Vermont Statewide ITS Plan Update

Standards Plan

Final Report

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Revision History

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1 Introduction

In February 2004, Consensus Systems Technologies Corp. (ConSysTec), was contracted by Vermont Agency of Transportation (VTrans), to update and expand its Statewide ITS Strategic Plan, and to develop policies, standards, and architecture plans for state, regional and local officials to use in the planning, deployment, operations, and maintenance of ITS.

As part of its deliverables for Task 3 in the Scope of Work, ConSysTec was to identify current practices and recommend a standards development process and guidelines for evaluating all existing and future ITS technology and systems deployed. The recommendations are to follow the requirements of FHWA Rule 940.9 and 940.11. In addition, the standards plan should include suggested performance measures and asset management tools for use in evaluating the ITS infrastructure deployed and its role/value in supporting the transportation network in Vermont.

This document is the third of three documents to be delivered to VTrans for this project. The first document is the Vermont Statewide ITS Architecture. The second document is the Vermont Strategic Plan for ITS Deployment, which describes the statewide vision and direction for ITS in Vermont. This document contains recommendations for a plan to develop and deploy ITS standards in the State of Vermont.

1.1 Intended Audience

Managers, planners, specification writers, and project managers from transportation agencies in the State of Vermont will benefit most from this Standards Development Plan document. At least one chapter in this Standards Development Plan is dedicated to each type of these users.

For managers or decision-makers, this Standards Development Plan document will provide these managers with background on ITS standards and discuss the issues that must be considered to implement ITS standards in the State of Vermont.

For planners, this Standards Development Plan document will introduce the relationship between ITS Standards and the Statewide (or regional) ITS Architectures. The document will also guide these planners on how to develop their transportation projects, define the scope of work, and request federal funding for ITS projects.

For specification writers, this document will show how the Statewide ITS Architecture can be used to identify operational concepts and functional requirements. The systems engineering analysis for developing projects will be introduced as a process for writing specifications. Then, the document will show how to select, specify and test ITS standards for a project, and how to develop a project ITS architecture.

For project managers implementing projects, this document will introduce them on the different types of testing that may be involved in verifying that a project, and the ITS devices and systems it contains, comply with the specifications and conforms with an ITS standard.

1.2 Purpose

This document is a guide to develop a process to deploy systems using ITS standards in the State of Vermont. This document will review the life cycle of ITS Standards in the development and deployment of ITS projects in Vermont, 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. The document will then guide the reader on how to specify the ITS standards, including how to test the use of the standard.

The key to this document, however, is that VTrans already has a project development process in place. This document will review that existing process, indicating where and how ITS standards fit into that process. The document will make suggestions and recommendations how the existing project development process may be altered to better accommodate and include ITS standards into the process.

What will the document NOT do? This document will not actually alter the VTrans project development process. Suggestions and recommendations will be made, but VTrans must address the suggested changes with staff in the affected departments of the agency.

This document will also not specify or recommend an ITS standard for adoption for the State of Vermont. The selection and adoption of an ITS standard should be based on an analysis of the needs and requirements for the State, which is not included in this Scope of Work. Once the needs and requirements have been determined, an ITS standard that best meets those needs and requirements should be selected and included in the project specifications. An ITS standard should not be adopted first, then checked if the needs and requirements can be met by the standard.

1.3 Report Organization

This document is separated into nine (9) chapters to support the various audience for this document, and to satisfy the requirements in the Scope of Work. The chapters are:

- **Chapter 1: Introduction.** Provides introductory and background information about this document, its purpose and why it is needed.
- **Chapter 2: ITS Standards.** Presents an introduction to ITS Standards, including their origins, a short discussion on USDOT requirements for standards, and the types of standards.
- **Chapter 3: Standards in ITS Architecture.** Reviews why ITS Standards appear in ITS Architectures and discusses their relationships.
- **Chapter 4: Project Systems Engineering Analysis.** Discusses the role of ITS Standards in writing project ITS architectures when requesting federal funding for ITS projects.
- **Chapter 5: ITS Standards in the Project Development Process.** Discusses how to use a statewide ITS architecture to develop projects, determine functional requirements,

then how to analyze the applicability of ITS standards for use in projects. Once an ITS standard is selected, the chapter will review how to specify the standard.

- **Chapter 6: Testing ITS Standards.** Describes the various types of testing for deploying ITS projects, and issues when developing a statewide standards testing program.
- **Chapter 7: Current ITS Activities.** Discusses the current status of relevant ITS Standards and testing activities. Also reviews current Vermont efforts and contracts in deploying ITS standards.
- **Chapter 8: Performance Measures.** Presents potential measures of performance for evaluating the deployment of various ITS systems.
- **Chapter 9: Asset Management Tools.** Presents an introduction to asset management tools.
- **Appendix A: DMS Concept of Operations Example.** Presents an example Concept of Operations document for operating a dynamic message sign.
- **Appendix B: DMS Specification Example.** Presents an example specification for the functional and NTCIP requirements for a dynamic message sign.
- **Appendix C: C2C Specification Example.** Presents an example outline for specifying center-to-center communications.

It is recommended that all users should read Chapters 1 and 2 for an introduction to this document and an introduction to ITS standards.

Managers should skim through Chapters 4 and 5 to gain a general understanding of the USDOT's requirements for federal funding of ITS projects and how ITS standards fit into VTrans's project development process.

Planners should read Chapter 3, which describes the relationship of ITS standards with the Statewide ITS Architecture, and Chapter 4, which discusses the USDOT requirements for federal funding of ITS projects. Planners may also wish to read Chapter 8, which presents some potential performance measures for calculating the effectiveness of deploying ITS projects.

Specification writers should read Chapters 4, 5, and 6, which introduces the systems engineering analysis for developing projects, indicates how to use the 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, which provides examples of the systems engineering analysis and how to write specifications for ITS standards.

Project managers should skim through Chapter 3 to obtain a general understanding of how their specific projects fit in the scheme of the statewide ITS architecture and the regional or statewide

goals and needs. Chapter 6 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. Chapters 8 and 9 provide performance measures that may be useful to the project managers.

Finally, anyone interested in current ITS standards activities on a national level, including a review of current ITS projects in Vermont where ITS standards may be applicable should read Chapter 7. Chapter 7 also provides a list of ITS standards that may be relevant in Vermont at this time, and provides additional information about these standards, including current version of the standard, its status, and contact information.

2 ITS Standards

2.1 Introduction

What are ITS standards? ITS standards establish a common way in which systems and devices connect and communicate with one another. ITS standards are industry-consensus standards that define how ITS system components operate within a consistent framework, for example, the National ITS Architecture. By specifying how systems and components interconnect, the standards promote interoperability, allowing transportation agencies to implement systems that cost-effectively exchange pertinent data and accommodate equipment replacement, system upgrades, and system expansion.

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

2.2 Origins

The U.S. Department of Transportation's (U.S. DOT) ITS Joint Program Office has been funding the development of ITS standards since 1996 in an extensive, multi-year program of accelerated standards development to strengthen and facilitate the successful deployment of ITS. From its beginning, this standards acceleration program has chosen to support, guide, and reinforce the existing consensus standards efforts in the U.S. by providing funding to existing Standards Development Organizations (SDOs). This "bottoms-up" approach was meant to allow U.S. DOT to leverage significant volunteer resources and to foster public-private partnerships in the deployment of ITS. The SDOs that are involved in the development of ITS standards are:

- American Association of State Highway and Transportation Officials (AASHTO)
- American Public Transportation Association (APTA)
- American Society for Testing & Materials (ASTM)
- Institute of Electrical and Electronics Engineers (IEEE)
- Institute of Transportation Engineers (ITE)
- National Electrical Manufacturers Association (NEMA)
- Society of Automotive Engineers (SAE)

The overall goal of the U.S. Department of Transportation's (U.S. DOT) ITS Standards Program has been to promote the widespread deployment of integrated ITS through robust, non-proprietary standards.

Through cooperative agreements with the standards development organizations (SDOs), the Standards Program is accelerating development of about 100 non-proprietary, industry-based, consensus ITS standards, and is encouraging public-sector participation in the development process.

2.3 Standards Conformance

One of the most common misconceptions regarding the USDOT Standards Program is that conformance to ITS standards is mandated by the program. The U.S. DOT has put in place a methodology for requiring conformance to ITS standards in the Final Rule for Architecture and Standards (Rule 940) and the corresponding FTA Final Policy. The Rule/Policy states that "all ITS projects funded with highway trust funds shall use applicable ITS standards and interoperability tests that have been officially adopted through rulemaking by the DOT". To date no standards or interoperability tests have been officially adopted by U.S. DOT. To do so will require a Notice of Proposed Rulemaking, an appropriate comment period, followed by issuance of a rule adopting the standard. To date not even the first step has been taken with any ITS standard. The USDOT has stated repeatedly that they will not consider mandating a standard until it is tested and proven in deployments. Currently there are only two standards that may be considered as close to this level of maturity. Therefore it is unlikely that any standards would be mandated in the next 12 to 24 months. Will some of the standards eventually be mandated? This could happen if the US DOT feels that state and local deployers are not implementing standards that they feel are tested and mature.

2.4 Types of ITS Standards

Standards application areas are deployment-oriented categories that focus on specific ITS services or systems. Each application area contains one or more interfaces in the National ITS Architecture. The types of interfaces include:

- **C2R - Center-to-Roadside.** This category of application areas includes those standards that provide communication links between a transportation or traffic management center and roadside equipment that regulates the flow of traffic.
- **C2C - Center-to-Center.** This category of application areas includes those standards that facilitate communication between transportation management centers. This category includes communications necessary for transit use.
- **C2T - Center-to-Vehicle/Traveler.** This category of application areas includes those standards that facilitate communication between transportation management centers and the driver of a vehicle or a traveler planning a trip. This category also includes communications necessary for coordination between transit management centers and their vehicles.

- **R2V - Roadside-to-Vehicle.** This category of application areas includes those standards that facilitate wireless communication between roadside equipment and vehicles on the road.
- **R2R - Roadside-to-Roadside.** This application area category includes standards that facilitate communications between railroad wayside equipment and highway roadside equipment.

In general, each information flow has up to three types of standards that are relevant: a message set standard, a data element standard, and one or more communications protocol standards. This is summarized below:

- **M - Message Sets.** Strings of data elements put together to provide related, relevant information. A group of pre-defined messages can accomplish a function.
- **D - Data Elements.** The smallest entity of data. Sometimes labeled as data objects or object definitions, they are the building blocks for transferring bits of information.
- **C - Communications Protocol.** The rules to move information. The protocol may consist of rules regarding data formats, control information coordination, error handling, or timing.
- **H – Human Interface.** Human interface standards provide standards for presentation of information to humans or address problems and issues related to human-machine dialog.

3 Standards in ITS Architectures

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

In 1997, Congress passed the Transportation Equity Act for the 21st Century (TEA-21) to address the need to begin working toward regionally integrated transportation systems. To implement Section 5206(e) of TEA-21, which requires ITS projects to conform to the National ITS Architecture (NITSA) and Standards, the Federal Highway Administration (FHWA) issued 23 Code of Federal Regulations Parts (CFR) 655 and 940, entitled "Intelligent Transportation Systems (ITS) Architecture and Standards" on 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 development of a regional ITS architecture. 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

It is the seventh component, Identification of ITS Standards, where ITS Standards is first identified for a region or state in the transportation planning process. The requirement is to identify the applicable ITS Standards that can be considered for implementation for that region. Note that the requirement is not the actual use of ITS standards, but the recognition of which

ITS standards may be applicable to implement the information exchanges defined in the regional ITS architecture.

3.2 Relationship

The National ITS Architecture is a reference framework that spans all of ITS standards activities and provides a means of detecting gaps, overlaps, and inconsistencies between the standards. The Logical and Physical Architecture provide a starting point for the standards development activities by identifying the applicable architecture flows and data flows to be standardized in the National ITS Architecture and the way in which the information is exchanged across those interfaces. The National ITS Architecture databases provide 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 regional or statewide 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.

