York, P.C. and New York State Department of Transportation, Contract D015186, PIN S148.00, Technical Support and Strategic Plan Development Services for NYSDOT Statewide ITS Program.

This Technical Issue Paper was prepared to satisfy the requirements of Task 2.A.2, Best Practices for ITS Specifications, and is the second of a series of technical issue papers on ITS Standards to be delivered to NYSDOT for this project. The first technical issue paper presented a comprehensive overview of the current status of the National ITS Standards Program and the Standards Testing Program and where they are going. The third technical issue paper will cover key ITS Standards, and will assess the current use of ITS standards in ITS deployments, identify those standards that are sufficiently mature for use or testing in the near term, and based on criteria to be determined with NYSDOT recommend ITS Standards that should be used for NYS ITS deployments. The fourth and final technical issue paper will build upon this Best Practices Report and the Key ITS Standards Report to provide a guide for NYSDOT planners, project managers, and specifications writers on how to specify ITS standards in its specifications.

1 Introduction

1.1 Report Overview

This document reviews the life cycle of ITS Standards in the development and deployment of ITS projects in New York, starting with a project's genesis in a regional or Statewide ITS architecture, how to use the architecture to determine applicable standards, how to use the systems engineering process to determine functional requirements, then how to determine what ITS standards, if any, to use in an ITS project.

This paper walks through the entire life cycle of an ITS project and is divided into 2 sections: 1) Project Programming, and 2) Project Design.

Section 1 – Project Programming - discusses the role of the ITS architecture in the transportation planning process. The paper discusses how ITS standards "evolve" from a simple list of applicable ITS standards in a regional ITS architecture, to further development through an agency's project development phases, to final development in project specifications and bid documents.

Section 2 – Project Design - provides a framework and best practices related to the development of ITS Standards-based specifications for the deployment of ITS systems in the State of New York.

The overarching framework (which brings context to the ITS Standards specification process) is the project development process that the New York State Department of Transportation already has in place. This document will review that existing process, indicating where and how ITS architecture and ITS standards fit into that process.

1.2 Intended Audience

This Best Practices Report is intended to be reviewed and used by project planners, specification writers, and project managers from transportation agencies in the State of New York.

For ITS project planners, this technical issue paper will introduce the relationship between ITS Architecture and the transportation planning process.

For specification writers, this document will show how to develop a Project Systems Engineering Analysis and identify operational concepts and functional requirements, which must be satisfied through ITS Standards-based project specifications.

1.3 Report Organization

Capital transportation projects in the State of New York follow a specific project development process. The process consists of:

- **Project Initiation Stage** – where projects are evolved from an identified transportation problem or need,

- **Project Scoping Stage** – where the project limits, requirements and design are identified.
- **Project Design Stage** – where the details of the projects are determined and documented in the form of a plans, specifications and estimates (PS&E) submittal, and,
- **Project Construction Stage** – where the project is built and implemented.

Section 1 focuses on the first two stages of the New York State Department of Transportation (NYSDOT) project development process, Project Initiation and Project Scoping. This section focuses on the requirements of FHWA Rule 940/FTA Policy, the development of a Regional (and Statewide) ITS Architecture and the Project Systems Engineering Analysis (PSEA). The impact of these two requirements on ITS standards and their relationship are discussed in detail. This discussion spans two chapters. The chapters are:

- **Chapter 2: The Role of Regional ITS Architecture in Project Programming.** Reviews the relationship between the regional ITS architecture and the transportation planning process in the State of New York.
- **Chapter 3: Project Systems Engineering Analysis.** Discusses the role of ITS Standards in writing project ITS architectures when requesting federal funding for ITS projects.

Section 2 focuses on how ITS Standards fit into New York State Department of Transportation's project development process, particularly in the Project Scoping and the Project Design stages.

- **Chapter 4: Project Design.** This section describes the information content required for ITS Standards in the Final Design stage of the project development process.

Several appendices are included in this document as reference and to support some of the concepts discussed in the document.

- **Appendix A: Overview of FHWA Rule 940/FTA Policy on Regional ITS Architecture and Project System Engineering Analysis.** Provides a high level overview of the requirements for regional ITS architecture and project-specific system engineering analysis.
- **Appendix B: DMS Specification.** Presents an example operations plan and specification, for the functional and NTCIP requirements for a dynamic message sign.
- **Appendix C: C2C Specification Example.** Presents an example specification for specifying center-to-center communications.

It is recommended that all users should read Chapter 1 for an introduction and overview to this document. All users unfamiliar with FHWA Rule 940/FTA Policy should also read Appendix A, which provides an overview to the intentions and requirements to the Rule/Policy.

Planners should read Chapter 2, which describes the relationship of ITS standards with the Statewide ITS Architecture, and Chapter 3, which discusses the USDOT requirements for federal funding of ITS projects.

Specification writers should read Chapters 3 through 4, which introduces the systems engineering analysis for developing projects, indicates how to use the a regional (or statewide) ITS architecture to determine high-level functional requirements, then how to write specifications for deploying ITS standards, and perhaps more importantly, how to test ITS standards. Specification writers should also look at the Appendices B and C, as appropriate, which provides examples of a concepts of operations document and specifications for ITS standards.

Project managers should skim through Chapter 2 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 3 then provides project managers with information on the different types of testing to verify an ITS project complies with the project specifications and conforms with an ITS standard. Chapter 4 then provides information on how to specify ITS standards.

1.4 Overview of Materials (Literature) Reviewed

During the writing of this technical issue paper, several documents were reviewed for guidance and for reference. These references included:

- **Federal Highway Administration (FHWA) 23 Code of Federal Regulations Parts (CFR) 655 and 940.** Entitled "Intelligent Transportation Systems (ITS) Architecture and Standards, also known as FHWA Rule 940/FTA Policy
- **National ITS Architecture Version 5.1.**
- **Regional ITS Architecture Guidance - Developing, Using and Maintaining an ITS Architecture For Your Region.** Dated October 21, 2001.
- **NTCIP (National Transportation Communications for ITS Protocol) Guide.** Version 3.
- **NTCIP Case Studies.** Includes NTCIP 9002 to 9009.
- **NTCIP Standards.** In particular, NTCIP 1201, 1203, 2306 and 9010, used in example materials in the appendices.
- **NYSDOT Highway Design Manual.** Revision 44, Chapter 21 – Contract Plans, Specifications and Estimates.
- **NYSDOT Project Development Manual.** Version EB05-007, dated January 20, 2005.
- **NYSDOT Region 11 – Project Systems Engineering Analysis.** Performed for the Western Queens Long Island Expressway Project, P.I.N. X228.65.

- **NITTEC Region 5 Specifications.** From NYSTA Contract D212922, Design of ITS in the Buffalo/Niagara Falls/Southern Ontario Region – Task 3 - Phase 3 Western New York ATMS Expansion
- **Stewardship and Federal-Aid Agreement Documents**. Various State Agencies.

2 Role of Regional ITS Architecture in Project Programming

2.1 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 and project programming process. The approach facilitates and provides a mechanism for the projects identified in a regional ITS architecture 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 (See Figure 3-1):

- Long Range Transportation Plan (LRP),
- Transportation Improvement Plan (TIP), and
- Project Scoping

In the State of New York, the Long Range Transportation Plan and Transportation Improvement Plan are generally developed under the auspices of a region's Metropolitan Planning Organization (MPO). Both these plans are fed by numerous transportation planning activities at the regional and local level. The third level of transportation planning is those developed by each transportation agency for its internal use and planning.

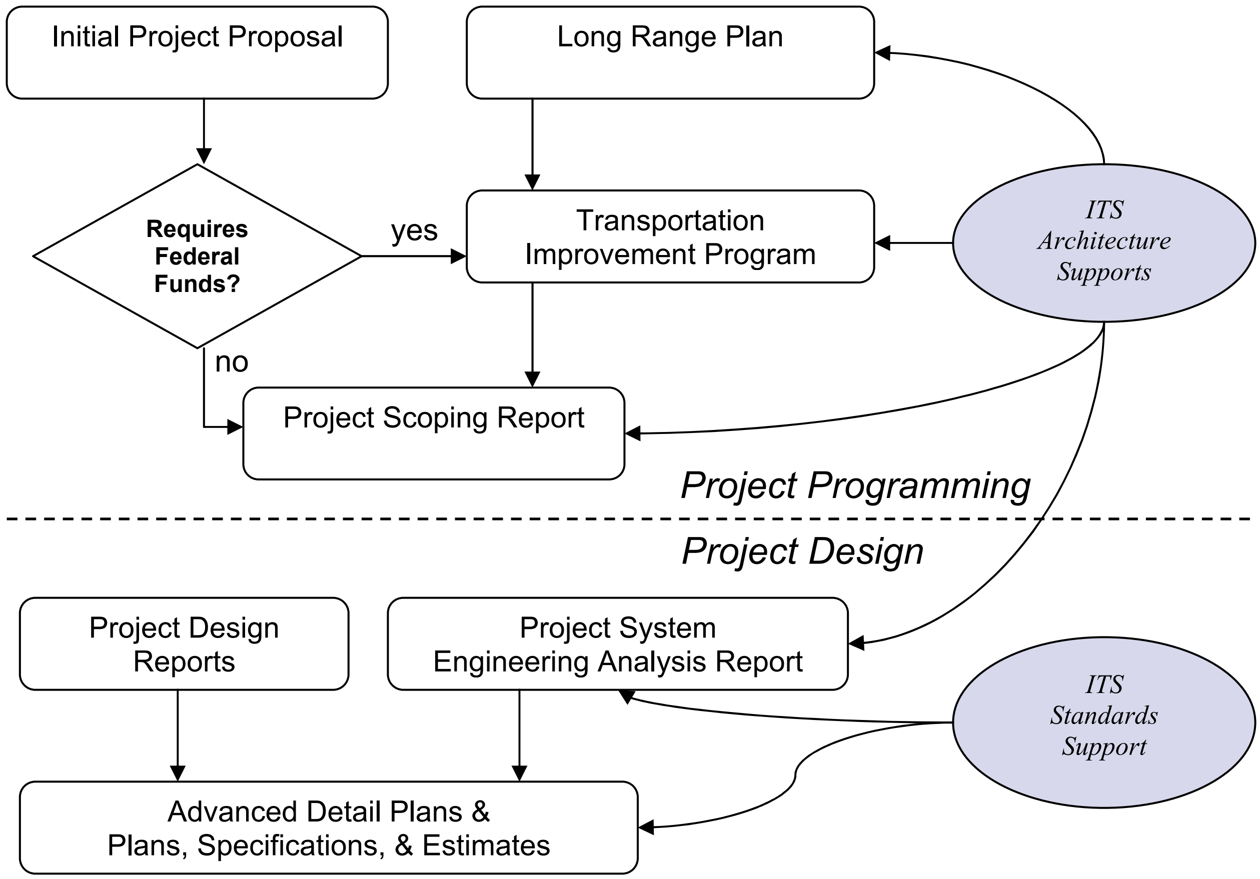

Figure 2-1. ITS Architecture and Standards Supporting NYSDOT's Project Development Process

2.2 *The Long Range Transportation Plan*

2.2.1 Introduction

The Long Range Transportation Plan (LRP) is one of the principal products of the transportation planning process for each Metropolitan Planning Organization. It is the representation of a region's long-term approach to constructing, operating, and maintaining the transportation systems in its region. It is also the forum for balancing transportation investments among modes, geographic areas, and institutions.