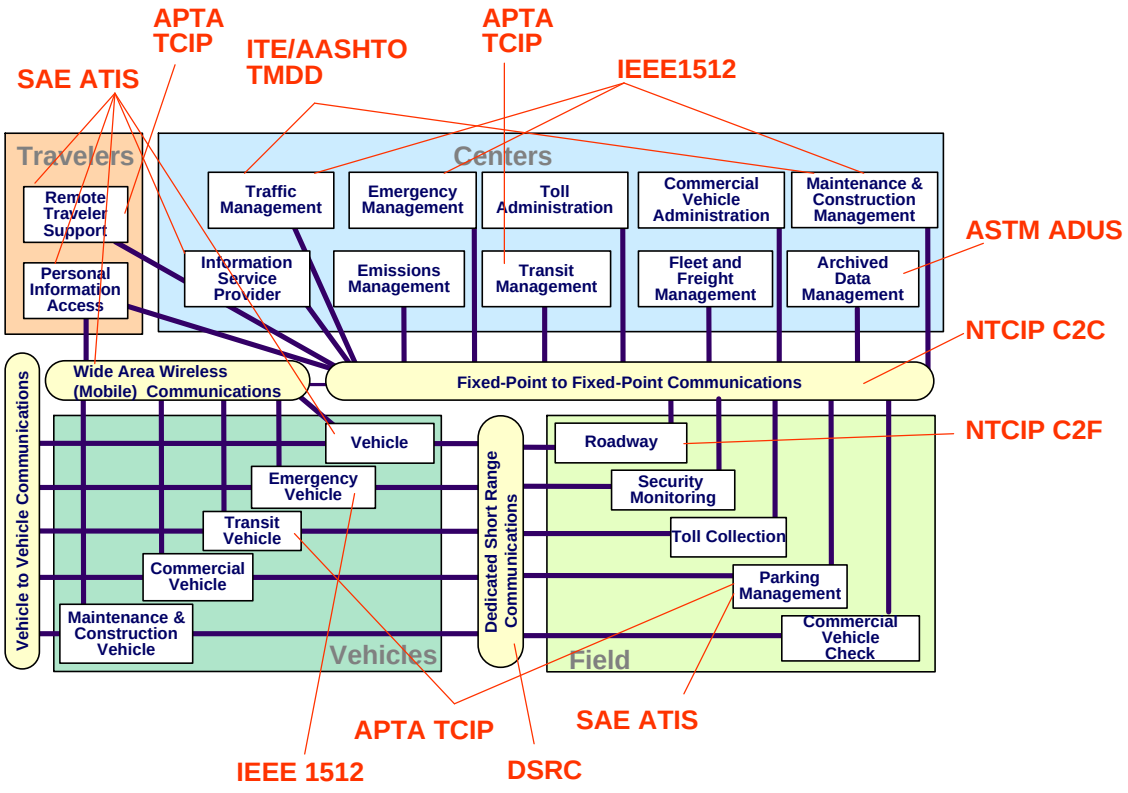

Figure 3-1. Relationship of the National ITS Architecture to ITS Standards

ITS standards address the interfaces between ITS systems. These interfaces, and the information flows between the interfaces are identified during the development of the statewide ITS architecture through the consensus process. Based on the identified data flow and interfaces, the statewide ITS architecture indicates what standards may be applicable.

The Vermont Statewide ITS Architecture report includes a map for each interface and each information flow in the statewide ITS architecture to applicable ITS standards (or interim standards) for that interface or flow, if an ITS standard exists. A set of standards can be identified for many of these interfaces and information flows. This may include message sets, data elements, and communications protocols. From this mapping, a project specifications writer can extract the applicable ITS standards for the project.

The Turbo Architecture database generated with the Vermont Statewide ITS architecture also provides an ITS Standards Report based on all of the architecture flows selected in the region. This report lists all standards associated with each architecture flow, either sorted by standard or by interface. The report only addresses ITS standards at a very high level but does narrow the ITS standards universe to those that may be used to implement the information exchanges defined for a region. The 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.

However, this does not suggest that the standards listed will support all the functions desired and needed by the the state, or by a particular region. Many of the ITS Standards are still in development and only a handful of ITS Standards can be considered mature at this time. By mature, it is meant that the standard has been deployed and tested by numerous agencies, and has industry-wide support. Although the standards development process attempts 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. This may require consideration of a different ITS standard, if it exists, or creating extensions to supplement a standard.

Unfortunately, the regional ITS architecture does not provide guidance on how to use the standard, or more importantly, how to test the standards. These issues are covered by this document and will be discussed in Chapters 5, 6, and 7.

4 Project Systems Engineering Analysis

4.1 Introduction

The Project Systems Engineering Analysis (PSEA) is a set of requirements from FHWA Rule 940/FTA Policy that states:

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

This section of the standards plan provides a discussion and examples of PSEA development to help move project specific information forward in the project development process.

4.2 PSEA Requirements

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

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

1. **Portions of Statewide ITS Architecture Being Implemented**. Assess portions of the statewide ITS architecture that apply to the project. This can be done by conducting a preliminary review of the customized market package diagrams from the Vermont Statewide ITS Architecture, ITS Inventory, and the “sausage diagram.” Extract the relevant portions of the customized market package diagrams to reflect only the ITS elements and architecture flows that apply to the

ITS project. As will be shown in the example in this section, ITS elements and architecture flows that do not apply are shown grayed out.

2. **Participating Agencies Roles and Responsibilities.** Based on the project specific customized market package diagrams and ITS elements, as well as the operational concept developed for the statewide 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 statewide 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. Note the Project Sequencing chapter of the Vermont Strategic Plan for ITS Deployment contains information regarding projects and their funding sources that might serve as a starting point for this section of the PSEA.

6. **Applicable ITS Standards and Testing Procedures**. Based on the project specific architecture flows, relevant ITS standards will be identified. In the case of center to field standards, the NTCIP document number will be sufficient. In the case of center to center standards, a preliminary list of messages should be developed. This would leave the process of selecting specific NTCIP objects (data elements), and data elements for messages to the detailed plan stages of the project development process. In a separate step, procedures to facilitate testing of conformance to the standards specifications will be developed. Also develop the section on testing requirements for factory and system acceptance test based on the previous PS&E documents for similar projects.

7. **Procedures and Resources Necessary for the Operations and Management of the System**. This section is part of a concept of operations for the project. A concept of operations is a document that discusses the overall environment in which the system(s) of the project will operate. It includes a description of organizational procedures or practices appropriate to the system(s), which covers this aspect of the PSEA. A complete concept of operations is not a specific requirement of the PSEA (only the aspects described above are covered by PSEA requirements), but it is part of an overall system engineering development process and should be considered particularly for major projects.

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

4.3 PSEA Example

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

4.3.1 Portions of the Statewide ITS Architecture Being Implemented

The VT 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 VTrans State TOC. The development of the VTrans State TOC (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 statewide ITS architecture elements being implemented as part of the project.

Table 4-1. PSEA Project ITS Elements

Project ITS Element	National ITS Architecture Subsystem
VTrans State TOC	Traffic Management Emergency Management
VTrans Vehicle Detectors	Roadway Subsystem
VTrans CCTV	Roadway Subsystem
VTrans DMS	Roadway Subsystem

The figure below shows the specific ITS project elements against a “sausage diagram” for the VT Statewide ITS Architecture. The sausage diagram shows the statewide 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.

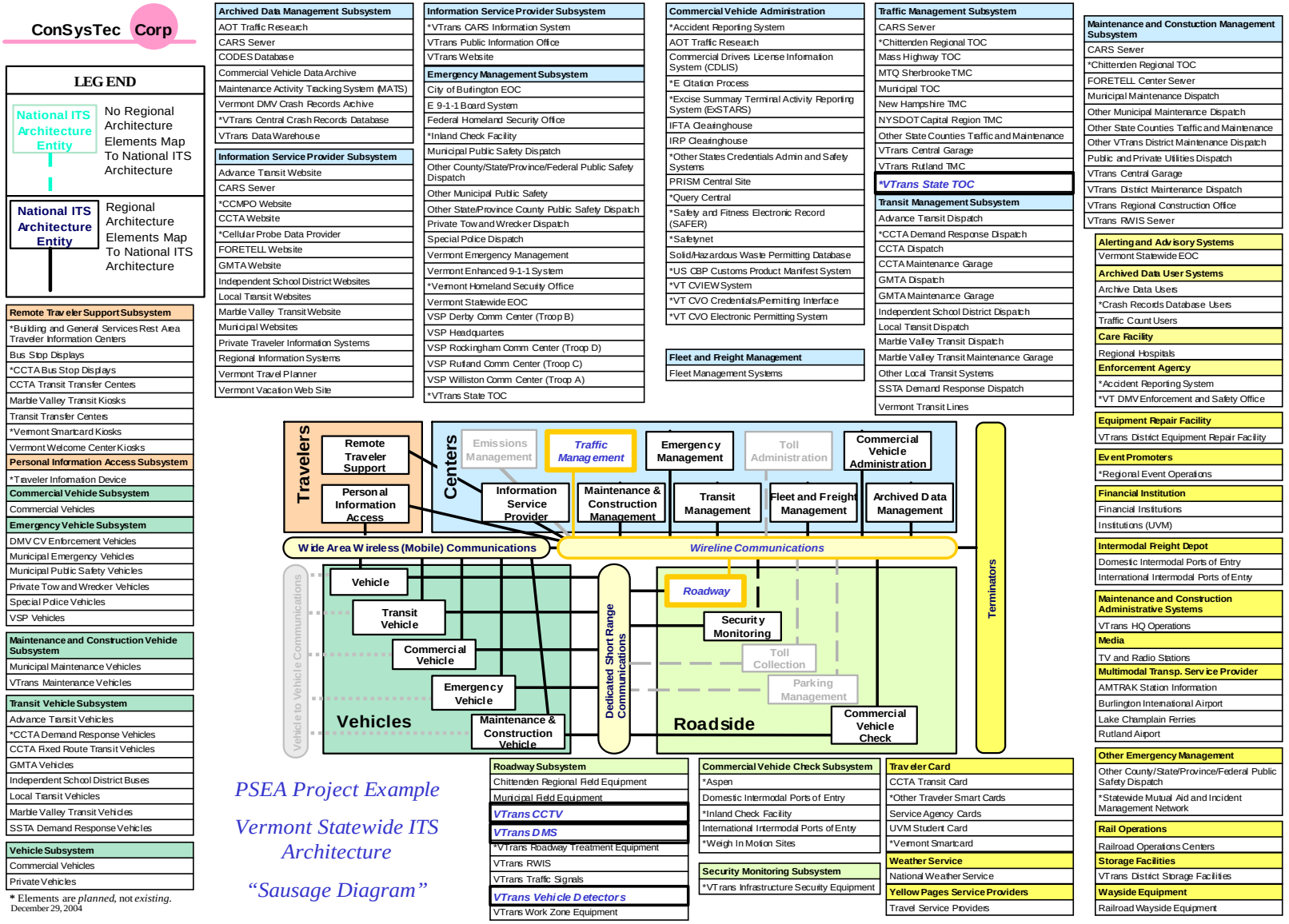

Figure 4-1. Portion of the Vermont Statewide ITS Architecture Covered by VT Freeway Expansion Project

4.3.1.1 Customized Market Package Analysis

The table below lists which customized market packages from the ITS architecture apply to the proposed project. Specifically, the table contains the ITS project elements in those market packages that apply to the proposed project.

Table 4-2. Customized Market Package Analysis Results

Market Package Diagram	MP Name	Applicable ITS Project Elements
ATMS01-2	Network Surveillance - VTrans State TOC	VTrans State TOC, VTrans Vehicle Detectors, VTrans CCTV
ATMS04-1	Freeway Control - VTrans State TOC	VTrans State TOC, VTrans Vehicle Detectors, VTrans CCTV
ATMS06-1	Traffic Information Dissemination - VTrans State TOC and VTrans Rutland TMC	VTrans State TOC, VTrans DMS

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. The ATMS04 customized market package is not shown because it includes the same architecture flows included in ATMS01.

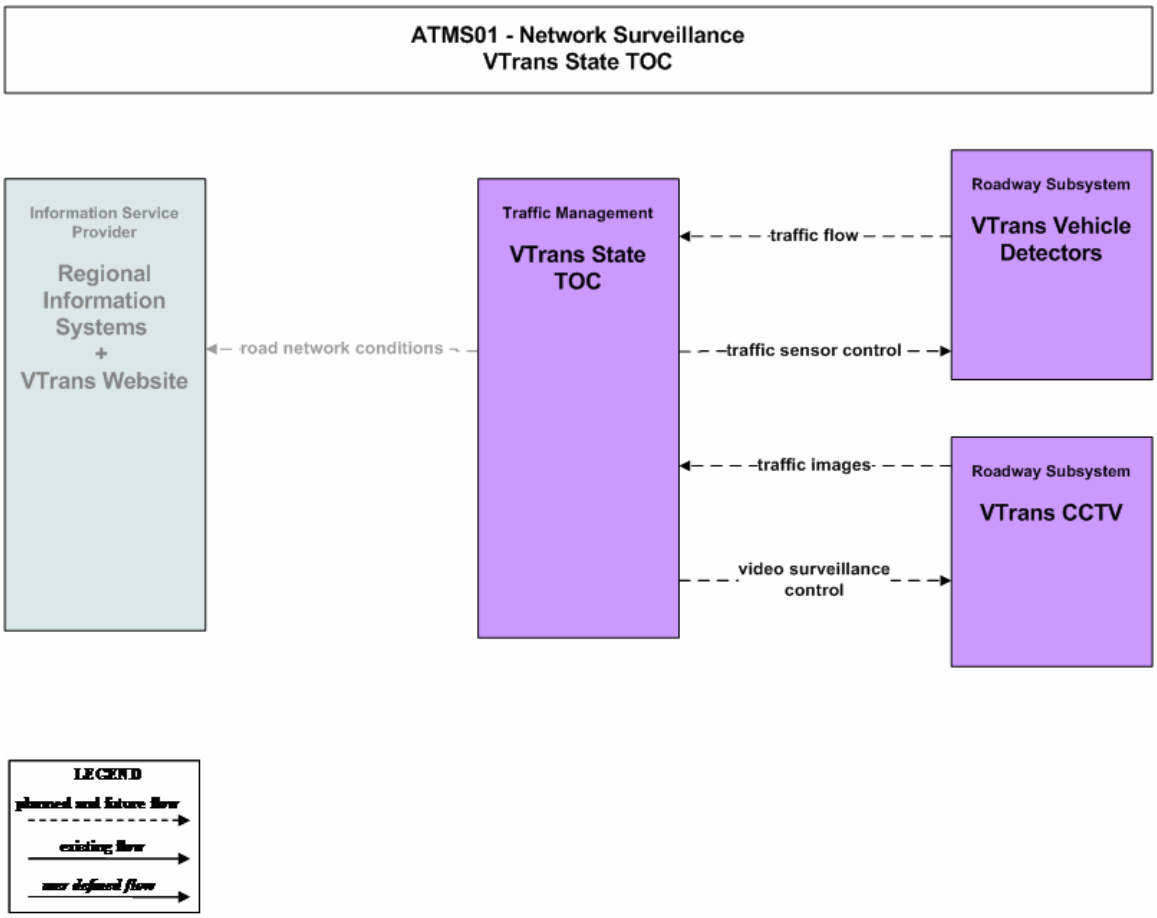

Figure 4-2. ATMS01 - Network Surveillance Customized Market Package

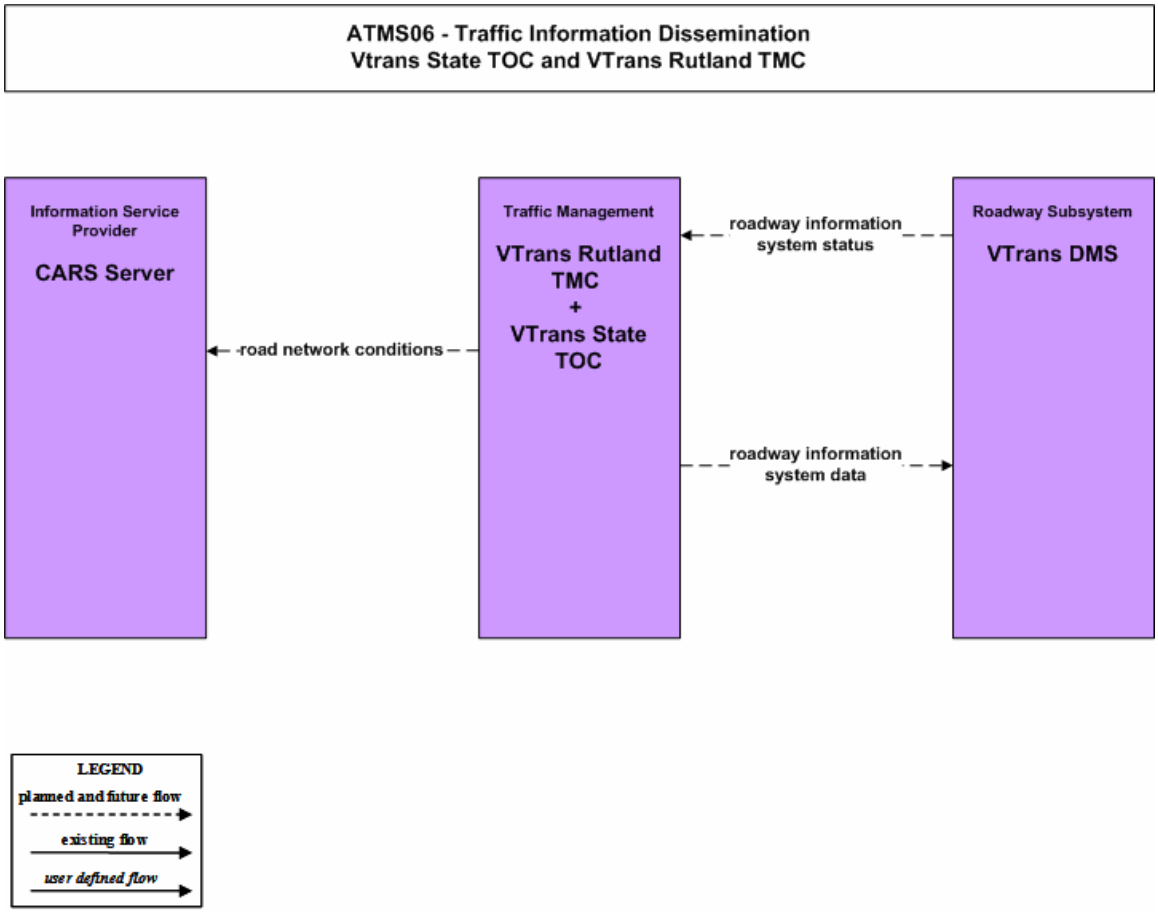

Figure 4-3. ATMS06 – Traffic Information Dissemination Customized Market Package

The table below summarizes the project specific architecture flows between the VTrans State TOC and VTrans field equipment.

Table 4-3. 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.
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).

4.3.2 Participating Agencies Roles and Responsibilities

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

Table 4-4. Participating Agencies Roles and Responsibilities

Stakeholders	Project ITS Elements	Roles and Responsibilities
VTrans	VTrans State TOC	VTrans manages and operates the State TOC. From the State TOC various project freeway field equipment will be operated and controlled.
	VTrans Vehicle Detectors, CCTV, and DMS	Freeway management field equipment operated and maintained by VTrans.

In the example project, all the project ITS elements, as identified in the project and in the statewide ITS architecture, are operated and managed by VTrans. Under this project, additional field equipment will be integrated into the VTrans State TOC. The VTrans State TOC is operated by VTrans Operations Division. Sharing of information with other operating agencies is not part of this project.

If sharing of information with other agencies was part of this project, each agencies' roles and responsibilities should be discussed. Roles and responsibilities may include the conditions when information is to be shared (event-driven, constant basis), how the information is to be used (e.g., for incident management only), and the functions of each agency during the conditions when information is shared.

4.3.3 Requirements Definition

This section of the PSEA includes high level functional requirements that may be derived directly from the Vermont Statewide ITS Architecture. The high level requirements for

each of the subsystems in the project have been defined in the Turbo Architecture database, which provides a mechanism for exporting functional requirements into a text file. The requirements can also be found in Appendix C of the Vermont Statewide ITS Architecture document. The requirements shown in the table below are those defined in Turbo Architecture and exported to the text file format.

The requirements table shows the following:

(a) For each ITS element, specific equipment packages (high level functional area requirements) were extracted. The applicable equipment packages for each ITS element are identified in the ITS architecture Turbo Architecture database. Using Turbo Architecture, the equipment package selections were customized (those not needed to support the project were de-selected) to match the project needs.

(b) For each equipment package, functional requirements were identified and those that applied to the project were kept. The functional requirements represent more detailed (but still high-level) functional requirements for the ITS element given the role of the ITS element within a project context. The functional requirements define what actions or activities the ITS element must perform to satisfy the project needs.

Table 4-5. Requirements Definition Table

ITS Element	Functional Area (Equipment Package)	Functional Area Description	Requirement
VTrans 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.
VTrans 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.
VTrans 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.
VTrans 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).
VTrans 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.
VTrans 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.
VTrans State TOC	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.
VTrans State TOC	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
VTrans State TOC	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.
VTrans State TOC	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.
VTrans State TOC	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.
VTrans State TOC	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.
VTrans State TOC	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.
VTrans State TOC	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.).
VTrans State TOC	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.
VTrans State TOC	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.
VTrans State TOC	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
VTrans State TOC	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.
VTrans 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.
VTrans 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.
VTrans Vehicle Detectors	Roadway Basic Surveillance	Field elements that monitor traffic conditions using loop detectors and CCTV cameras.	The field element shall return sensor and CCTV system fault data to the controlling center for repair.

4.3.4 Analysis of Alternate System Configurations and Technology Options

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

(a) Operational alternatives

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

(c) Communications alternatives

Each is reviewed briefly below:

- **Operational Alternatives**. For the purposes of a PSEA, this section would reflect which centers that house operational staff are involved. In the case of this example, all staff will be housed in the VTrans State TOC. Other considerations may include if the center is staffed 24 hours a day/7 days a week. However, another project may include the construction of a new center, or the bringing together of several separate centers and staff under one roof.
- **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 "VTrans Vehicle Detectors" subsystem including radar detectors, inductive loops, and magnetometers. Likewise, fulfilling the requirements of the "VTrans CCTV" may be done with still frame, slow scan, or full motion video cameras. Each of these alternatives may carry additional or reduced cost to the project.
- **Communications Alternatives**. Communications alternatives will depend on some of the factors included in the bullets above (number of centers involved, the location of equipment, and the bandwidth of information that needs to be transferred. Communication options may include: fiber, dial-up, wireless, and a wide selection of network equipment (e.g., modems, Ethernet communications equipment, and fiber communications equipment) and communications protocols.

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

4.3.5 Procurement Options

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

For the purposes of this example one can assume that the VT Freeway Expansion project was identified in the Statewide Transportation Improvement Program (STIP), and VTrans Capital Plan. It should also be stated that the scoping, design, specification development and procurement documents will follow VTrans Project Development Process. A table showing the STIP and Capital Program identifiers and funding available for the project may be included to show traceability to the funding documents. An example is shown below.

Table 4-6. Procurement Options

Project Document	Project ID	Funding
Vermont State TIP	VT-LMNOP	$X million
VTrans Capital Plan	VTrans-12345	$Y00,000

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

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

4.3.5.1 Example ITS Equipment Cost

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

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

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

4.3.5.2 Example System Integration and Engineering Support Cost

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

- Materials (shop drawings and materials): $W0,000

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

4.3.5.3 Example Operations and Maintenance

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

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

4.3.6 Applicable ITS Standards and Testing Procedures

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

4.3.6.1 Selection of Applicable ITS Standards

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

Table 4-7. 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	Yes
NTCIP 1208	Object Definitions for Closed Circuit Television (CCTV) Switching	Yes
NTCIP 1209	Data Element Definitions for Transportation Sensor Systems	Yes
NTCIP 2101	Point to Multi Point Protocol (PMPP) Using RS-232 Sub network Profile	Yes
NTCIP 2103	Point-to-Point Protocol (PPP) Over RS-232 Sub network Profile	Yes
NTCIP 2201	Transportation Transport Profile (“NULL” Transport Profile)	Yes
NTCIP 2202	Internet (TCIP/IP and UDP/IP) Transport Profile	Yes
NTCIP 2301	Simple Transportation Management Framework (STMF) Application Profile	Yes

4.3.6.2 ITS Standards Related Considerations

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

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

(b) It may be possible that a State agency has developed an SNMP MIB (Management Information Base) that may be re-used under this project. Or, VTrans may choose to develop a MIB (Management Information Base), as defined by the NTCIP, as the method of specifying device object definitions for the various devices (CCTV, video switches, and sensors). The following summarizes the minimum necessary actions to develop the necessary project-specific NTCIP device object (specifications) for field equipment:

1. Develop an operational concept and requirements for the devices.
2. Develop an NTCIP MIB for each of the device types that is conformant with VTrans's operational concept and requirements, and the NTCIP conformance statement.
3. Develop performance requirements for communications between the central system and devices

(c) While manufacturers advertise that their products are NTCIP conformant, this does not mean that VTrans *project* requirements will be met. That is, the products may conform to the NTCIP standards, but do not comply with all the functional requirements in the specifications. It would therefore be prudent to test any devices destined for the field in a controlled environment (e.g., factory acceptance test) for compliance to the specifications and to conformance to the ITS Standard.

4.3.6.3 System Testing

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

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

(a) Design Verification Tests

(b) Power-On Tests

(c) Stand-alone Tests

(d) Final Acceptance Test

1. System Interface Tests
2. System Performance Tests, and
3. 30 Day Operational Tests

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

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

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

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

4.3.6.4 NTCIP Testing

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

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

- NTCIP documentation shall be provided on a CD-ROM and shall contain ASCII versions of the following Management Information Base (MIB) files in Abstract Syntax Notation 1 (ASN.1) format:
    - The relevant version of each official standard MIB modules referenced by the device functionality.
    - If the device does not support the full range of any given object within a standard MIB Module, a manufacturer specific version of the official standard MIB Module with the supported range indicated in ASN.1 format in the SYNTAX and/or DESCRIPTION fields of the associated OBJECT TYPE macros shall be provided. The filename of this file shall be identical to the standard MIB Module except that it will have the extension ".man".
    - A MIB module in ASN.1 format containing any and all manufacturer specific objects supported by the device with accurate and meaningful DESCRIPTION fields and supported ranges indicated in the SYNTAX field of the OBJECT-TYPE macros.
    - A MIB containing any other objects supported by the device.