The LRP documents the goals and objects for the region over a 20-year (or longer) period. Federal requirements dictate that the LRP be updated minimally every three years and that an LRP 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 LRP. 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 LRP 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 achievements 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.

2.2.2 Regional ITS Architecture and Long Range Transportation Plan

Unfortunately, the Long Range Transportation Plan only provides a high level overview of the strategies, actions and transportation services desired for the region. Once the transportation goals and objectives for the region are defined, it is necessary to define more specific details of the strategies and transportation services needed to satisfy the regional goals depicted in the Long Range Transportation Plan.

A regional ITS architecture provides a short-term and long-term, multi-modal vision of how ITS and ITS projects can be deployed in the region to satisfy the goals and objectives outlined in the Long Range Transportation Plan. The regional ITS architecture provides the details on how ITS can be deployed to provide the transportation services and satisfy the strategies identified for the region. These details may include the interfaces, data exchanges, 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.

The regional ITS architecture also includes a complete inventory of the current and proposed ITS systems across all modes in the region (or state). 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.

However, like the overall transportation planning process, the relationship between the regional ITS architecture and the development of the LRP is an iterative process (See Figure 2-2). As ITS projects are implemented and completed, their deployment status should be updated in the regional ITS architecture. Updates to the regional ITS architecture provide feedback and information to the transportation planning process, including some necessary information to update to the LRP, such as 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.

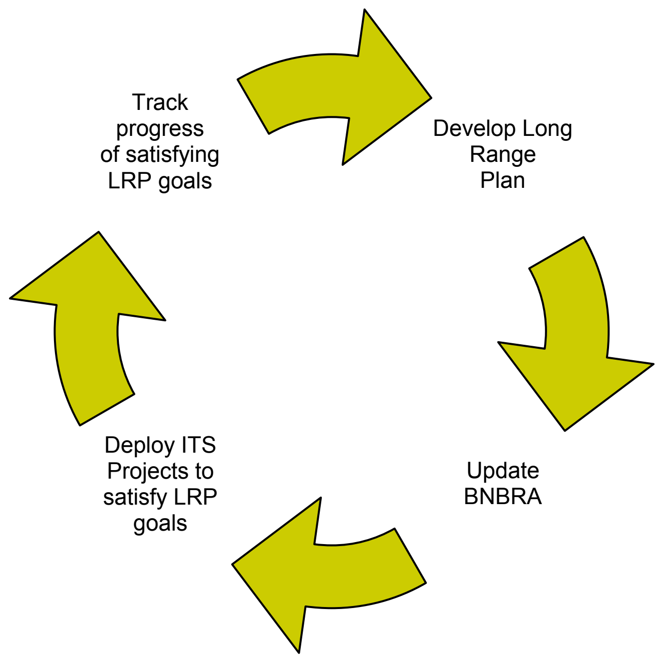

Figure 2-2. Regional Transportation Plan Process

As the LRP is updated, goals that were satisfied with the successful deployment of the ITS projects and transportation services should be noted. The goals and action plans in the LRP may need updates to reflect new needs and requirements as previous goals and plans are attained. New regional goals and strategies can be established based on new transportation needs, or the next steps in satisfying existing goals.

The process starts again as these new regional goals and strategies may then require updates to the transportation services provided by the regional ITS architecture, which may include 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 LRP is updated. New ITS projects may then be derived from the regional ITS architecture to satisfy the new regional goals and objectives.

2.2.3 Other Roles in the LRP

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 LRP 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.

2.2.4 Use Case – Contribution to the Long Range Transportation Plan

One of the goals defined in the Long Range Transportation Plan (LRP) of a fictitious MPO is to improve regional mobility and accessibility. Specifically, it is the ease of movement through the transportation system by users, with the appropriate access to desired destinations and alternative transportation modes. Improving the integrated multi-modal transportation system (which includes efficient and safe travel for travelers, seamless and overlapping service, and a few other objectives) were also goals of the TIP.

In the regional ITS architecture, several transportation services were identified that will contribute to meeting these regional objectives. They include ATMS08 – Incident Management; ATMS16 – Parking Facility Management; APTS7 – Multi-Modal Coordination, and ATIS1 – Broadcast Traveler Information.

Table 2-1. Use Case – Transportation Services

Market Package	Description	Services Provided
ATMS08	Incident Management	Manages both unexpected incidents and planned events so that the impact to the transportation network and traveler safety is minimized. Includes incident detection capabilities through regional coordination with other traffic management, maintenance and construction management and emergency management centers as well as rail operations and event promoters.
ATMS16	Parking Facility Management	Provides enhanced monitoring and management of parking facilities. It collects current parking status, shares this data with Information Service Providers and Traffic Management.
APTS7	Multi-Modal Coordination	Establishes communications between multiple transit and traffic agencies to improve service coordination to increase traveler convenience at transit transfer points and improve operating efficiency. Transit transfer information is shared between Multimodal Transportation Service Providers, Transit Agencies, and ISPs.
ATIS1	Broadcast Traveler Information	Collects traffic conditions, advisories, general public transportation, parking information, and incident information and broadly disseminates this information through existing infrastructures. The information may be provided directly to travelers so that they can better inform their customers of travel conditions.

Customized market package diagrams were developed in the Buffalo-Niagara Bi-National Regional ITS Architecture to provide these transportation services, and are depicted here as examples. A customized market package diagram for each transportation service identified is provided in the following figures.

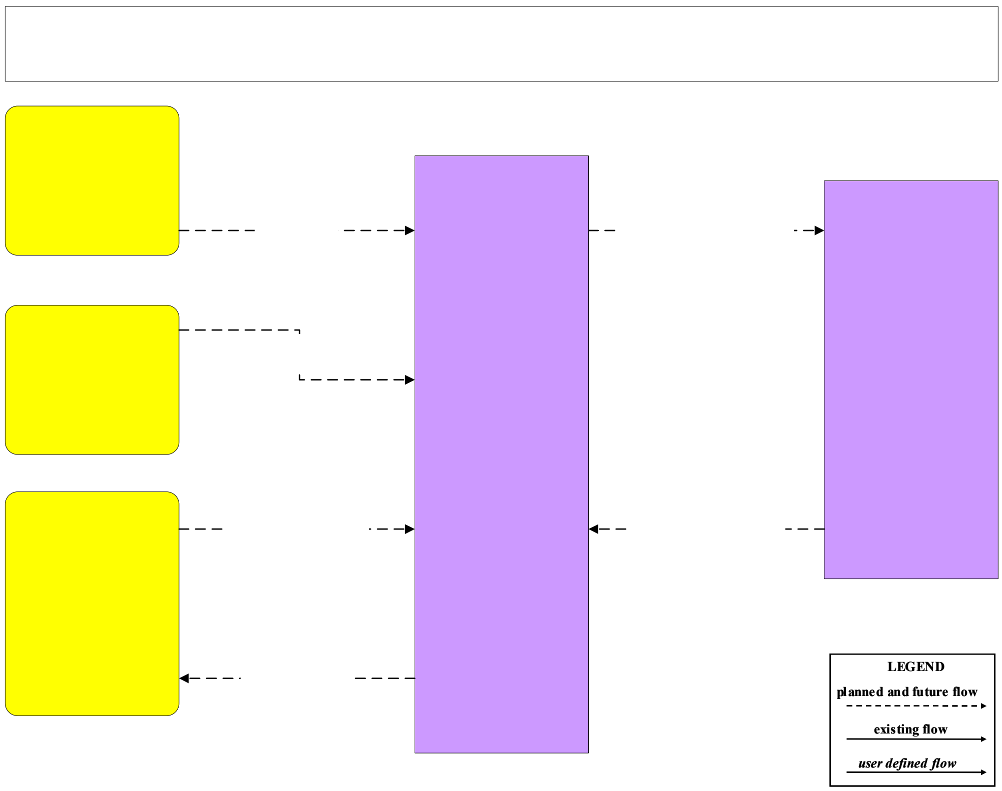

Figure 2-3. Use Case - Transportation Services – Incident Management

Event Promoters

Local Venue Event Scheduling System
+
Municipalitv Event
Permi

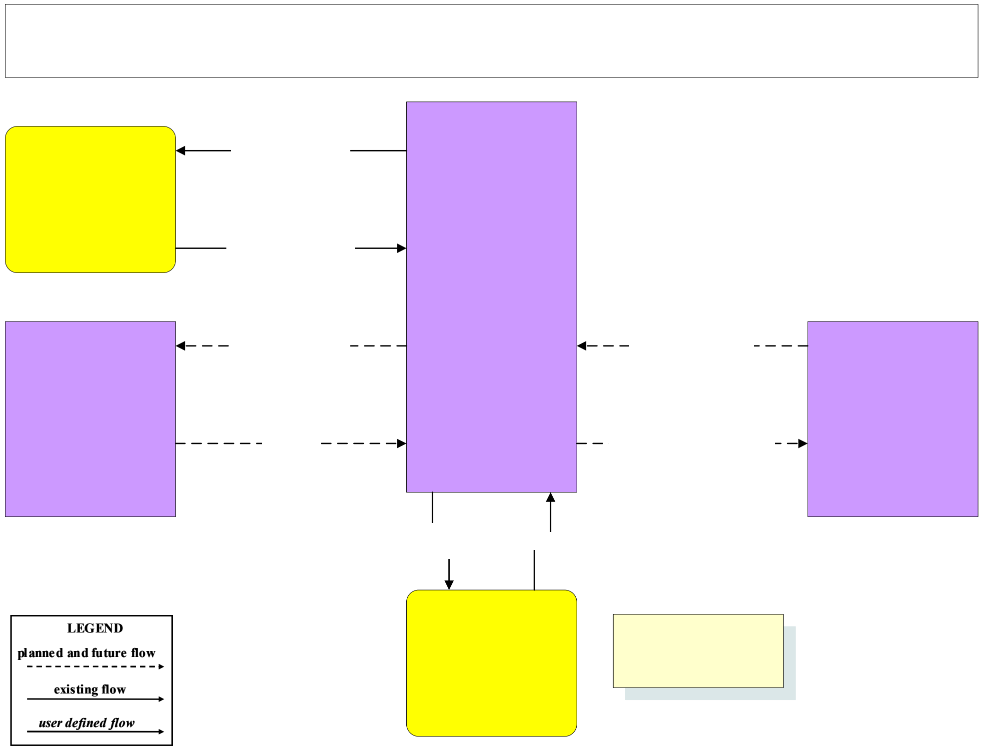

Figure 2-4. Use Case – Transportation Services – Parking Facility Management

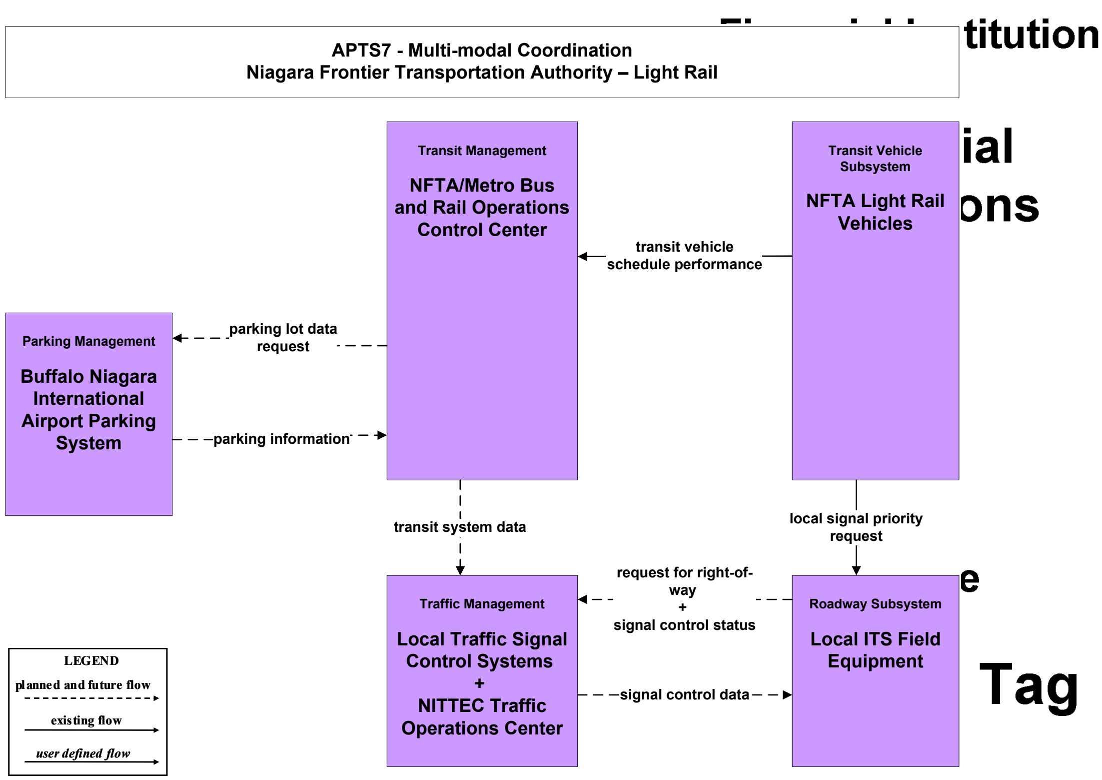

Figure 2-5. Use Case – Transportation Services – Multi-modal Coordination

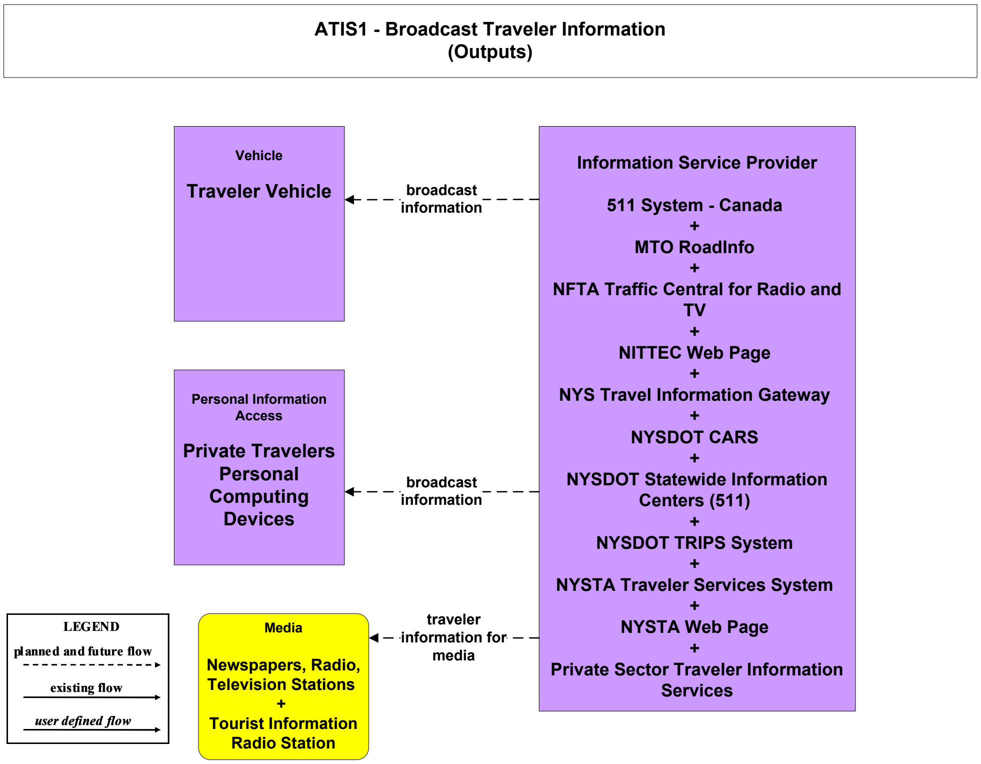

Figure 2-6. Use Case – Transportation Services – Broadcast Traveler Information

2.3 The Transportation Improvement Program (TIP)

2.3.1 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 Long Range Transportation Plan (LRP). For some MPOs, the TIP is also the capital program, normally over a 5-year period, which implements the goals and objectives identified in the region's Long Range 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 LRP. 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 the transportation agency members that comprise the MPO 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 of ITS projects on the TIP does not guarantee Federal funding, but it does make that funding possible. For some MPOs, 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 LRP 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

2.3.2 The Initial Project Proposal and Transportation Improvement Program Process

Federal requirements mandate that an MPO periodically updates its TIP. The process to update a TIP varies for each MPO, but generally involves the formation of a committee responsible for reviewing and making recommendations for including projects on the TIP. This committee, generally comprised of transportation officials from member agencies in the region, is 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.

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

It is also during this updating process that new improvement projects are identified, individual plans and programs of the MPO member agencies are considered, and the status of projects already in the TIP are updated. MPO members, local municipal officials and the public are also solicited for additional proposals for new transportation improvements.

To be considered for inclusion in the TIP, proposed projects are generally submitted via an application form to the committee. Some MPOs have their own application forms, but some other MPOs use the NYSDOT Initial Project Proposal (IPP) application to initially record their proposed improvement projects for inclusion on the TIP (See Section 2.1.5 of the NYSDOT

Project Development Manual). The completed application forms are evaluated based on their relevance to the Long Range Transportation Plan and on the criteria of the proposed funding source. The proposed improvements are studied in greater detail by the subcommittee with alternative solutions developed and analyzed along with other external factors (such as economic and environmental impacts) before improvement projects are defined.

Next, the committee selects the transportation improvement projects to be included in the next update of the TIP. These improvements are organized by the priorities of the member agencies, and then the committee makes recommendations on the amendments to the TIP as necessary to maintain project viability and fiscal constraints.

It is recommended that the TIP Process for each MPO be updated so that the criteria for identifying ITS projects for the TIP include whether the ITS project is represented in its regional ITS architecture. The criteria may also be expanded to also consider if the ITS project is considered a short-term or long-term priority in the regional ITS architecture. A discussion of the priority of an ITS project within a regional ITS architecture is discussed in the next two sections (Sections 2.3.3 and 2.3.4).

2.3.3 Role of the Regional ITS Architecture in defining the TIP

2.3.3.1 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 ITS projects; ITS projects are an output of a regional ITS architecture. The regional ITS architecture defines projects, and project descriptions, via the customized market packages that are created during the regional ITS architecture development process. Using these customized market packages, projects can 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 operational concepts, functional requirements, system interfaces and the information flows between the systems required to support the desired transportation services depicted in the diagrams. The diagrams identify elements, system interfaces and information flows that do not exist or are already part of project scopes with identified funding sources.

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 Long Range 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.

2.3.3.2 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 require a significant investment by the public agencies and private companies in the region. Unfortunately, funding is never immediately available to support all these desired 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 MPO committee determine those 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?).

One of the requirements of FHWA Rule/FTA Policy on ITS Architectures (FHWA Rule 940“Intelligent Transportation Systems (ITS) Architecture and Standards”, and FTA Policy “National ITS Architecture Policy on Transit Projects” - See Appendix A) is that a regional ITS architecture include a project sequence for implementing ITS projects in the region. Using the list of projects identified in 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. This same sequence of projects can provide a major input to this aspect of prioritization for the TIP.

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 may 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 Long Range 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 could be the lack of a common street names database between different agencies, such as NYSDOT, county public works departments, local police departments, or the transit agency, 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 include 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 provide 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.

Project dependencies also include the status of current and planned ITS and non-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 ITS systems, or elements, are required to satisfy a regional need. In these cases, both ITS systems (one to send the information flow, one to receive the information flow) must be deployed before the information can be exchanged. If one system is not deployed, the flow will not exist, thus the regional need cannot be satisfied and the desired transportation services cannot be provided. For example, a dynamic message sign that is deployed in the field has limited effectiveness if no DMS software is available to control the sign from a remote location, such as a traffic management center.

Based on the project sequencing in the regional ITS architecture, high priority projects and market 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, regional transportation goals/initiatives, 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.

2.3.4 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 (from the regional ITS architecture) 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 indicates 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. Although ATMS06 was deemed a medium priority project, the addition of this market package was also added to the project description in the TIP because of the financial analysis, 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 packages were 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."

2.4 Project Scoping

A major step in the deployment of ITS systems is the development of design documents and procurement specifications. The project development process (at a high level) for the State of New York for deployment of field equipment and systems includes: project scoping, review of alternative designs, and the development of plans, specifications, and estimates (PS&E). The general development process for center-based systems (those not including any field equipment) will be similar.

The exact details and steps to write a procurement may differ from agency to agency within the State of New York, but the general process is similar. However, this technical issue paper focuses on the project development process adopted by NYSDOT.

Capital transportation projects in the State of New York follow a specific project development process. The process consists of:

- **Project Initiation Stage** – where projects are evolved from an identified transportation problem or need,
- **Project Scoping Stage** – where the project limits, requirements and design are identified.
- **Project Design Stage –** where the details of the projects are determined and documented in the form of a plans, specifications and estimates (PS&E) submittal, and,
- **Project Construction Stage** – where the project is built and implemented.

Project scoping begins after the approval of the Initial Project Proposal (IPP). The purpose of the project scoping includes:

- Understanding the problems and the needs
- Establishing project objectives and the design criteria
- Identifying feasible alternatives

Although the project scope should have already been defined in the transportation plan and for the approval of the IPP, the details of the project must be updated to fit the current situation and needs. The increased detail may result in a design report, known in the NYSDOT project development process as the Project Scoping Report.

2.4.1 Project Scoping Report

The output of the project scoping stage is a Project Scoping Report. The Project Scoping Report documents the scoping decisions and the considerations upon which those decisions were made. The design report includes an analysis of existing conditions and explains what will be designed and reviews alternate design options. A well prepared Project Scoping Report provides a clear, understandable, and acceptable "picture" of what is to be accomplished. The report is a structured record of the evolution of a project and ensures that project needs have been well defined, a consensus on objectives has been achieved, design criteria established, feasible alternative(s) identified, and a cost estimate prepared. Information in the Project Scoping Report includes estimating the resources required to complete the project, the roles and responsibilities of the agencies and departments involved, and defining the constraints on the project. For projects that incorporate ITS elements, compliance with the Statewide or Regional ITS Architecture must be ensured.