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

- The acceptance test will use the NTCIP Wiz-Ban Testing Unit or other testing tool.
- The manufacturer will submit an NTCIP test plan a minimum of 90 days prior to NTCIP acceptance testing. NTCIP acceptance testing will be performed on one of the field devices manufactured under this contract. Testing will be performed at the manufacturer's (or agency's, if this applies) facility.

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

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

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

This section of the PSEA should outline the organizational procedures that will be put in place for the operations and management of the project's capabilities (in this example freeway device operations). In addition, any resources necessary for operations and management would be considered. In this example, the VT Freeway Expansion Project ITS field elements will be integrated into the VTrans State TOC. The VTrans State TOC will be operated by the VTrans Operations Division, which operates and manages the ITS infrastructure along I-89. In the case of the VT 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 VTrans resources will be utilized to maintain the additional ITS elements provided under this project.

5 ITS Standards in the Project Development Process

5.1 Introduction

A major step in the development of ITS systems is the development of design documents and procurement specifications. The project development process (at a high level) for VTrans 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.

5.2 Project Definition and Scoping

Once funding has been allocated, the project definition and scoping phase begins. Although the project scope should have already been defined in the transportation plan and the request for funding, the details of the project must be updated to fit the current situation and needs. The actual amount of funding available as opposed to the amount of funding requested may also have changed, which may require adjustments to the scope of the project. This may result in a design report. The design report includes an analysis of existing conditions and explains what will be designed and reviews alternate design options.

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 statewide ITS architecture. At this level of granularity a high level discussion of which standards may be considered in the project would be sufficient.

5.3 Concept of Operations

Development of a Concept of Operations (ConOps) document is recommended. 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 defines the relationship between the system and the organization. Or, put in different words, the ConOps describes how the ITS "system" will be used (its operational characteristics) and what transportation problem is being solved through the implementation of the system. It should be developed as part of the PS&E process to clearly define the user needs and operational context for the functions that the ITS system will support.

The ConOps should be developed using easy-to-use understand terms and as a stand-alone section, as it may be left out 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 includes:

- **Identification of Stakeholders**. Includes who the users are, and who is affected by the system. This may include 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 or events, such as poor weather conditions or 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.

From an ITS Standards point-of-view, the concepts of operations is 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. The ConOps is then used to develop the system functional requirements, based on the needs and operational concepts identified in the Concept of Operations.

To provide an illustration of the concepts discussed above, a partial ConOps and Specification with key portions filled in for a DMS (dynamic message sign) system is included in Appendix A.

5.3.1 ConOps for Center to Field Communications

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

- **Introduction.** The introduction will contain a general overview of the project elements and locations of field equipment.
- **Physical Features.** This section will contain an overview of the type or types of equipment being considered, and the physical characteristics of the field and central system.
- **Normal Operations.** This section contains a narrative of how the field and central control system should operate under normal conditions. The focus will be on what functions the ITS system should support. Ideally, a description of what detailed information is required for the function to be completed, paving the way for an analysis of NTCIP object requirements.
- **Exception Operations.** This section will contain a narrative of how the field and central control system should operate under abnormal conditions, such as during equipment or power failures.
- **Control Modes.** The section will focus on control modes, functions, and which operations are available during which control modes.
- **Monitoring.** The section will outline the behavior of the system during status monitoring, event logging, and diagnostics.
- **Installation/Testing.** This section will outline what testing is required under various times/conditions. For example, during installation, routine maintenance, and failure.

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

5.3.2 ConOps for Center to Center Communications

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

- **Introduction.** The introduction will contain a general overview of the project elements and physical locations of major centers involved in the project.
- **Candidate Message Set Standards.** This section of the ConOps would include a brief discussion of the candidate message set standards and list of messages. Message set standards that may be considered for center-to-center communications include:

  - **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.
  - **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. This section should be divided into 2 subsections:
  - Normal Operations and Candidate Messages
  - Exception Operations and Candidate 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.

5.4 Design Documents and Specification Development

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. Conversely, there is also a possibility that an ITS standard does not support all the user and functional requirements that have been defined. In the latter case, agency-specific objects or messages may be needed. It is during the project design phase that the portions of the ITS standards documents that apply to the project scope will take place (after user and functional requirements have been defined in the Concept of Operations, and after the PSEA has submitted for approval).

Some 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.

5.4.1 Specification for 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.

5.4.2 Specification for 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 AP-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 Vermont, the rest of this section will focus on the XML-based standards for center to center communications.
- **AP-C2CXML Protocol Implementation Conformance Specification (PICS)**. The AP-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 AP-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 AP-C2CXML provides for 2 message encoding mechanisms.
        - SOAP (Simple Object Access Protocol)
        - XML
    - **Message Transport.** The AP-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 AP-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.

6 ITS Standards Testing Program

Testing is important in the deployment of technology projects, such as ITS, because it serves as validation and confirmation that an implementation is correct. In Standards, testing is an important step because it provides information to procurers on the reliability, functionality, and performance of the ITS system based upon the applicable standards.

The bulk of the discussion in this section revolves around the testing of NTCIP standards, but many of the philosophies discussed are applicable to the other ITS Standards.

6.1 Testing Philosophy

Testing of devices to determine NTCIP compliance to a project specification has been an issue since the available of the initial draft release of an NTCIP Standard in 1995 by NEMA. There are different philosophies to testing, which are continuously being debated by the ITS Standards community. These different philosophies revolve around the questions:

- What is being tested? Is it the functional specifications, performance specifications, environmental specifications, and/or communications specifications?
- How to determine if an implementation conforms to the ITS Standard? Who should perform the testing?

This section addresses these basic questions.

6.1.1 Compliance versus Conformance

The primary difficulty with testing ITS Standards is the misconception of what ITS Standards are and are not.

ITS Standards ARE:

- communications protocols
- data elements, and/or
- message sets

ITS Standards are NOT:

- functional requirements – that is, it does not define how an ITS device performs a function
- performance requirements – that is, it does not define how quickly an ITS device should perform a function

This common misconception leads to differences in the goals of testing. These goals can be classified into two areas, compliance to the project specifications, and conformance to the ITS Standards.

- Compliance to Specifications – The use of standards may be a requirement of a project specification or part of the functional requirements. Although it may be determined that an ITS System "conforms" to a Standard, it does not mean that the ITS System performs the functions, or in the manner, that the procuring agency requires it to. Compliance to the specifications involves meeting any functional, environmental, or performance requirements that are required in the project specifications. This is a different type of testing, and may include functional, performance, and/or environmental testing.
- Conformance to Standards – ITS Standards specifies the manner and format that a device or subsystem communicates with other devices or subsystems. These Standards do not specify how that device or subsystem is implemented (i.e., is not technology prescriptive), but does express the minimum requirements for the assertion of "conformance".

The NTCIP Standards, for example, simply specify a consistent manner that information is transferred between components of a system, such as a center and field devices. They do NOT specify what functions will the device perform, nor do they specify how the device will implement a process to perform a function.

However, while defining how the information is expressed when developing the NTCIP Standards, it was necessary to describe what piece of information was being defined and what was it used for. Inadvertently, these descriptions became, in effect, a functional description of how a device used the piece of information and its effect on the operation of the components. Since there are currently no equivalent functional standard (description) of many of these devices, the NTCIP field device standards became the de facto functional standards.

Thus, by default, many users equate the test for conformance to the standard, correctly or incorrectly, to a test for compliance for specifications or functional requirements. One opinion is to clearly distinguish Standards testing and functional testing, however, BOTH testing must be performed for the device to work properly with respect to the project specifications.

For example, the NTCIP Standards defines the communications protocols and the data element formats to be transferred between devices. Although the data elements may be transferred properly (conforms to the standard), the sequence and processes that are performed will affect if the device performs the desired functions properly. For example,

for a DMS, a brightness value of 10 may still result in different light outputs (luminence) between a DMS manufactured by Vendor A and a DMS manufactured by Vendor B.

Thus, when deploying ITS systems, the goals of testing should be two-fold, achieving conformance to the applicable standards, and compliance to project deployment specifications.

The NTCIP Standards also lack any discussion of performance requirements, which can be an important issue for the implementation of NTCIP devices, particularly those with low bandwidth communications devices (e.g., 1200 baud dial-up modems). However, ITE and NEMA are sponsoring several on-going activities to define functional requirements for traffic signal controllers, dynamic message signs, and environmental sensor stations.

6.1.2 Compliance Testing

The focus of this chapter is on conformance to standards. Although testing for compliance to specification is important, particularly to the procuring agency, the topic is not the primary focus of this section. However, it is important to distinguish the difference between the two types of tests, to facilitate the discussion on conformance. The following distinguishes the different types of testing that can be categorized as compliance testing.

- **Functional Testing.** This form of testing is performed to verify that the ITS systems or devices being procured meets functional requirements of the specification. Functional requirements are normally identified in specifications by “shall” statements. Functional testing can be performed in a controlled environment, such as a factory, or after it has been installed, or both.
- **Environmental Testing.** This form of testing is performed to confirm that the ITS systems or devices properly operates in its normal operating environment. Environmental requirements may include temperature ranges, humidity ranges, vibration frequencies (such as a truck rumbling by in the field), and electrical power ranges.
- **Performance Testing.** Performance testing can be defined as testing the responsiveness of the ITS system or device to a command or action that has been initiated. For a field device, a performance criterion may be the time from when a command is received by the device to the time when the commanded action is performed and completed. For an ITS center system, the performance criterion may be the time when the command is sent by an operator at a workstation (e.g., a mouse click) to the time when the commanded action is completed (a new screen or window appears).
- **Factory Acceptance Testing.** Factory acceptance testing should be the satisfactory performance of several types of testing in a controlled environment. Besides verifying hardware requirements in the specifications (electrical,

mechanical and other hardware requirements), factory acceptance testing may include functional testing, environmental testing, performance testing, and conformance (to the ITS Standard) testing.

- **Stand-Alone Testing.** Stand-alone testing is the systematic performance of tests of individual components, devices, or a system. Since ITS usually involves the integration of multiple ITS systems, stand-alone tests verify the proper operation of a device or system before it is integrated with other devices or systems. For example, a stand-alone test may involve a VMS system before it is integrated into a statewide ATMS system.
- **Integration Testing.** As opposed to stand-alone testing, integration testing involves the continued proper operation of a device or system after it is "integrated" with other devices or systems. For example, an integration test may verify proper control and monitoring of a dynamic message sign after it is "integrated" into the statewide ATMS system.
- **Systems Acceptance Testing.** Also known as Systems Commissioning, satisfactory performance of the Systems Acceptance Test is usually a milestone for payment. Besides satisfactory performance of all testing, it is recommended that the requirements for passing the systems acceptance test include delivery of all required documentation, performance of all required training, and delivery of all spare parts and equipment.

6.1.3 Conformance Testing

Each ITS Standard should clearly indicate how a device or system can claim "conformance" to the standard. The specification should then point to that statement or section as the criteria for satisfactory completion of conformance testing. However, at this time, not all ITS Standards have such a statement. Thus, it is recommended that a specification clearly indicate how a device or system that is required to use a standard, can prove it "conforms" to the required standard.

Generally, a standard has two components, a mandatory component and an optional component. The mandatory components are required of all devices and systems wishing to conform to the standard. Thus, to claim conformance with the referenced standards, the implementation must satisfy the mandatory requirements identified in the referenced standards.

A standard may also have optional components, that is, these components are not required to be conformant to the standard. However, if a specification requires that optional component, that optional component must be provided in the manner dictated by the standard to remain conformant to the referenced standard.

Some standards, such as the NTCIP suite of standards, allow procurers and manufacturers/systems integrators to create custom objects or messages. This flexibility is provided because it was recognized that the standards cannot realistically support all the functionality that a procuring agency may need. If they did the standards could then become extremely large and unwieldy. If a function is required by the agency but is not supported by the standards, the agency should work with the manufacturer on how the functionality will be supported and tested. However, if the function can be supported by a referenced standard, the procured device or system shall support the function in the manner dictated by the referenced standard to remain conformant, and for interoperability purposes.

6.2 Issues and Approaches

To further clarify some of the issues of standards testing, this section discusses the advantages and disadvantages of one approach that has been considered for testing ITS standards, certification testing.