The Project Scoping Report is also used to grant scope approval and to guide subsequent stages of project development. The Project Scoping Report becomes a first draft of a draft design report or draft design report/environmental document. The format of the report serves as a checklist to ensure that relevant issues are considered prior to project scope approval. The same document, with appropriate changes and details, can also be used for design approval.

Following this format, makes it possible to use the same report format to cover the scoping and project design phases I-IV.

2.4.2 Regional ITS Architecture in Project Scoping

Projects that emerge from the Project Initiation Stage can benefit from the use of the regional ITS Architecture in their definition and development. The regional ITS architecture can be used to support in developing the project scope. A project extracted from a regional ITS architecture can be defined in terms of the transportation services it will provide and by the major system pieces it contains. The regional ITS architecture can also indicate the project constraints. Types of constraints may include geographical (e.g., a specific freeway, transit line or geographical area), functional (detailed descriptions of the functional requirements, and perhaps what functional requirements are not required), and financial.

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. Through the regional ITS architecture, the author of the project scoping report can identify and include in the project descriptions what transportation services the project provides. Descriptions of the transportation services can be derived from the market package definitions. 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.

Because project definition and scoping focus on meeting transportation users' needs, and not on solutions, it is recommended that the level of detail covered during project definition and scoping be that which is contained in the regional ITS architecture.

Through an analysis of the applicable customized market package diagrams in the regional ITS architecture, the relevant information exchanges (architecture flows) between ITS systems can also be derived. From the regional ITS architecture, analyzing these architecture flows will yield a list of ITS standards that may be applicable to the project. At this level of granularity a high level discussion of which standards may be considered in the ITS project would be sufficient.

3 Project Systems Engineering Analysis

3.1 Introduction

The intent of the FHWA Rule / FTA Policy On ITS Architectures is to provide policies and procedures by which to implement ITS projects in an efficient manner and to accelerate the deployment of integrated Intelligent Transportation Systems (ITS). There are two (2) key requirements resulting from the FHWA Rule/FTA Policy to satisfy the FHWA Rule / FTA Policy. The first requirement is the development of a regional ITS architecture in a region for ITS projects. The second requirement is that all ITS projects in the region be developed using a systems engineering analysis.

The systems engineering analysis is a methodical process to define and develop a system. It ensures the development of a system that reflects the needs of the user (agency), leads to improved systems reliability and stability, and improves the chances of a system development that is on-time and on budget. To satisfy the systems engineering analysis requirements, agencies are required to submit a Project Systems Engineering Analysis document that demonstrates the use of systems engineering during the development of the ITS project.

3.2 Systems Engineering Analysis for ITS

The Project Systems Engineering Analysis (PSEA) is the document that defines a project scope and systems engineering approach for these ITS projects, and is required for projects that use federal funds. There are 7 requirements for a PSEA, of which several sections address details about the application of ITS standards in projects.

First, the PSEA identifies those portions of the regional ITS architecture being implemented. The PSEA identifies the ITS elements and architecture flows (information and control exchanges) applicable to the ITS project for which funding is requested. Given a list of architecture flows, one can make a project-specific selection of applicable ITS standards, as the architecture flows are mapped to the ITS Standards in the National ITS Architecture.

Second, the PSEA identifies the functional requirements for systems (and/or system interfaces) that will be developed within the ITS project. This section should use the system functional requirements defined in the regional ITS architecture as a starting point.

The PSEA includes an analysis of alternative system configuration and technology options. While the regional ITS architecture is technology neutral, most of the ITS standards address specific requirements and design details that are technology specific. Therefore, the standards have been developed to support a variety of design choices. To the extent that certain design constraints have been identified for an ITS project (e.g., compatibility with existing equipment, desire to leverage an existing communications infrastructure, etc.), this section should present the alternatives with their associated ITS standards-based technical solution(s).

Finally, the PSEA discusses the applicable ITS standards and testing procedures. This section of the PSEA should include a discussion about which standards were considered for implementation and which were selected for the project. It also explains why, where one or more standards exist for implementation, an ITS standard will not be considered for the project. For example, the justification may include an explanation that the standard is not mature, or that there are not sufficient vendors that have implemented the standard in their products, etc.

This section of the PSEA needs to specify WHAT needs to be in the project's PS&E or consultant contract regarding ITS Standards. It should narrow the scope of ITS standards to:

- For center-to-center communications, list of applicable messages, but not necessarily specific message content, and whether to use DATEX or XML.
- For center-to-field communications, a complete list of ITS standards required for the project, per device, including support standards (e.g., 1100 series, Global Objects, etc.) but not the specific data objects themselves.

This section of the PSEA also identifies the data communications options/protocols required. Examples of data communications options that are relevant to center-to-field communications and covered by the ITS Standards include: Ethernet, Dial-up, and FSK modem. Example of center-to-center data communications options include XML-based, and DATEX protocols.

For testing procedures, this section of the PSEA should provide an outline of what needs to be tested, and an outline of what test procedures need to be specified in the PS&E.

3.3 PSEA Requirements

Information used in a PSEA will be derived from a variety of sources including: New York Statewide ITS Architecture, National ITS Architecture Version 5.1, 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 an PSEA. Each represents one of the seven (7) stated requirements for a complete PSEA document.

1. **Portions of Regional ITS Architecture Being Implemented**. Assess portions of the regional ITS architecture that apply to the project. This can be accomplished by conducting a preliminary review of the customized market package diagrams from the New York Statewide ITS Architecture or regional ITS architecture, the 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 statewide or 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 a 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.
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.

3.4 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 New York City Freeway Expansion project. This example shows only one possible means to satisfy the PSEA requirements.

3.4.1 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 3-1. 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 ITS architecture are shown mapped to one or more subsystems or terminators of the National ITS Architecture. ITS project elements are highlighted in italic, bold, blue text.

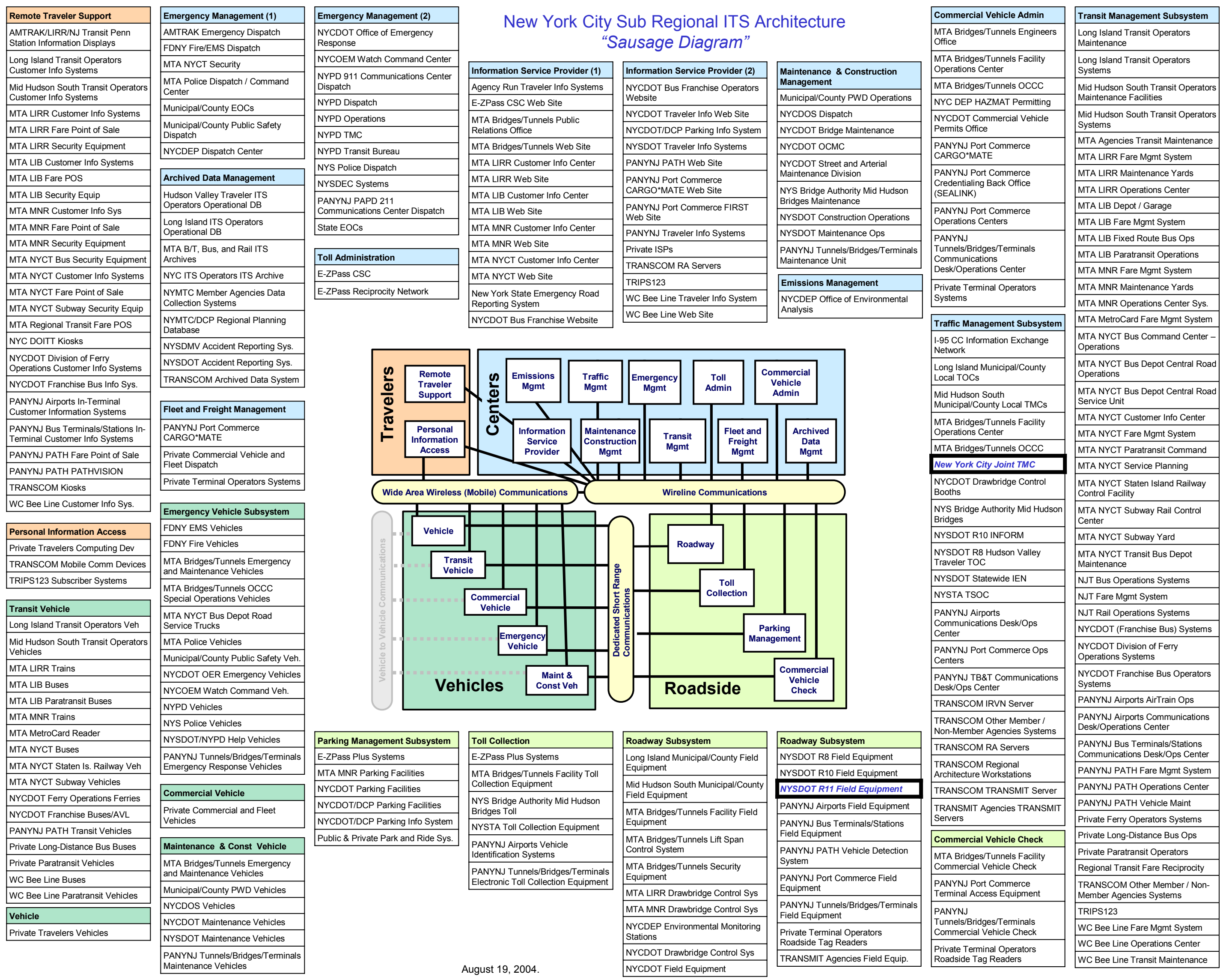

Figure 3-1. Portion of the Regional ITS Architecture Covered by NYC Freeway Expansion Project

3.4.1.1 Customized Market Package Analysis

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

Table 3-2. Customized Market Package Analysis Results

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

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

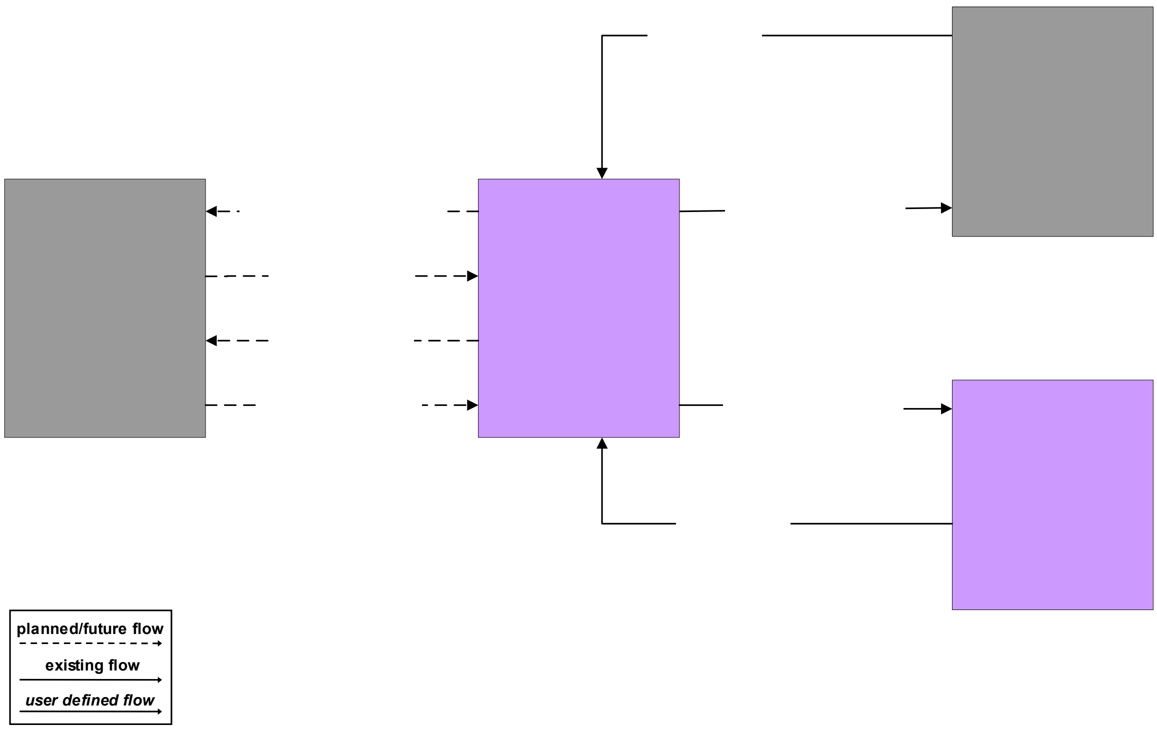

Figure 3-2. ATMS01 - Network Surveillance Customized Market Package

Information Service Provider

road net

NYCDOT Traveler Information W

Site

traffi

traffi

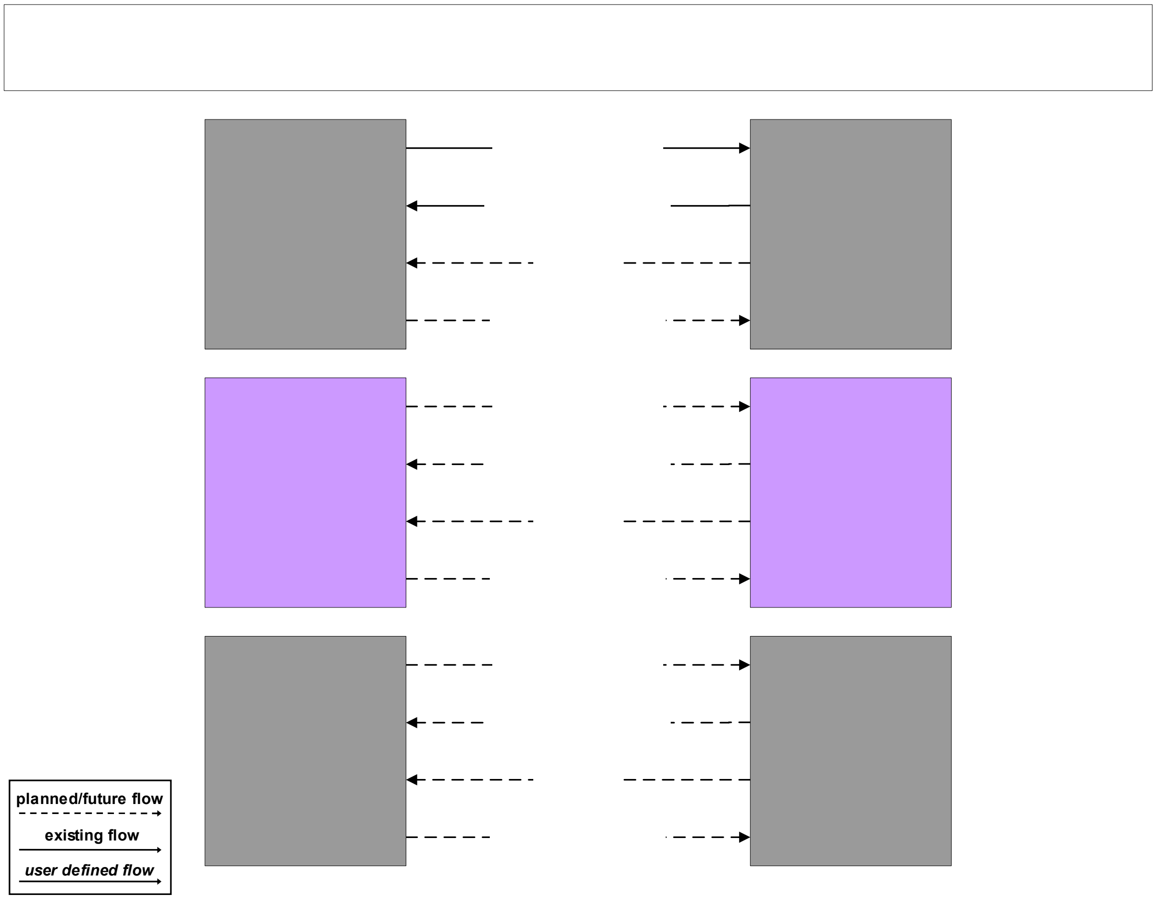

Figure 3-3. ATMS04 – Freeway Control Customized Market Package

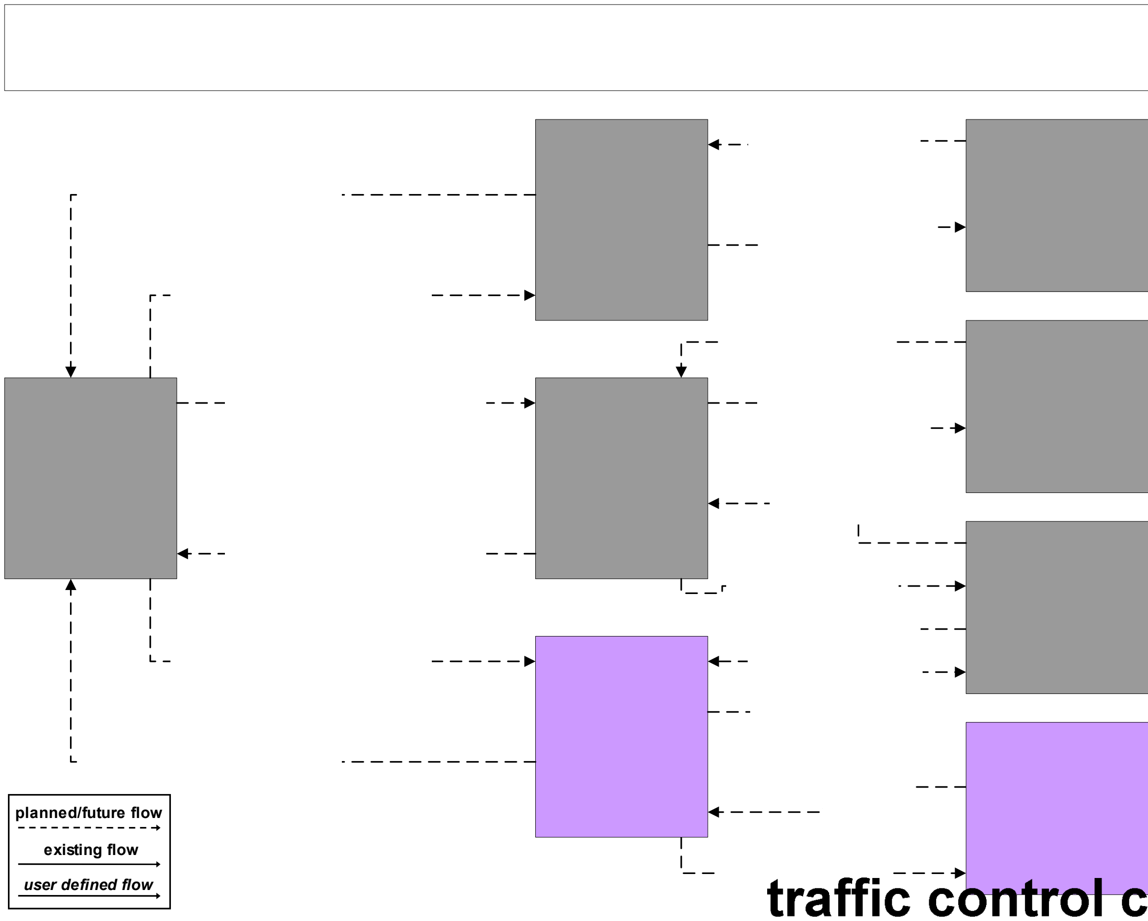

Figure 3-4. ATMS06 – Traffic Information Dissemination Customized Market Package

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

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

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

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

3.4.2 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 3-4. Participating Agencies Roles and Responsibilities

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

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

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

This includes:

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

3.4.3 Requirements Definition

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

The requirements table shows the following:

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

Table 3-5. Requirements Definition Table

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

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

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

3.4.4 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 two categories:

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

Each is reviewed briefly below:

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

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

3.4.5 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 3-6. Procurement Options

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

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

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

3.4.5.1 Example ITS Equipment Cost

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

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

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

3.4.5.2 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*

3.4.5.3 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.

3.4.6 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.