6.2.1 Certification Testing

From the various surveys on standards testing, users have indicated their desire for a certification laboratory to certify that products conform to the appropriate or desired ITS Standards. To the agencies, there are several benefits to this approach. The most obvious benefit are the savings in costs, time and effort to perform the testing. Otherwise, multiple agencies will be performing the same tests repeatedly. Arguably, once a manufacturer/systems integrator properly "communicates" a data element or message set correctly, it will always do so, unless there is a significant change in its software. Why have multiple agencies pay again to perform the same test multiple times?

However, there are several institutional issues that must be addressed before a certification laboratory can be established. Who certifies the third-party (laboratory) to perform the certification testing? What tools are acceptable and allowable to be used during the testing? Who approves the procedures to be used in the Standards testing? Where will the funding come from?

From an implementation point of view, requirements also will be different from agency to agency, one agency may request only a certain subset of a referenced ITS Standard, while another agency may request the entire set. A vendor may "pass" the certification test if the entire subset is implemented, but it might also "fail" the certification test for a specific implementation if only a subset is required by a procuring agency. While it may be simple to request the entire set of the Standard, it may also significantly increase the cost of the implementation.

Also, while it is possible to test that the data elements are communicated in a "standard" manner, as defined by the ITS Standard, the laboratory cannot certify that the data

elements are used in the manner intended by the procuring agency, nor can it certify that the performs the functions required.

For example, a DMS manufacturer may properly transmit the data elements for controlling the scheduler on a DMS, but it may use a proprietary (non-standard) object or data element to actually implement one of the scheduler functions. This use of a proprietary data element to implement the scheduler function highlights a potential deficiency, although the DMS manufacturer properly transferred the data elements involving the scheduler, and thus arguably passed the test for conforming to the Standard, the DMS manufacturer should have failed because it did not follow the intent of the standard. However, the certification test did not test the functionality or the implementation of the scheduler, it only tested that the data elements were properly transferred.

7 Current ITS Standards Activities

This section reviews the current status of relevant ITS Standards and ITS Standards testing activities on a national level. This section also review current Vermont efforts and contracts in deploying ITS standards. This includes Environmental Sensors, Advanced Traveler Information Systems, and CARS (IEEE 1512).

7.1 National ITS Standards Activities

What is the current scope and vision of the U.S. DOT's ITS Standards Program? The following paragraphs are excerpted from the *ITS Standards Program 2002 Update*.

> "The ITS Standards Program is the U.S. DOT's primary vehicle for encouraging the use of open interface standards in publicly funded ITS deployments. It is an integral part of the DOT's overall effort to build safe, integrated, and interoperable transportation systems. In the six years since its inception, the Standards Program has grown into a robust and multifaceted program and is regarded as a leading source of ITS standards information and activity for both the domestic and international transportation communities.
>
> The Program encompasses five key areas of standards activity: Development, Testing, Deployment, Technical Assistance, and Training and Outreach.
>
> Initially, the Program identified 100 standards that should be given development priority. These standards were either essential for achieving device interoperability or were used in ITS applications designated as the top priorities necessary to achieve national transportation objectives.
>
> Over the past 24 months, the Program has migrated its focus from standards development to standards deployment, aggressively building up resources—technical assistance, training, and outreach programs—that help state and local deployers implement standards- based ITS. This evolution is essential, given that standards need to be evaluated in real transportation applications if they are to gain widespread use. By focusing on deployment strategies, the Program is building upon the intensive standards development activities that took place in preceding years. [The program supports the following activities:]
>
> - Development Activities
>   - Establish cooperative agreements between the Program and standards development organizations (SDOs) to accelerate the development of standards
>   - Fund technical support for standards development working groups
>   - Support the participation of representatives from public agencies in the standards development process
> - Testing Activities

- Measure the operation, correctness, and completeness of ITS standards in realistic transportation settings
- Measure the degree of interoperability of ITS systems
- Provide testing results and information about the performance of standards

o Deployment Activities

- Provide tools that help state and local deployers implement standards-based ITS
- Provide platforms that allow state and local deployers to exchange ideas and to discuss standards deployment-related issues

o Technical Assistance Activities

- Deliver a comprehensive program of technical assistance to state and local deployers
- Increase the knowledge base of state and local deployers on ITS standards evaluation, procurement, deployment, and maintenance issues

o Training and Outreach Activities

- Develop materials and resources that promote the awareness and use of ITS standards
- Offer comprehensive technical training in various ITS standards at locations throughout the country

While the emphasis on standards development has decreased in the past couple years, the U.S. DOT is still actively supporting a wide array of standards development activities. As of January 2005, the U.S. DOT reported the following statistics on standards development:

Table 7-1. U.S. DOT ITS Standards Status Levels

Status Level	Status Level Description
75 - Published	Standards that are available for purchase.
10 - Approved	Standards that have passed all necessary ballots and have been approved by a standards development organization, but not yet published.
5 - Ballot	Standards that are being voted upon by a committee or working group, or are undergoing other SDO procedures.
27 - Under Development	Standards that are being written, but are not yet ready for a formal ballot.

While these statistics seem to indicate that ITS standards development is fairly complete, the reality of the situation is far different. Most of the published standards have not been tested, and some of the key ones (e.g. transit and traffic management standards) are undergoing major rewrites as the originally published versions are considered inadequate for use.

The following sections will provide details of the individual standards efforts.

7.1.1 National Transportation Communications for ITS Protocol (NTCIP)

AASHTO, teamed with the National Electrical Manufacturers Association (NEMA) and the Institute of Transportation Engineers (ITE), is the lead standards development organization for developing and advising on the National Transportation Communications for ITS Protocol (NTCIP) standards. NEMA is one of the largest standards development organizations (SDOs) in the nation and represents over 600 member organizations. NEMA is a member organization of NTCIP and acts as the publisher of NTCIP standards.

Table 7-2. NTCIP Standards

Type	Document Number	Standard Title	Status	Description	Contact
C	NTCIP 1101	NTCIP Simple Transportation Management Framework (STMF) – TS3.2, Amendment 1	To be replaced by NTCIP 1102, NTCIP 1103, and NTCIP 8004	The STMF describes the simple transportation management framework used for managing and communicating information between management stations and transportation devices. It covers integrated management of transportation networks, networking devices, and transportation specific equipment attached to NTCIP-based networks.	Robert De Roche, Robert De Roche Consulting
C	NTCIP 1102	NTCIP - Octet Encoding Rules (OER) – v01.12	Recommended Standard	Defines the presentation layer data encoding rules that are used in conjunction with application layer protocols defined in other standards. serves as a replacement for part of NTCIP 1101 (STMF), but also defines additional features.	Robert De Roche, Robert De Roche Consulting
C	NTCIP 1103	NTCIP Transportation Management Protocol (TMP) – v01.15	User comment draft	Includes STMP (NTCIP 1101) with additional definitions.	Robert De Roche, Robert De Roche Consulting
	NTCIP 1104	NTCIP CORBA Naming Convention Specification	Recommended Standard	Defines the naming Defines the naming service for CORBA for use in center-to-center communications in the transportation domain, and lists the requirements for establishing names for management systems and for the objects managed by those systems.	Manny Insignares, ConSysTec Corp.
	NTCIP 1105	NTCIP CORBA Security Service Specification	User comment draft	Defines the standard security feature for CORBA NTCIP systems	Manny Insignares, ConSysTec Corp.

Type	Document Number	Standard Title	Status	Description	Contact
	NTCIP 1106	NTCIP CORBA Near Real-Time Data Service Specification	Approved work item	Defines the standards way in which real-time data should be exchanged within CORBA systems.	Manny Insignares, Consensus Systems Technologies Corp.
C2C D, M	NTCIP 1201	NTCIP - Global Object Definitions – Version 1, Amendment 1	Version 2 submitted for balloting	Defines the pieces of data that are likely to be used in multiple device types, such as time, schedules, report generation	Ken Vaughn, Trevilon Corp.
C2C D, M	NTCIP 1202	NTCIP - Object Definitions for Actuated Traffic Signal Controller Units – Version 1, Amendment 1	Version 2 in user comment draft (v02.13)	Defines the data that are frequently found in actuated traffic signal controllers.	Peter Ragsdale, McCain Traffic Supply, Inc. Beth Ramirez, City of Dallas
C2C D, M	NTCIP 1203	NTCIP - Object Definitions for Dynamic Message Signs – Version 1, Amendment 1	Version 2 in user comment draft.	Defines the data that are found in dynamic message signs, including blank-out signs, changeable message signs, and variable message signs.	Mark Morse, Washington State DOT
C2C D, M	NTCIP 1204	NTCIP - Object Definitions for Environmental Sensor Stations – Version 1, Amendment 1	Version 2 in user comment draft.	Defines the data that are found in road weather information stations and air quality sensors.	
C2C D, M	NTCIP 1205	NTCIP - Object Definitions for Closed Circuit Television Camera Control – Version 1	Amendment 1 in user comment draft.	Defines the data that are used to control video cameras	Michael Forbis, Washington State DOT
C2C D, M	NTCIP 1206	NTCIP – Object Definitions for Data Collection – User Comment Draft - v01.21	Version 1 submitted for balloting	Deals with the data stored in roadside count stations.	Rick Stalowski, Peek Traffic Systems. Inc.
C2C D, M	NTCIP 1207	NTCIP - Object Definitions for Ramp Meter Control – Version 1	Recommended Standard	Defines the data that are found in ramp meters	Brian Simi, CalTrans
	NTCIP 1208	NTCIP - Object Definitions for Video Switches – User Comment Draft – v01.04	Version 1 submitted for balloting	Defines the data to control a video switch to enable multiple monitors to view multiple video feeds.	Michael Forbis, Washington State DOT

Type	Document Number	Standard Title	Status	Description	Contact
C2C D, M	NTCIP 1209	NTCIP - Object Definitions for Transportation Sensor Systems – Version 1	Recommended Standard	Deals with the data collected by various types of detectors used by real-time management systems.	TBD
C2C D, M	NTCIP 1210	NTCIP – Objects for Signal System Masters – User comment draft – v01.14	Resolving user comments	Defines the data used to control a field master	Richard Denney, Iteris, Inc.
C2C D, M	NTCIP 1211	NTCIP – Objects for Signal Control and Prioritization – User comment draft – v01.26	Version 1 submitted for balloting	Defines the data for controlling traffic signal systems in priority applications	Ronald Atherley, King Count DOT – Metro Transit
	NTCIP 1212	NTCIP – Objects for Network Camera Operations – Working Group Draft	In development	Defines the data that are used with digital image cameras	Michael Forbis, Washington State DOT
C2C D, M	NTCIP 1213	NTCIP – Objects for Electrical and Lighting Management Systems – Working Group Draft	In development	Defines the data for roadside electrical and lighting management systems	Karl Burkett, Texas DOT
C2C D,M	NTCIP 1301	NTCIP Weather Report Message Set for ESS – Working Group Draft	In development	Defines the message set to exchange weather and pavement data between centers	E.A. (Gene) Martin, Virginia DOT
C2C	NTCIP 1602	NTCIP - Generic Reference Model	In development	Defines a UML-based model for traffic management center communications	Manny Insignares, ConSysTec Corp.
	NTCIP 2001	NTCIP - Class B Profile – Version 1, Amendment 1	To be rescinded by NTCIP 2201, NTCIP 2301, NTCIP 2101, and NTCIP 2102	Defines the low bandwidth NTCIP protocol.	Robert De Roche, Robert De Roche Consulting
	NTCIP 2002	NTCIP - Class A and Class C Profile	Withdrawn	Withdrawn.	
	NTCIP 2101	NTCIP - Point-to-Multipoint Protocol/RS232 Subnetwork Profile – Version 1	Recommended Standard	Defines how to communicate over a multi-drop serial communications link.	Robert De Roche, Robert De Roche Consulting
	NTCIP 2102	NTCIP - Point-to-Multipoint Protocol/FSK Subnetwork Profile – Version 1	Recommended Standard	Defines how to communicate over twisted wire using FSK modems.	Robert De Roche, Robert De Roche Consulting

Type	Document Number	Standard Title	Status	Description	Contact
	NTCIP 2103	NTCIP - Point-to-Point Protocol/RS232 Subnetwork Profile – Version 1	Recommended Standard	Defines how to communicate over a dial-up link or other serial point-to-point link.	Robert De Roche, Robert De Roche Consulting
	NTCIP 2104	NTCIP - Ethernet Subnetwork Profile – Version 1	Recommended Standard	Defines how to communicate over ethernet links.	Robert De Roche, Robert De Roche Consulting
	NTCIP 2201	NTCIP Transport Profile – Version 1	Recommended Standard	Defines a bandwidth efficient mechanism to transit data when the subject devices are directly connected and do not require network services.	Robert De Roche, Robert De Roche Consulting
	NTCIP 2202	NTCIP - Internet (TCP/IP & UDP/IP) Transport Profiles – Version 1	Recommended Standard	Defines how to communicate using the Internet suite of protocols.	Robert De Roche, Robert De Roche Consulting
	NTCIP 2301	NTCIP – Simple Transportation Management Framework Application Profile – Version 1	Approved	Defines how to exchange data between a management system and a field device.	Robert De Roche, Robert De Roche Consulting
	NTCIP 2302	NTCIP - Trivial File Transfer Protocol - Application Profile – Version 1	Approved	Defines how to use the Trivial File Transfer Protocol within transportation networks	Robert De Roche, Robert De Roche Consulting
	NTCIP 2303	NTCIP - File Transfer Protocol - Application Profile – Version 1	Approved	Defines how to use the File Transfer Protocol within transportation networks	Robert De Roche, Robert De Roche Consulting
	NTCIP 2304	NTCIP - Application Profile - Data Exchange (DATEX)	Recommended Standard	Defines how to use the DATEX-ASN protocol within US-based transportation networks.	Manny Insignares, ConSysTec Corp.
	NTCIP 2305	NTCIP - Application Profile - CORBA	User Comment Draft – Development on hold	Defines how to use the Common Object Request Broker Architecture protocol within transportation networks.	Manny Insignares, ConSysTec Corp.
	NTCIP 2306	NTCIP Application Profiles for XML Message Encoding and Transport in ITS Center to Center Communications (NTCIP AP-C2CXML)	User Comment Draft	Defines XML message encoding and transport using SOAP, HTTP, and FTP. Also defines the format for WSDL for defining center-based interfaces including: center operations supported,, message inputs and outputs, and applicable message set schemas.	Manny Insignares, ConSysTec Corp.
	NTCIP 7001	NTCIP InP-DATEX – Working Group Draft	Development on hold	Defines what services are required within DATEX centers to determine what messages and data the center supports	Manny Insignares, ConSysTec Corp.