3.4.6.1 Discussion - Relationship of ITS Architecture to Standards

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

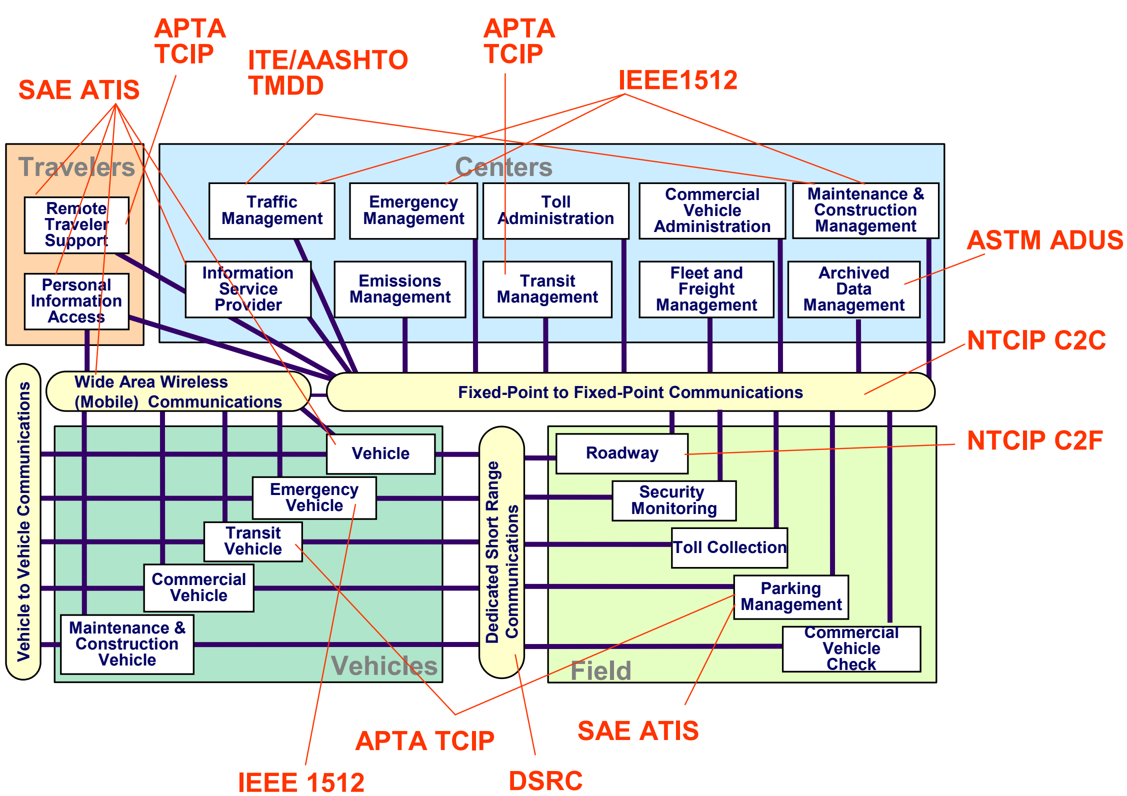

Figure 3-5. Relationship of the National ITS Architecture to ITS Standards

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

3.4.6.2 Selection of Applicable ITS Standards

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

Table 3-7. List of Applicable ITS Communications Standards

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

3.4.6.3 ITS Standards Related Considerations

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

- Adding NTCIP communications may require modification to the central software. The previously developed central software may be based on non-standard , proprietary protocols of the manufacturers. To integrate NTCIP compliant field equipment, the central software will need to be modified to support SNMP (Simple Network Management Protocol), as defined by NTCIP as the transport of objects to/from ITS devices. In addition, the central software may need to continue to support the existing (legacy) equipment. Additional effort, measured in terms of cost and schedule, may be necessary to incorporate the ability of the central software to communicate with the field equipment.

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

3.4.6.4 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:

- Design Verification Tests
- Power-On Tests
- Stand-alone Tests

- Final Acceptance Test
    - System Interface Tests
    - System Performance Tests, and
    - 30 Day Operational Tests

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

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

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

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

3.4.6.5 NTCIP Testing

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

Documentation
The manufacturer should always provide NTCIP and MIB documentation in electronic form. Statements similar to the following should be included in the 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-Bang* Testing Unit or other testing tool.
- The manufacturer will submit an NTCIP test plan a minimum of 30 days prior to NTCIP acceptance testing. NTCIP acceptance testing will be performed on one of the field devices manufactured under this contract. Testing will be performed at the manufacturer's (or agency's, if this applies) facility.

NTCIP Interpretation Resolution

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

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

3.4.7 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.

4 Project Design

4.1 Introduction

The Project Design stage of a project consists of six design phases, some of which may not apply depending on the type of project, scope of work, environmental classification, public involvement, etc. The first four design phases make up the preliminary design stage of a project and the last two design phases make up the final (or detailed) design stage. It is suggested that the PSEA be completed and approved prior to the Project Design stage, and that a concepts of operations be performed as a pre-step of the Project Design stage (as relates to ITS Standards specification development).

- **Design Phase I - Development of Feasible Design Alternatives, Identification and Assessment of Impacts.** Design Phase I consists of the steps necessary to continue the involvement of all stakeholders to further develop the design alternatives and to prepare the draft design approval document and progress appropriate reviews.
- **Design Phase II - Advisory Agency Review.** Design Phase II is the distribution of the draft design approval document for review and comment by federal, state and local advisory agencies. This phase will not apply to most projects.
- **Design Phase III - Public Hearing/Information Meeting.** Design Phase III consists of the steps necessary to prepare for and conduct the public hearing or information meeting. This phase will not apply to most projects.
- **Design Phase IV - Final Evaluation, Recommendation, and Design Approval.** This phase consists of the approval of a design report. The design report contains the final evaluation of comments received from the public and advisory agencies, and the selection of the preferred alternative. All plans and profiles should contain sufficient detail to support the selection of the build alternative.
- **Design Phase V - Advance Detail Plans (ADPs).** This phase consists of the steps necessary for the preparation of 90% complete plans and the review of the plans within NYSDOT and, if applicable, by FHWA, local agencies, and organizations with jurisdiction over the project area.
- **Design Phase VI - Final Plans, Specifications And Estimates (PS&E).** This design phase consists of the steps necessary to prepare and submit the Final PS&E for contract letting.

Only Design Phases V (ADPs) and VI (PS&E) need to include specific information about ITS standards.

4.2 Final Design

The output of the preliminary design stage (Design Phases I-IV) is a Final Design Report. The information and details in the Final Design Report will vary depending on the type of project, the complexity of the project and the funding source. Information included in the Final Design Report may include expanded details from the Project Scoping Report, final evaluation of comments from the public and participating agencies, environmental determinations, and the selection of the preferred design alternative.

The outputs of the Detailed/Final design stage are the Advanced Detailed Plans (ADP) from Design Phase V, and the Final Plans (if applicable), Specifications, and Estimates (PS&E) from Design Phase VI. The Advanced Detailed Plans are 90% complete and are used for final review by NYSDOT and other participating agencies. The Final PS&E are used by NYSDOT for contract letting.

4.2.1 ITS Standards in the Final Design

Since ITS Standards are communications standards, the appearance of ITS Standards in the Detailed/Final Design will be limited to the Specifications of the project. From the PSEA, a list of ITS standards that may be applicable to the project has been created. The next step is to determine if any applicable ITS standard supports the user and functional requirements that have been defined. Rarely will an agency need all the functions and messages that an ITS standard supports, thus the project specifications should specify the required data objects (center-to-field) or messages (center-to-center) for a project.

Many ITS standards also contain mandatory and optional elements. To "conform" to an ITS standard, a system must support ALL the mandatory elements of that standard. However, the system is NOT required to support ANY of the optional elements to "conform" to the same standard…those optional elements are just that, optional. Thus the project specifications should specify which of the OPTIONAL elements of the ITS standard is required to be implemented for the project. In that case, if the system is to "conformant" to the ITS standard, it must also implement those optional elements as required by the ITS standard.

Conversely, there is also a possibility that an ITS standard does not support all the user and functional requirements that have been defined. 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 be deployed and tested by numerous agencies, and has industry-wide support. Although the standards development organizations attempt to support the most common user requirements and needs, it cannot always do so, or may satisfy those requirements and needs in a different manner. In this case, agency-specific objects or messages may be needed, and the requirements should be included in the specifications.

Although the regional ITS architecture identifies the applicable national standards, the individual projects must 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. It may also be necessary to consider any regional standards that have been adopted in use in the region or state. Common examples of regional standards in New York State include the E-ZPass IAG interfaces or the TRANSMIT data interfaces.

Some center-to-field ITS standards 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. In the case of center-based system message set standards, the solutions are in the form of data elements and messages that must be supported.

4.3 ITS Standards-based Specification - Concept of Operations

One of the steps in the systems engineering process is the development of a concepts of operations document, or ConOps for short. The ConOps in ITS defines the relationship between the ITS system being deployed and organization what will operate the system. It describes in easy to understand terms how the ITS "system" will be used (its operational characteristics) and what transportation problem is being solved through the implementation of the system.

The ConOps should be developed as part of the project development process to clearly define the user needs and operational context for the functions that the ITS system will support. It is also recommended that the ConOps and PSEA documents be developed within a similar timeframe and prior to the project design phase. The ConOps should be developed as a stand-alone document, as it may become part of the final PS&E.

The ConOps should also be developed with participation from the various stakeholders and users of the ITS System. Information belonging in a Concept of Operations document may include:

- **Identification of Stakeholders**. Includes who the users are, and who is affected by the system. This may includes the operations department (operates the system), maintenance department (maintains the system), and public safety agencies (makes requests).

- **Development of a Vision.** What the outcome of the ITS System will be. For example, will provide travelers with real-time incident and diversion information.
- **Description of Where the System will be Used**. What is the geographic area, what jurisdictions will have use the system, and what organizations will the ITS system support?
- **Description of Organizational Procedures or Practices.** Defines what activities are to be performed, the information flows between organizations, and the organizational relationships and responsibilities. For example, it may include the procedures on how public safety agencies make requests for action, and how maintenance requests are monitored and made.
- **Definition of Critical Performance Parameters**. Defines the expectations.
- **Utilization Environment.** Describes the conditions under which various parts of the system(s) will be used. This may include “normal” conditions, poor weather conditions, and incidents.
- **Performance Measures.** Defines how the system “performs” its intended “mission”.
- **Life Cycle Expectations.** How long is the ITS System expected to last? This affects the vision, the system capacity (expandability), provision for future upgrades, and budgeting (capital and maintenance).
- **Environmental.** Defines the conditions under which the ITS system must operate. This includes environmental conditions such as temperature, humidity, power failures, and communications failures.

4.4 Project Systems Engineering Analysis in Project Design

An activity that is suggested to be performed prior to the developing the Concept of Operations is the Project Systems Engineering Analysis. The PSEA can be used as a starting point for development of the ConOps. This includes:

- Assessing the portions of the regional ITS architecture being implemented in this project
- Roles and responsibilities for the participating agencies (and stakeholders) in this project
- High level functional requirements
- Alternative system configuration and technology options
- Procurement options, and

- A general concept of operations outlining the procedures and resources necessary to operate and maintain the new system

The example in Section 3.3 provides detail and suggestions on how to apply the regional ITS architecture and ITS Standards in the PSEA.

4.5 Operations Plan

From an ITS Standards point-of-view, the concepts of operations document should be much more focused on the operational aspects. Although some of the more institutional and planning aspects do contribute to how the system is used, they do not directly affect what or how ITS standards are used in the ITS system. Instead, based on the concept of operations document, an operations plan may be desired. The operations plan focuses more on the details on how the ITS system will be used once the system is deployed, both under normal operation and abnormal operations (such as during an emergency or during maintenance). This operations plan can then used to develop the detailed system functional requirements, based on the needs and operational concepts identified in the document.

4.5.1 Center-To-Field Communications

The operations plan for an ITS system requiring 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.
- **Operations 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.

To provide an illustration of the concepts discussed above, a partial operations plan for a DMS (dynamic message sign) system is included in Appendix B.1.

4.5.2 Center to Center Communications

Similarly, an operations plan may be desired for ITS systems utilizing center to center communications. An operations plan for focuses on the details and conditions on what data exchanges will occur between central systems, both under normal operation and abnormal operations. The operations plan may also include when and how these data exchanges will occur. This operations plan can then used to develop the detailed system functional requirements, based on the needs and operational concepts identified in the document. The operations plan should include discussion of 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.

4.6 NTCIP Communications Specification

4.6.1 Center to Field Communications

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.2.

4.6.2 Center to Center Communications

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 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.

Appendix A – Overview of FHWA Rule 940/FTA Policy on Regional ITS Architecture and Project Systems Engineering Analysis

Introduction

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 (CFR) Parts 655 and 940, entitled "Intelligent Transportation Systems (ITS) Architecture and Standards" on January 8, 2001. The rule became effective on April 8, 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 Final FTA 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:

(a) the development of a local implementation of the National ITS Architecture, referred to as a regional ITS architecture.

(b) that all ITS projects be developed using a systems engineering analysis.

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.

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.

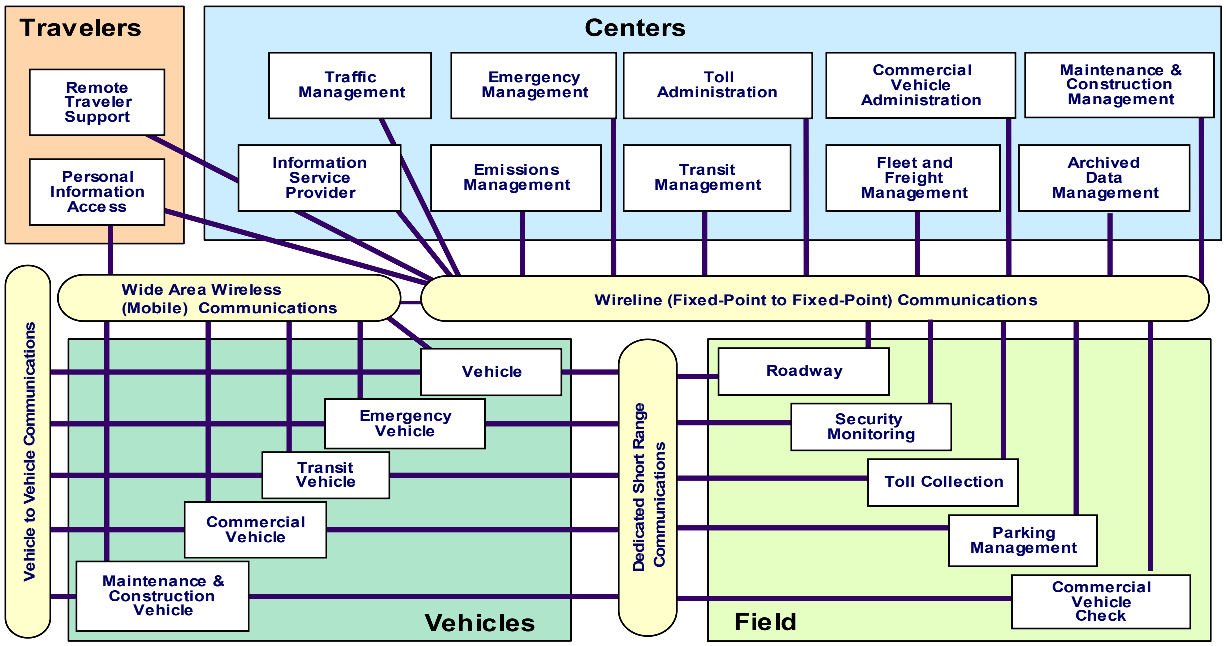

Figure A-1. National ITS Architecture Version 5.0 Sausage Diagram

The regional ITS architecture, which is based on the National ITS Architecture but customized to meet a region's (or a state'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

Project Systems Engineering Analysis (PSEA)

Systems engineering can be defined as a structured process for arriving at a final design of a system. The final design is selected from a number of alternatives that would accomplish the same objectives and considers the total life-cycle of the project including not only the technical merits of potential solutions but also the costs and relative value of alternatives.

The Project Systems Engineering Analysis (PSEA) is a set of requirements from FHWA Rule 940/FTA Policy for project implementation. The requirements state:

(a) All ITS projects funded with highway trust funds shall be based on a systems engineering analysis.

(b) The analysis should be on a scale commensurate with the project scope.

(c) The systems engineering analysis shall include, at a minimum:

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

All ITS projects are required to conform to the systems engineering requirements listed above. The requirement is that project development of ITS projects are to be based on the relevant parts of the regional ITS architecture that the project implements. ITS projects are also required to use applicable ITS standards and interoperability tests that have been officially adopted by U.S. DOT. However, as of the date of this report, no ITS standard or interoperability test has been officially adopted.

Appendix B.1 – Example DMS Specification Operations Plan

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.2 – Example DMS Specification NTCIP Communications

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	
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.	

Requirements ID	Functional Requirement	Project Requirement
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.	
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.	

Requirements ID	Functional Requirement	Project Requirement
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);
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);

Requirements ID	Functional Requirement	Project Requirement
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.	
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.	

Requirements ID	Functional Requirement	Project Requirement
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.	
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.	

Requirements ID	Functional Requirement	Project Requirement
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.	
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).	

Requirements ID	Functional Requirement	Project Requirement
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.	

Requirements ID	Functional Requirement	Project Requirement
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.	
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.	

Requirements ID	Functional Requirement	Project Requirement
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.	

Requirements ID	Functional Requirement	Project Requirement
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.	

Requirements ID	Functional Requirement	Project Requirement
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.*

Requirements ID	Functional Requirement	Project Requirement
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.	

Requirements ID	Functional Requirement	Project Requirement
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.*

Requirements ID	Functional Requirement	Project Requirement
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.

Appendix C – Example Center to Center Interface Specification

Introduction

This section includes a general introduction to the project. The introduction should include the following sub sections.

Project Background
List of Involved Centers and Center Types

General Requirements

This section includes general normative information related to this specification. The introduction should include the following sub sections.

Definitions
References
Conformance
Property/Ownership Rights

Center Interface Definitions

This section defines the NYSDOT center's interfaces to external center systems including: operations (functions) supported, message inputs and outputs, and message transport.

Operations

Operation: OP_ShareTrafficLinkInformation

The figure below illustrates the message inputs and outputs of the OP_ShareTrafficLinkInformation operation.

Operation: OP_ShareTrafficLinkInformation
State Traffic Management Center

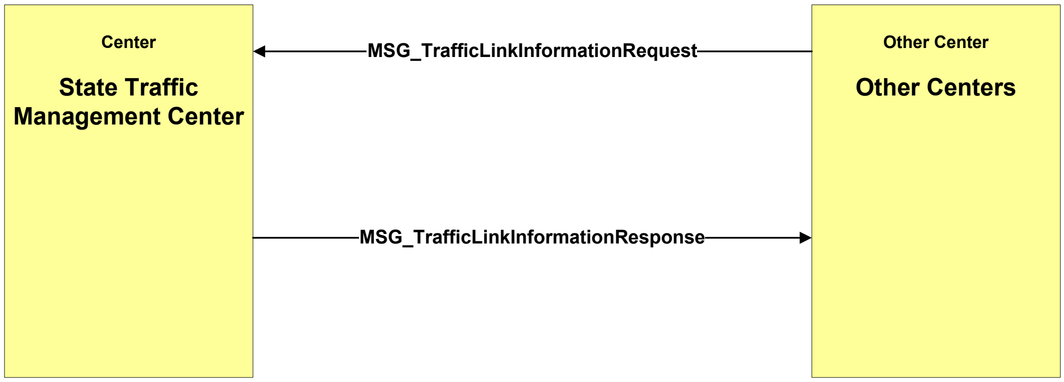

Figure C-2. OP_ShareTrafficLinkInformation Operation Message Exchange Diagram

Center Interface Definition Worksheet

The worksheet provided below lists the system interface elements (operations, message encoding, message inputs, message outputs, and transport) in table form. This table provides the information necessary to further develop the WSDL.

Table C-1. Center Interface Definition Worksheet

Service	Operation	MSG Input	MSG Output	MSG Pattern	MSG Encoding	MSG Transport
atisService	OP_ShareTrafficLinkInformation	MSG_TrafficLinkInformationRequest	MSG_TrafficLinkInformationResponse	R/R	SOAP	HTTP

MSG Patterns:

R/R - Request/Response

S/CB - Subscribe/Callback

1-Way - One-Way

Application Profile for Center to Center Communications and PICS

The NYSDOT Freeway Expansion Project shall use the Application Profile for XML Message Encoding and Transport for ITS Center to Center Communications, NTCIP 2306 (NTCIP C2C XML). A Project Implementation Conformance Statement (PICS) for the project, based on the WSDL worksheet in shown below. (Optionally, NYSDOT may decide to only items that relate to the project requirements -- Profile Requirement column marked 'Y').

Table C-2. NTCIP 2306 PICS (Profile Implementation Conformance Statement)

Profile Requirements List (PRL)		NTCIP 2306 Section	NTCIP 2306 Mandatory / Optional	NTCIP 2306 Profile Require-ment	Project Require-ment
1.0	**SOAP over HTTP**				
	a) WSDL Request-Response		**M**		**Y**
	- WSDL General	6.1	M		Y
	- Definitions	6.2	M	PR 3.1	Y
	- Types/Schema	6.3	M	PR 3.1, 3.2	Y
	- Message	6.4	M	PR 3.3	Y
	- PortType (Interfaces)	7.1.1	M	PR 4.1.1	Y
	- Binding (Transport)	7.1.2	M	PR 4.1.2a	Y
	- Service (Transport)	7.1.3	M	PR 4.1.2a	Y
	b) WSDL Publish-Subscribe		**O**		**N**
	- WSDL General	6.1	M		N
	- Definitions	6.2	M	PR 3.1	N
	- Types/Schema	6.3	M	PR 3.1, 3.2	N
	- Message	6.4	M	PR 3.3	N
	- PortType (Interfaces)	6.5, 7.2.1	M	PR 4.2.1	N
	- Binding (Transport)	7.2.2	M	PR 4.2.2a	N
	- Service (Transport)	7.2.3	M	PR 4.2.2a	N
	c) Message Encoding				**Y**
	SOAP	4.2.2	M	PR 1.2, 4.2.1a, 4.2.1b	Y
	d) Message Transport				**Y**
	HTTP	5.1.3	M	PR 2.1a, 4.1.2a, 4.2.2a	Y
	HTTPS	5.1.4, 6.6	O	PR 2.1b	N

Profile Requirements List (PRL)		NTCIP 2306 Section	NTCIP 2306 Mandatory / Optional	NTCIP 2306 Profile Require-ment	Project Require-ment
2.0	**XML over HTTP**				
	a) WSDL Request Only (XML Direct)		**M**		**N**
	- WSDL General	6.1	M		N
	- Definitions	6.2	M	PR 3.1	N
	- Types/Schema	6.3	M	PR 3.1, 3.2	N
	- Message	6.4	M	PR 3.3	N
	- PortType (Interfaces)	8.1.1	M	PR 4.4.1, 3.4	N
	- Binding (Transport)	8.1.2	M	PR 4.4.2a	N
	- Service (Transport)	8.3	M	PR 4.4.2a	N
	b) WSDL Request-Response		**O**		**N**
	- WSDL General	6.1	M		N
	- Definitions	6.2	M	PR 3.1	N
	- Types/Schema	6.3	M	PR 3.1, 3.2	N
	- Message	6.4	M	PR 3.3	N
	- PortType (Interfaces)	8.2.1	M	PR 4.1.1	N
	- Binding (Transport)	8.2.2	M	PR 4.1.2b	N
	- Service (Transport)	8.3	M	PR 4.1.2b	N
	d) Message Encoding				**N**
	XML Text	4.1.2	M	PR 1.1a, 4.2.2b	N
	XML Gzip	4.1.2	O	PR 1.1 a, 4.2.2b	N
	e) Message Transport				**N**
	HTTP	5.1.1, 5.1.2	M	PR 2.1a, 4.2.2b	N
	HTTPS	5.1.4, 6.6	O	PR 2.1a, 4.2.2b	N
3.0	**XML over FTP**				**N**
	a) WSDL Request Only (XML Direct)		**M**		**N**
	- WSDL General	6.1	M		N
	- Definitions	6.2	M	PR 3.1	N
	- Types/Schema	6.3	M	PR 3.1, 3.2	N
	- Message	6.4	M	PR 3.3	N
	- PortType (Interfaces)	9.1.2	M	PR 4.4.1, 3.4	N