Type	Document Number	Standard Title	Status	Description	Contact
	NTCIP 7002	NTCIP InP-CORBA – Working Group Draft	Development on hold	Defines what CORBA services are required in ITS systems.	Manny Insignares, ConSysTec Corp.
	NTCIP 9000	NTCIP Guide	Recommended Standard	General information guide for NTCIP. Focus is primarily on center to field communications	TBD
C2C	NTCIP 9010	NTCIP Information Report – Using XML in Center-to-Center Communications	Recommended Information Report	General information report describing future XML-based standards development efforts.	Manny Insignares, ConSysTec Corp.

7.1.2 American National Standards Institute (ANSI)

The American National Standards Institute (ANSI), the U.S. administrator and coordinator of private sector voluntary standardization, does not itself develop standards. An ANSI committee [the Accredited Standards Committee (ASC) X12] was chartered to develop standards to facilitate electronic data interchange (EDI) for business transactions. This committee is in the process of developing ITS-related standards involving commercial vehicle operations (CVO).

Table 7-3. ANSI Standards

Type	Document Number	Standard Title	Status	Description	Contact
	ANSI TS284	Commercial Vehicle Safety Reports	Accepted	Defines the format and data to request and send reports on the safe operation of commercial road vehicles	The John Hopkins University Applied Physics Laboratory
	ANSI TS285	Commercial Vehicle Safety and Credentials Information Exchange	Accepted	Defines the format and data to request and send information on safety and credentials information.	The John Hopkins University Applied Physics Laboratory
	ANSI TS286	Commercial Vehicle Credential	Accepted	Defines the format and data to apply for required credentials.	The John Hopkins University Applied Physics Laboratory

7.1.3 American Public Transportation Association (APTA)

APTA is an international organization that represents and promotes all aspects of the transit industry, including bus, rapid transit and commuter rail systems, as well as the organizations responsible for planning, designing, constructing, financing and operating transit systems. The organization has recently assumed the lead role in the development of standards for the transit community. A suite of Transit Communications Interface Profiles (TCIP) standards were originally developed and published by ITE (through the NTCIP effort). These standards, which covered most of the interfaces to the Transit Management Subsystem of the National ITS Architecture, defined data and messages for the interfaces. However the standards failed to define a sequenced set of messages (or dialogs) that would be needed to actually implement systems using TCIP. An effort to develop these dialogs was begun by ITE, but was terminated prior to completion. The effort was passed to APTA in 2003 and they currently have a contractor team developing the dialogs and revising the standard to provide a usable result.

TCIP is divided into 9 areas as follows:

1. TCIP Framework
2. Common Public Transportation (CPT)
3. Incident Management (IM)
4. Passenger Information (PI)
5. Scheduling/Runcutting (SCH)
6. Spatial Representation (SP)
7. On-board (OB) Objects
8. Control Center (CC) Objects
9. Fare Collection (FC) Objects

Table 7-4. TCIP Standards

Type	Document Number	Standard Title	Status	Description	Contact
D, M	TCIP 3.0	Transit Communications Interface Profiles	Under Development	A single standard is being developed that covers the multiple business areas of the previous suite of standards. Draft Version 2.6 is currently in review. The initial draft for ballot is expected in mid 2005.	Isaac K. Takyi, Ph.D., MTA
D, M	UTFS-xxx	Universal Transit Farecard Standard	Under Development	This standard will define the interfaces needed for regional fare cards.	Tom Parker, BART

7.1.4 ASTM International

ASTM International provides a forum for producers, users, consumers, and others who have interests in standard test methods, specifications, practices, guides, classifications, and terminology. ASTM leads efforts in ITS standards concerning dedicated short range communications (DSRC). Standards for DSRC at the 5.9 GHz frequency range are being developed through a cooperative agreement between the Federal Highway Administration and ASTM International to support both public safety and other non-governmental operations in roadside-to-vehicle and vehicle-to-vehicle communication environments.

Table 7-5. ASTM Standards

Type	Document Number	Standard Title	Status	Description	Contact
	E17.54.02.1	Standard Specification for Metadata Content for ITS-Generated Data	In development	Specifies how to annotate data for subsequent uses.	Rich Margiotta, Cambridge Systematics
	E17.54.02.2	Standard Specification for Archiving ITS-Related Traffic Monitoring Data	In development	Specifies a data dictionary for archiving traffic data.	Rich Margiotta, Cambridge Systematics
	E2158-01	Std. Spec. for Ded Short Range Comm. (DSRC) Physical Layer Using Microwave in the 902-928 MHz Band	Published Standard	Specification for the RF characteristics (physical layer) for DSRC operating in the range of 902-928 MHz. Supports both active and backscatter transponders.	Dan Smith, ASTM

Type	Document Number	Standard Title	Status	Description	Contact
	E2213-02	Std. Spec. for Telecomm. and Info. Exchange between Roadside and Vehicle Systems: 5.9 GHz DSRC	Published Standard	A medium access control layer (MAC) and physical layer (PHY) specification for wireless connectivity using dedicated short-range communications (DSRC) services.	Dan Smith, ASTM
	E2259-03	Standard Guide for Archiving and Retrieving ITS-Generated Data-	Published Standard	This guide covers desired approaches to be considered and followed in planning, developing, and operating specific ADMS for the archiving and retrieval of ITS-generated data	Rich Margiotta Cambridge Systematics
	PS105-99	Standard Specification for DSRC - Data Link Layer	Published Standard	Specification for the protocol (data link) communications. Supports both synchronous and asynchronous modes for operations.	Daniel Smith, ASTM

7.1.5 Electronics Industries Alliance (EIA)/Consumer Electronics Association (CEA)

The Consumers Electronics Association (CEA) is a sector of the Electronic Industries Alliance (EIA). Two ITS standards have been developed under the auspices of CEA, both having to do with traveler information radio and subcarrier systems.

Table 7-6. EIA Standards

Type	Document Number	Standard Title	Status	Description	Contact
	EIA-794	Data Radio Channel (DARC) System	Published Standard	Specifies the DARC FM Subcarrier waveform for the delivery of traveler information, messages and data services to mobile, portable and fixed receivers.	Jean Johnson, CEA
	EIA-7945	Subcarrier Traffic Information Channel (STIC) System	Published Standard	A flexible waveform defined for the physical and data link layers for delivery of data to mobile and fixed users using a sub-carrier on a broadcast FM station.	Jean Johnson, CEA

7.1.6 Institute of Electrical and Electronics Engineers (IEEE)

The Institute of Electrical and Electronics Engineers (IEEE) develops and disseminates voluntary, consensus-based industry standards involving all types of electrotechnology. ITS-related standards being developed by IEEE include message sets and data dictionaries. The Institute for Electrical and Electronic Engineering sponsors a Standards Coordinating Committee 32 (SCC32) responsible for coordinating, developing, and maintaining standards, recommended practices, and guidelines related to Intelligent Transportation Systems (ITS) within the scope of IEEE interests. SCC32 works with other national and international standards writing bodies to coordinate area of involvement and has had a role in establishing the ITS Data Registry.

The USDOT ITS Standards Program made the decision in late 2003 to operate the ITS Data Registry (ITS-DR) in house, and to focus the ITS-DR on being a support tool to ITS standards developers. This realignment of the purpose of the ITS-DR fits with a new strategic plan to accelerate the completion and deployment of specific standards applications to field settings within the next three years. In conjunction with these goals, the ITS-DR will undergo a redesign to make it more user friendly and better parallel the standards development process, reuse, and harmonization activities.

This relocation and redesign effort requires a shut down of the ITS-DR for about a month in early 2004. We currently understand that the ITS-DR will be shut down from April - June of 2004, although these dates have not yet been confirmed. During the shut down time, the physical server and website will be relocated from IEEE in Piscataway, NJ to the U.S. DOT's Volpe Center in Cambridge, MA, and run through a set of security checks before linking it to the Internet. The ITS-DR will have a new URL address when in returns to the Internet. It's access will be limited to those consultants who are aligned with the Standards Development Organization's to develop ITS standards.

The ITS-DR will look and operate in a similar manner for the first couple of months. Based on a prototype, testing, and user input, the ITS Standards Program is estimating that a redesigned site will be available in Summer 2004. The redesign will be based on a set of interviewers with users that will occur during the months of January and February 2004. It is expected that the redesigned ITS-DR will operate more in parallel with the development working groups and harmonization committee processes.

Table 7-7. IEEE Standards

Type	Document Number	Standard Title	Status	Description	Contact
	Bks 1-6: SH94633-SH 94638	The Survey and Analysis of Existing Standards and those Under Development Applicable to the Needs of the ITS Communications Technologies	Published Standard	The survey and analysis of existing standards (and those under development) that include requirements for both wireline and wireless transmissions.	Patricia Gerdon, IEEE
	P1556	Standard for Security and Privacy of Vehicle/Roadside Communication Including Smart Card Communications	Balloting	Identifies security methods to be used in DSRC message transmission at specific frequencies, and develops a single standard methodology for the protection of information between the vehicle and the roadside.	Patricia Gerdon, IEEE
	P1609.1	Standard for Dedicated Short Range Communications Resource Manager	Balloting	This standard describes a resource manager that arbitrates requests for transponder usage.	Tom Kurihara, TKstd Management
	P1609.2	Standard for Dedicated Short Range Communications Application Layer	In development	Describes an application layer standard to be used for 5.9 GHz DSRC.	Tom Kurihara, TKstd Management
	P1609.3	Standard for IP Interface for Dedicated Short Range Communications	In development	Describes standard that supports higher layer communication stacks, including TCP/IP.	Tom Kurihara, TKstd Management
	P1609.4	Standard for Data Dictionary and Message Sets for Dedicated Short Range Communications	In development	Describes various standard message formats for DSRC applications at 5.9 GHz.	Patricia Gerdon, IEEE
	Std 1404-1998	Guide for Microwave Communications System Development	Published Standard	A guide that addresses all the requirements for microwave system design, procurement, construction, maintenance, and subsequent operations	Patricia Gerdon, IEEE
	Std 1488-2000	Standard for Message Set Template for Intelligent Transportation Systems	Published Standard	A standard for an ITS message set template. Approved for trial use through June 2002.	Patricia Gerdon, IEEE
	Std 1489-1999	Standard for Data Dictionaries for Intelligent Transportation Systems - Part 1 Functional Area Data Dictionaries	Published Standard	A set of meta entities and meta attributes for ITS data dictionaries, as well as associated conventions and schemas, that enable describing, standardizing, and managing all ITS data.	Patricia Gerdon, IEEE
	Std 1512-Base	Standard for Common Incident Management Message Sets for use by Emergency Management Centers	Published Standard	Standards describing the form and content of the incident management messages sets for emergency management systems (EMS) to traffic management systems (TMS) and from emergency management systems to the emergency telephone system (ETS) or (E911).	Patricia Gerdon, IEEE

Type	Document Number	Standard Title	Status	Description	Contact
	Std 1512.1	Standard for Traffic Incident Management Message Sets for Use by EMCs	Published Standard	Enables consistent standardized communications among Incident Management centers, fleet and freight management centers, information service providers, emergency management centers, planning subsystems, traffic management centers and transit management centers.	Patricia Gerdon, IEEE
	Std 1512.2	Standard for Public Safety Incident Management Message Sets for Use by EMCs	Published Standard	A comprehensive set of messages required for incident management that is unique to public safety communications. These message sets will be generated and transmitted among the emergency management subsystem to all the other subsystems and public safety providers.	Patricia Gerdon, IEEE
	Std 1512.3	Standard for Hazardous Material Incident Management Message Sets for Use by Emergency Management Centers	Published Standard	Enables consistent standardized communications among incident management centers, HAZMAT teams, police, local government, special emergency and emergency management centers.	Patricia Gerdon, IEEE
	Std 1512.4	Standard for Common Traffic Incident Management Message Sets for Use in Entities External to Centers	Requirements are under development	This standard will address Traffic Incident Management Message Sets which will be exchanged by and between mobile data terminals in response vehicles including mobile command posts and to their respective response and/or dispatch centers such that the exchange of information will be standard and produce the needed response(s). This standard will be limited to common message sets for use by emergency management including transportation, fire/rescue, enforcement, HazMat, etc.	Patricia Gerdon, IEEE
	Std 1570-2002	Standard for the Interface Between the Rail Subsystem and the Highway Subsystem at a Highway Rail Intersection	Published Standard	This standard defines the logical and physical interfaces, and the performance attributes for the interface between the rail subsystem and the highway subsystem at a highway rail intersection.	Patricia Gerdon, IEEE

7.1.7 Institute of Transportation Engineers (ITE) and American Association of State Transportation Officials (AASHTO)

The Institute of Transportation Engineers (ITE) is one of the largest professional transportation organizations in the world. ITE members include traffic engineers, transportation planners, and other professionals who are responsible for planning, designing, implementing, operating and maintaining surface transportation systems worldwide. ITE is involved in the development of NTCIP, TCIP, and other ITS standards. The Institute of Transportation Engineers is one of five standards development organizations designated by the U.S. Department of Transportation (U.S. DOT) to develop ITS standards under a cooperative agreement with the U.S. DOT. The US DOT has recognized the potential value of NTCIP standards for reducing deployment costs and increasing

opportunities for regional integration. Because of these benefits, the US DOT has funded both the development and testing of ITS standards by contract with SDO and private contractors.

Table 7-8. ITE and AASHTO Standards

Type	Document Number	Standard Title	Status	Description	Contact
	9603-1	Application Program Interface (API) Standard for the Advance Transportation Controller (ATC)-	Recommended Standard	An advanced transportation controller (ATC) software application program interfaces (APIs) that support ITS data flows and standards enabling the deployment of ITS functions.	James Cheeks, ITE
	9603-2	Advanced Transportation Controller (ATC) Cabinet	Balloting	Functional physical design requirements for an advanced transportation controller (ATC) cabinet that supports the deployment of multiple ITS functions in a single cabinet.	James Cheeks, ITE
	9603-3	Advanced Transportation Controller (ATC)	Balloting	Standard for advanced transportation controller (ATC) devices to support ITS data flows and standards that enable deployment of ITS.	James Cheeks, ITE
	TM 1.03	Standard for Functional Level Traffic Management Data Dictionary (TMDD)- working on amendment	Published Standard (Version 2.1 to be adopted April 30, 2005)	This document contains data elements for roadway links and for incidents and traffic-disruptive roadway events. Includes data elements for traffic control, ramp metering, traffic modeling, video camera control traffic, parking management and weather forecasting, as well as data elements related to detectors, actuated signal controllers, vehicle probes, and dynamic message signs.	James Cheeks, ITE
	TM 2.01	Message Sets for External TMC Communication (MS/ETMCC)- working on amendments	Published Standard (Version 2.1 to be adopted April 30, 2005)	A message set standard for communication between traffic management centers and other ITS centers, including information service providers, emergency management systems, missions management systems, and transit management systems	James Cheeks, ITE

7.1.8 Society of Automotive Engineers (SAE)

This organization is made up of more than 75,000 engineers, business executives, educators, and students who share information and exchange ideas for advancing the engineering of mobility systems. Information about SAE's ITS standards activities can be found within the "Technical Committee" section of this Web site. The Society of Automobile Engineers ITS Program office, coupled

with industry representatives and SAE ITS Staff Program Team work together to develop and promote ITS based standards nationally and globally. The SAE ITS Division is comprised of committees that address Advanced Traveler Information Systems, ITS Data Bus architecture and Safety and Human Factors research.

Table 7-9. SAE Standards

Type	Document Number	Standard Title	Status	Description	Contact
	SAE-J1663	Truth-in-Labeling Standard for Navigation Map Databases	Published Standard	This standard defines consistent terminology, metrics, and tests for describing the content and quality of navigable map databases.	Jack Pokrzywa, SAE
	SAE-J1708	Serial Data Comm. Between MicroComputer Systems in Heavy-Duty Vehicle Applications	Published standard	Defines a recommended practice for implementing a bi-directional, serial communication link among modules containing microcomputers. Defines those parameters of the serial link that relate primarily to hardware and basic software compatibility such as interface requirements, system protocol, and message format.	Jack Pokrzywa, SAE
	SAE-J1746	ISP-Vehicle Location Referencing Standard	Published standard	referencing format for information service provider (ISP)-to-vehicle and vehicle-to-ISP references. This standard will reflect the cross-streets profile of the current location reference message specification (LRMS) document as expressed in the National Location Referencing Information Report (SAE J2374).	Jack Pokrzywa, SAE
C, D, M	SAE-J1760	ITS Data Bus Data Security Services Recommended Practice	Published standard	Specifies definition of data security requirements between devices on the ITS data bus (IDB) and definitions of device and message level security. Also includes a mechanism to discourage theft of data bus modules.	Jack Pokrzywa, SAE
	SAE-J1761	Information Report on ITS Terms and Definitions	Published standard	A dictionary of terminology in the ITS field, with a focus on the vehicle and interfaces to the vehicle.	Jack Pokrzywa, SAE
	SAE-J1763	A Conceptual ITS Architecture: An ATIS Perspective	Published standard	This Information Report describes a general reference architecture for integration of multiple advanced traveler information system (ATIS) devices.	Jack Pokrzywa, SAE
D, M	SAE-J2313	On-Board Land Vehicle Mayday Reporting Interface	Published standard	A general specification that prescribes protocol methods which enable vendors with different communication methods to communicate with response agencies in a standard format.	Jack Pokrzywa, SAE

Type	Document Number	Standard Title	Status	Description	Contact
	SAE-J2352	Mayday Industry Survey Information Report	Published standard	A summary of information obtained by way of a survey conducted in 1997 of MAYDAY system manufacturers. The information is limited to technical data as it pertains to vehicle and on-board MAYDAY system operations.	Jack Pokrzywa, SAE
	SAE-J2353	Data Dictionary for Advanced Traveler Information Systems (ATIS)	Folded into J2354	A minimum set of medium-independent data elements needed by potential information service providers to deploy ATIS services and provide the basis for future interoperability of ATIS devices.	Jack Pokrzywa, SAE
M	SAE-J2354	Message Set for Advanced Traveler Information System (ATIS)	Published standard	A basic message set and data dictionary needed by potential information service providers to deploy ATIS services and to provide the basis for future interoperability of ATIS devices.	Jack Pokrzywa, SAE
	SAE-J2355	ITS Data Bus Architecture Reference Model Information Report	Published standard	A reference model for an in-vehicle data bus. The ITS data bus (IDB) will enable manufacturers, dealers, and vehicle owners to install a wide range of electronics equipment reliably and safely in a vehicle at any time during the vehicle lifecycle.	Jack Pokrzywa, SAE
C	SAE-J2366-2	ITS Data Bus Protocol - Link Layer Recommended Practice	Published standard	Requirements for the link layer (layer 7 of the OSI model) for the ITS data bus.	Jack Pokrzywa, SAE
C	SAE-J2366/1	ITS Data Bus Protocol - Physical Layer Recommended Practice	Published standard	A physical interface device (connector) that will ensure compatibility between vehicles and aftermarket devices. Physical interface performance requirements, circuit identification and configuration, and electrical requirements for the physical layer of the ITS data bus.	Jack Pokrzywa, SAE
C	SAE-J2366/4	ITS Data Bus Protocol - Thin Transport Layer Recommended Practice	Published standard	Requirements for the thin transport layer (Layer 4 of the OSI model) for the ITS data bus.	Jack Pokrzywa, SAE
C, D, M	SAE-J2366/7	ITS Data Bus Protocol - Application Layer Recommended Practice	Published standard	Requirements for the application layer (layer 7 of the OSI model) for the ITS data bus.	Jack Pokrzywa, SAE
C, D, M	SAE-J2367	ITS Data Bus Gateway Recommended Practice	Published standard		Jack Pokrzywa, SAE

Type	Document Number	Standard Title	Status	Description	Contact
C, D, M	SAE-J2369	Standard for ATIS Message Sets Delivered Over Bandwidth Restricted Media	Published standard	A general framework allowing transmission of traveler information via bandwidth reduced media such as found in wireless applications. Creates a uniform coding and message structure for link travel times, incident text, weather and transit for broadcast delivery.	Jack Pokrzywa, SAE
	SAE-J2372	Field Test Analysis Information Report	Published standard	This information report presents the results of field tests on location-referencing standards.	Jack Pokrzywa, SAE
	SAE-J2372	Stakeholders Workshop Information Report	Published standard	Results of workshops to solicit and discuss stakeholder requirements for location referencing standardization.	Jack Pokrzywa, SAE
	SAE-J2374	Location Referencing Message Specification	Published Standard	A basis for location referencing standardization activities by various application communities and SDOs.	Jack Pokrzywa, SAE
H	SAE-J2395	ITS In-Vehicle Message Priority	Published standard	Specifies orderly temporal and spatial presentation of ITS information to the driver.	Jack Pokrzywa, SAE
H	SAE-J2396	Measurement of Driver Visual Behavior Using Video Based Methods (Def. & Meas.)	Published standard	Procedures for collecting, reducing, analyzing, and reporting on driver-eye glance data in a manner suitable for evaluating ITS systems and comparing alternative designs for a particular system in terms of visual demand. Helps insure that systems minimize the time a driver's eyes are off the road.	Jack Pokrzywa, SAE
H	SAE-J2399	Adaptive Cruise Control: Operating Characteristics and User Interface	Published standard	This standard presents the minimum requirements for safety-related elements of the operating characteristics and user interface of vehicles equipped with adaptive cruise control (ACC). It also coordinates the operating characteristics and user interface with collision warning and avoidance, along with other driver systems.	Jack Pokrzywa, SAE
H	SAE-J2400	Forward Collision Warning: Operating Characteristics and User Interface	Published standard	Minimum safety and human factor requirements for front collision warning (FCW) operating characteristics and driver interfaces to ensure consistency across vehicles so that drivers can quickly understand and safely use a FCW-equipped vehicle.	Jack Pokrzywa, SAE
M	SAE-J2529	Rules for Standardizing Street Names and Route IDs	Published standard	Specifies the rules for standardizing street names for use in ATIS and other ITS applications.	Jack Pokrzywa, SAE

Type	Document Number	Standard Title	Status	Description	Contact
	SAE-J2539	Comparison of GATS Messages to SAE ATIS Standards Information Report	Published standard	An overview and comparison of Global Automotive Telematics Standard (GATS) messages developed for use on global system mobile (GSM) cellular phone systems (European).	Jack Pokrzywa, SAE
M	SAE-J2540	Messages for Handling Strings and Look-Up Tables in ATIS Standards	Published standard	Describes the process used in various SAE ATIS message set standards to deliver textual strings and provides national tables used in the delivery of incident description.	Jack Pokrzywa, SAE
D, M	SAE-J2540-1	RDS (Radio Data System) Phrase List	Published standard		Jack Pokrzywa, SAE
D, M	SAE-J2540-2	ITIS (International Traveler Information Systems) Phrase Lists	Published standard		Jack Pokrzywa, SAE
D, M	SAE-J2540-3	National Names Phrase List	Published standard		Jack Pokrzywa, SAE
	SAE-J2630	Converting ATIS Message Standards from ASN.1 to XML	Published standard		Jack Pokrzywa, SAE

7.2 National ITS Standards Testing Activities

This section provides a review of the current status of FHWA's ITS Standards Testing activities. It provides an introduction to the issues regarding standards testing, an evaluation of the different philosophies on standards testing, then summarizes some of the activities that are on-going in the area of standards testing.