Profile Requirements List (PRL)		NTCIP 2306 Section	NTCIP 2306 Mandatory / Optional	NTCIP 2306 Profile Require-ment	Project Require-ment
	- Binding (Transport)	9.1.3	M	PR 4.4.2b	N
	- Service (Transport)	9.1.4	M	PR 4.4.2b	N
	b) Message Encoding (one of the following)				**N**
	XML Text	4.1.1	O	PR 1.1a, 4.4.2b	N
	XML Gzip	4.1.2	O	PR 1.1b, 4.4.2b	N
	c) Message Transport				
	FTP	5.2.1	M	PR 2.2a, 4.4.2b	

WSDL - Web Services Description Language

This section provides the formal Web Services Description Language document for the subject project. WSDL must be provided for a center system to be in conformance with the NTCIP C2CXML. WSDL for the subject project is shown below.

Figure C-3. Project WSDL

```
<?xml version="1.0" encoding="UTF-8"?>

<!-- Project:  State Traffic Management Center -->

<!-- Revision History -->
<!-- Person         Organization  Description         Date             -->
<!-- M. Insignares  ConSysTec     Document Created    February 11, 2005  -->


<definitions name="atisService" targetNamespace="http://www.atis-service"
        xmlns:tns="http://www.atis-service"
        xmlns:atis="http://www.atis-address"
        xmlns:soap="http://schemas.xmlsoap.org/wsdl/soap/"
        xmlns:xs="http://www.w3.org/2001/XMLSchema"
        xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
        xmlns="http://schemas.xmlsoap.org/wsdl/"
        xmlns:mime="http://schemas.xmlsoap.org/wsdl/mime/"
        xmlns:http="http://schemas.xmlsoap.org/wsdl/http/"
>

      <!-- TYPES -->

      <types>
            <schema targetNamespace="http://www.atis-service"
                  xmlns:atis=http://www.atis-address
                  xmlns="http://www.w3.org/2001/XMLSchema"
                  xmlns:xs="http://www.w3.org/2001/XMLSchema"
                  elementFormDefault="qualified">
                  <appInfo>
                        <documentation>
                        ATIS (SAE-J2354) XMLSchema Version 0.6.275,
                        20-Apr-2004
                        </documentation>
                  </appInfo>
                  <xs:import namespace=http://www.atis-address
                        schemaLocation="atis.xsd"/>
            </schema>
      </types>

      <!-- MESSAGES -->

      <!-- The information below was derived from the XML Schema specified above -->


      <!-- Descriptive Name: TrafficLinkInformationRequest -->
      <message name="MSG_TrafficLinkInformationRequest">
               <part name="message" element="atis:informationRequest"/>
      </message>

            <!-- Descriptive Name: TrafficLinkInformationResponse -->
      <message name="MSG_TrafficLinkInformationResponse">
               <part name="message" element="atis:informationResponse"/>
```

```
    </message>

    <!-- atisService - PORT TYPE OPERATION INPUT / OUTPUTS SOAP PORT -->
    <portType name="atisServiceSOAPPort">

        <!-- Share Traveler Information -->
        <operation name="OP_ShareTrafficLinkInformation">
            <input message="tns:MSG_TrafficLinkInformationRequest"/>
            <output message="tns:MSG_TrafficLinkInformationResponse"/>
        </operation>
    </portType>

    <!-- BINDING - OPERATION INPUT / OUTPUTS  - SOAP -->
    <binding name="atisServiceSOAPBinding" type="tns:atisServiceSOAPPort">
        <soap:binding style="document"
            transport="http://schemas.xmlsoap.org/soap/http"/>

        <!-- Traffic Link Information -->
        <operation name="OP_ShareTrafficLinkInformation">
            <soap:operation soapAction="OP_ShareTrafficLinkInformation"
                style="document"/>
            <input>
                <soap:body use="literal"/>
            </input>
            <output>
                <soap:body use="literal"/>
            </output>
        </operation>
    </binding>

    <!-- ENDPOINT LOCATIONS BELOW SHOULD BE MODIFIED FOR EACH -->
    <!-- CENTER IMPLEMENTATION -->
    <!-- wsdl:service names a new service "atisService" -->
    <service name="atisSOAPService">
        <documentation>Advanced Traveler Information Service</documentation>
        <!-- connect it to the binding "atisServiceSOAPBinding" above -->
        <port name="atisServiceSOAPPort" binding="tns:atisServiceSOAPBinding">
            <!-- give the binding an network address -->
            <soap:address
            location="http://www.mycenter.org/c2cxml/atis/atisSOAPService"/>
        </port>
    </service>
</definitions>
```

Required XML Schemas, Messages, and Data Elements

Required XML Schemas

The NYSDOT Freeway Expansion Project shall accept and generate messages that validate against the following schemas:

Table C-3. Project Schemas

Number	Schema	Version	Date	Status
1	SAE-J2354 - Advanced Traveler Information Systems (ATIS) Message Sets	0.6.275	20-Feb-2004	DRAFT

Required Messages and Data Concepts

The NYSDOT Freeway Expansion Project shall use the following messages, referenced as schema elements:

The following table lists the required data concepts (data frames and data elements) on a message by message basis.

Table C-4. Required Messages and Data Concepts

Schema Name: SAE-J2354

Schema Element Name: informationRequest

WSDL Message Name: MSG_TrafficLinkInformationRequest

Xpath	Data Concept Name	Data Frame (DF) or Data Element (DE)	Mandatory (M) or Optional (O)	May Repeat	Max Occurrences
//atisMessage/informationRequest/messageHeader	messageHeader	DF	M	N	1
//atisMessage/informationRequest/messageHeader/sender	sender	DF	M	N	1
//atisMessage/informationRequest/messageHeader/sender/agencyIdentifier	agencyIdentifier	DE	O	N	1
//atisMessage/informationRequest/messageHeader/sender/agencyName	agencyName	DE	M	N	1
//atisMessage/informationRequest/messageHeader/sender/person	person	DF	M	N	1
//atisMessage/messageHeader/sender/person/lastName	lastName	DE	M	N	1
//atisMessage/informationRequest/messageHeader/messageID	messageID	DE	M	N	1
//atisMessage/informationRequest/messageHeader/timeStamp	timeStamp	DF	M	N	1
//atisMessage/informationRequest/messageHeader/timeStamp/date	date	DE	M	N	1
//atisMessage/informationRequest/messageHeader/timeStamp/time	time	DE	M	N	1
//atisMessage/informationRequest/returnAddress	returnAddress	DE	O	N	1
//atisMessage/informationRequest/filter	filter	DF	M	N	1
//atisMessage/informationRequest/filter/location	location	DF	M	N	1
//atisMessage/informationRequest/filter/location/location	location	DF	M	N	1
//atisMessage/informationRequest/filter/location/location/areaLocation	areaLocation	DF	M	Y	1
//atisMessage/informationRequest/filter/location/location/areaLocation/adminAreas	adminAreas	DF	M	Y	10
//atisMessage/informationRequest/filter/location/location/areaLocation/adminAreas/ stateFIPS	stateFIPS	DE	M	N	1
//atisMessage/informationRequest/filter/location/location/areaLocation/adminAreas/ countyFIPS	countyFIPS	DE	O	Y	9

Xpath	Data Concept Name	Data Frame (DF) or Data Element (DE)	Mandatory (M) or Optional (O)	May Repeat	Max Occurrences
//atisMessage/informationRequest/filter/dataTypes	dataTypes	DF	M	Y	1
//atisMessage/informationRequest/filter/dataTypes/roads	roads	DE	M	Y	5

{Additional tables should be included to reflect all messages used in the subject project.}

Sample Messages

This section includes sample messages used in the subject project. These are shown in the figures below.

Figure C-4. Sample MSG_TrafficLinkInformationRequest Message


```
<?xml version="1.0" encoding="UTF-8"?>
<atisMessage>
	<informationRequest>
		<messageHeader>
			<sender>
				<agencyIdentifier>23495876</agencyIdentifier>
				<agencyName>NH DOT TMC</agencyName>
				<person>
					<lastName>NH DOT Operations</lastName>
				</person>
			</sender>
			<messageID>34385</messageID>
			<timeStamp>
				<date>20030411</date>
				<time>153840</time>
			</timeStamp>
		</messageHeader>
		<returnAddress> <!-- Optional -->
			mailto:opstaff.statetoc@nhdot.nh.us
		</returnAddress>
		<filter>
			<location>
				<location>
					<areaLocation>
						<adminAreas>
							<stateFIPS>
								50  <!-- Vermont -->
							</stateFIPS>
						</adminAreas>
					</areaLocation>
				</location>
			</location>
			<dataTypes>
				<roads>
					0 <!-- all -->
				</roads>
			</dataTypes>
		</filter>
	</informationRequest>
</atisMessage>
```


Figure C-5. Sample MSG_TrafficLinkInformationResponse Message


```
<?xml version="1.0" encoding="UTF-8"?>
<atisMessage>
	<informationResponse>
		<messageHeader>
			<sender>
				<agencyIdentifier>98731</agencyIdentifier>
				<agencyName>VTrans State TOC</agencyName>
				<person>
```

```
                    <lastName>
                          VTrans Operations Division Staff
                    </lastName>
              </person>
        </sender>
        <messageID>34386</messageID>
        <timeStamp>
              <date>20030411</date>
              <time>155510</time>
        </timeStamp>
  </messageHeader>
  <responseGroups>
        <responseGroup>
              <links> <!-- Max = 100 -->
                    <link>
                          <location>
                                <linkLocation>
                                      <linkId>
                                            <idAlpha>
                                                  12-345678
                                            </idAlpha>
                                      </linkId>
                                </linkLocation>
                          </location>
                          <status>
                                <!--  no-determination (1),
                                      open (2),
                                      restricted (3),
                                      closed (4) -->
                                2
                          </status>
                          <lanesMinimumNumber>
                                4  <!-- lane count -->
                          </lanesMinimumNumber>
                          <lanesNumberOpen>
                                4
                          </lanesNumberOpen>
                          <speed>
                                85  <!-- in km per hour -->
                          </speed>
                          <travelTime>
                                100  <!-- in seconds -->
                          </travelTime>
                    </link>
                    <!-- Continue with additional links -->
              </links>
        </responseGroup>
  </responseGroups>
      </informationResponse>
</atisMessage>
```