7.2.1 ITS Standards Testing

In March 1999, the U.S. Department of Transportation (USDOT) contracted with Battelle to test ITS standards that have been approved and published, or are currently under development by the Standards Development Organizations (SDOs). The purpose of this Program was to build confidence in the maturity and quality of the ITS Standards that have been developed. The Program hoped to prove that:

- Deploying Standards are effective and will lead to interoperability and interchangeability
- Standards supports the core functionality and capabilities of the relevant technology
- Standards are unambiguous, complete, and consistent
- Standards are stable

The Program was intended to be an objective assessment and evaluation of deployed, operational systems, with the focus on field test sites as opposed to laboratory testing. Each field test site was evaluated for the effectiveness, usability, and performance of the implementation using an ITS Standard. Two testing evaluations of ITS Standards were completed:

- An NTCIP 1203 - Dynamic Message Sign (DMS) implementation (formerly NTCIP TS3.6), with variable message signs from two different sign vendors
- An NTCIP 1204 – Environmental Sensor Station (ESS) implementation

A summary of the test reports is provided in Section 7.2.1.2. The full test reports are available at the US DOT Standards web site.

7.2.1.1 Testing Process

The Battelle ITS Standards Testing process was comprised of four major parts:

- **Establish the Standards Baseline**. Examined the implementation to determine the standards content. Does the implementation faithfully follows the standard, or does the implementation make any non-conforming use of the standard? Does the implementation use any proprietary or non-standard protocols, data

elements or message sets? This analysis of the implementation provided the basis for the next phase of the process, the interviews.

- **Conduct Interview(s).** Gathered information from the procuring agency, the systems integrator, the manufacturer, the user/operators and the maintainers on the experience in procuring, specifying, testing, and using the standard. The interviews were conducted using questionnaires, with follow-ups via face-to-face or telephone interviews. The experiences collected include the perceived benefits, problems, and effectiveness of using the standard, including lessons learned. Weaknesses, strengths, and problems with the standard are also derived from these interviews.
- **Examine the Integrity and Purity of External Interface(s)**. Since the Battelle Testing Program only focused on the NTCIP suite of communications protocol, examined the data packets between the two components of the system. Reviewed the data packets for conformance with the syntax and format of the Standard, and searched for the use of data elements not specified in the Standard.
- **Perform Field Testing.** Performed controlled field testing of the field device at an operational site. These controlled field tests included examining the core functions and features of the technology and testing for exception or "non-standard" conditions.

Battelle then produced a Standards Test Report that identifies the "Findings" and associated recommendations about how to make the subject standard better. The reports focus only on the findings relative to the features of the standards and does not critique the implementation or the host site.

7.2.1.2 Test Reports

This section summarizes the test reports that were produced as a result of the two field evaluation tests performed to date by the ITS Standards Testing team.

Dynamic Message Signs

Examined an implementation of NTCIP 1203 in March 2000, with two (2) different vendors. Reviewed 19 core functions and features in the Standard. Found an ambiguity in the Standard that resulted in two different implementations of the Scheduler function by two different vendors.

Beyond this one major exception and several minor exceptions, the conclusion of the test team is that NTCIP 1203 is effective and makes a positive contribution to the interoperability of DMS systems. Please note that an amendment to the NTCIP 1203 has been approved since the time of the report, and Version 2 of the Standard is being balloted.

Environmental Sensor Stations

Examined an implementation of NTCIP 1204 in May 2001. Reviewed 52 core functions and features in the Standard. Found that the implementation had created four (4) custom objects to provide functionality needed by the procuring agency that were not supported by the Standard. These functions were support to

- Save historical data for a longer period of time
- Use a CCTV camera to collect a snapshot of current weather conditions
- Collect solar radiation data at 10 minute intervals
- Measure subsurface soil moisture levels

Beyond the four custom objects, the conclusion of the test team is that NTCIP 1204 is effective and makes a positive contribution to the interoperability of ESS systems. Please note that an amendment to the NTCIP 1204 has been approved since the time of the report, and the Working Group is drafting Version 2 of the Standard.

7.3 Testing and Conformity Assessment (TCA) NTCIP Working Group

7.3.1 Introduction

The Testing and Conformity Assessment (TCA) NTCIP Working Group was created in the Summer of 2002 to address the issues of how to test the NTCIP suite of standards that were being developed. The technical work activities of the working group under its initial work plan will help achieve the following goals and benefits:

- Develop testing guidance for the NTCIP Work Groups to utilize in order to develop testing artifacts for the standards they develop.
- Develop testing guidance for users (e.g. vendors, DOTs, system integrators) of the NTCIP standards. This guidance will address how testing should be addressed by the end users of the standards.
- Develop a high-level ITS testing framework that should be used for ITS Standards Testing.
- Provide “testing input” to the NTCIP Guide.
- Develop a paper that describes the state of the practice in NTCIP testing. The paper will focus on philosophy of testing, testing methodologies, and testing tools.
- Develop a paper that will discuss potential testing strategies the NTCIP community should consider utilizing.

The working group planned to issue the following reports that will address and provide guidance on the testing issues:

- NTCIP 8007 – Process, Control, and Information Management Policy – Testing and Conformity Assessment Documentation within NTCIP Standards.
- NTCIP 9011 - Information Report – Guide on NTCIP Testing Certification
- NTCIP 9012 – Information Report – NTCIP Testing Guide for Users
- NTCIP 9013 – Information Report – Case Study on NTCIP Testing, State of the Practice

7.3.1.1 NTCIP 8007 – Testing and Conformity Assessment Documentation with NTCIP Standards Publications

This document provides rules and guidelines for the NTCIP working groups on how to develop the test documentation for the NTCIP standards. The results of this document is intended to promote a consistent look and feel for testing documentation throughout the NTCIP standards development effort. This document is not intended for direct use by manufacturers or public agencies to develop their testing procedures when building or procuring NTCIP equipment. However, agencies and other end users indirectly benefit because there will be a single approach to the testing documentation for all NTCIP standards.

The rules and guidelines to develop NTCIP Test Specifications consists of three major activities:

- Develop Requirements – Ensure that there are well-defined requirements. These requirements shall be the basis for the other activities.
- Develop NTCIP Test Cases – An NTCIP Test Case describes what is to be accomplished by performing the test and identifies the inputs to the test and the expected outputs, but does not define the exact process to be followed.
- Develop NTCIP Test Procedures – The NTCIP Test Procedure describes the exact sequence of steps to be followed to execute the associated NTCIP Test Case.

For each activity, the Guide defines the process, the rules, and the guidelines for completing that activity.

This document was released for user comment in August 2004.

7.3.1.2 NTCIP 9011 – Guide on NTCIP Testing Certification

This is a white paper originally intended to discuss the topic of conformity assessment and certification. It discusses the issues and challenges in certifying third-parties to perform testing and certify that a specific deployment conforms to the tested Standard. The document considers how to certify third-parties to perform testing, how to test the Standard, how to test the tools, and the possibility of developing a qualified product list. This document is currently in a working group user draft.

7.3.1.3 NTCIP 9012 – NTCIP Testing Guide for Users

This document considers issues such as types of testing, testing requirements, testing extended functionality, and testing documentation. This document is currently in a working group user draft, although no significant progress has been made on this document recently until other issues are resolved.

7.3.1.4 NTCIP 9013 – Case Study on NTCIP Testing State of the Practice

The purpose of this document is to report on the various aspects and issues facing agencies and vendors regarding testing the NTCIP Standards. The document addresses the various philosophies of testing, and the different processes currently employed. The document considers the different types of testing, what test tools are being employed, what is missing from current practices and the testing techniques utilized. The document also focuses on user comments and feedback from a user workshop (NTCIP Standards Testing Requirements Workshop) held in April 2003. This document is currently in a working group user draft.

7.4 Other Activities

7.4.1 FHWA

Beyond the above mentioned activities, the FHWA continues to actively sponsor studies and projects to assist vendors and agencies in testing their ITS Standards-based projects. For example, the FHWA recently produced a document entitled “NTCIP Testing Study: State of the Practice”. This study presents the current “State of the Practice” of testing in the NTCIP community, and includes the results of a survey on Standards testing from several state transportation agencies, a summary of the available testing tools, a discussion on testing philosophies, and several white papers on testing standards.

The ITS Standards Testing Team is also working with other ongoing or planned standards testing and validation efforts. For example, the John Hopkins University/Applied Physics Laboratory is performing tests on the Electronic Data Interchange (EDI) standards in the Commercial Vehicle Operation (CVO) applications.

Currently, FHWA has indicated interest in procuring a consultant to perform a feasibility study on whether certification testing related to ITS Standards is practical. The proposed scope of the study will consider several areas relevant to certification testing,

including technical feasibility, business feasibility, and institutional feasibility. Other areas include defining requirements for certification organizations, conformance testing tools, and certified products.

7.4.2 ENTERPRISE

The ENTERPRISE Program is a coalition of various state agencies and organizations that have pooled their resources and experiences to deploy and implement ITS projects. Some of their activities include developing NTCIP specifications, deploying ITS projects, and developing and maintaining test plans. One activity of the Enterprise program was the INCH (Integrating NTCIP Compliant Hardware) project. This project consisted of three major components:

- Developing a procurement specification guide
- Developing test procedures
- Performing an initial round of testing

7.5 Vermont ITS Standards Activities

This section reviews current Vermont efforts and contracts in deploying ITS standards. In reviewing the available information, we identified only one current effort that is standards based. A high-level review was made of the Statement Of Work for a Request For Proposals, Equipment Specifications, for a Roadway Weather Information System, dated August, 2003. The Statement of Work was analyzed for completeness and clarity in specifying ITS standards activities. Based on the recommendations in Section 5.4.1, Specifications for Center to Field Communications, the results of the analysis was as follows:

- General NTCIP Requirements. The specification covered this section very well. Definitions and references were included, and details on how the vendor can show conformance for each requirements was discussed. Ownership, documentation and rights to use any proprietary NTCIP objects that may be necessary to support the functionality requested was not clearly discussed.
- Functional Requirements / Physical Features. The specifications covered the physical features very well. The functional requirements for the RPU was very descriptive, explaining what features were expected of the RPUs and how it would operate. The functional requirements for the server/central side was less clear and exact. One area where detail was lacking is the rate data was collected. For example, one requirement was “Store historical data from the RPUs for up to five (5) years.” However, the polling rate was not discussed in the specification, both by the RPU of the sensors (how often each RPU “polls” each sensor), and the server of the RPUs (how often the server “polls” each

RPU). The polling rate and how the data is stored affects the amount of storage required, and more importantly, the responsiveness of the alarms or failures.

- Protocol Implementation Conformance Specification (PICS). The specification covered the requirements covered very well by providing a table of which NTCIP objects, and the required range of values, were to be provided for the project.
- Software and Integration Support. No performance requirements (responsiveness) was discussed, and the responsibilities of the vendor to "coordinate" with the systems integrator to provide motorist/tourist information was vague.
- Testing. "Nationally accepted standard tests for meteorological equipment" for equipment is somewhat vague. A discussion on the minimal documentation required to document testing is recommended (e.g., checklist, space for signatures, etc.).
- Documentation. The specification discussed documentation in very little detail. The specification should also stipulate that the vendor provide NTCIP and MIB documentation in electronic form..

8 Performance Measures

This section of the Vermont Standards Plan documents the initial effort in identifying performance measures that could be used for the ITS program in the state. Performance measurement is an integral part of transportation system management. It provides a means of accountability to the public, improved communication between operators and users of the transportation system, and provides assistance in the state's delivery of transportation services. In addition, some performance measures can be used to set policy, allocate resources, and report on results (before and after ITS improvement projects).

Usually performance measures are addressed from a "system-wide" view. The Federal Highway Administration's (FHWA) Office of Operations has indicated that travel time and travel time reliability are the most effective measures of the performance of the system from the user's perspective, and are championing more detailed levels of data collection and analysis in order to more accurately calculate these measures across the entire transportation network.[1] This section will examine the issue of performance measures from the standpoint of ITS deployments, attempting to identify performance measures that would be appropriate for specific ITS technology deployments.

VTrans has a number of areas where ITS technology is or will be deployed. Defining performance measures for each of these areas could assist in identifying how operations are positively affected and in improving the transportation service and aid in the efficiency of the transportation network for the traveling public in Vermont. Each area listed below is defined and explored in more detail in the following sections:

- Roadway Weather information Systems (RWIS)
- Dynamic Message Signs (DMS)
- Closed Circuit Television (CCTV)
- Weigh-in-Motion Sensors
- Coordinated Traffic Signals
- Coordination between centers

Each area listed above has been reviewed in accordance with a set of defined performance criteria. This criteria, or outcome, explores the performance of an ITS technology within a set of transportation goals. Each is defined in a reasonable, applicable, and thorough way to best satisfy the needs of the transportation users in the State of Vermont. The performance measures listed in the following sections relate

[1] "Operations Performance Measurement", FHWA-OP-04-039, April 2004.

specifically to the goals of the transportation system, and speak to measures for determining if these goals are being met. The criteria is as follows:

- **Mobility/Accessibility.** How accessible the transportation system is, or how mobile it becomes as a direct result of the ITS deployment being analyzed.
- **Reliability**. How reliable is the transportation system as it relates to the ITS deployment being analyzed.
- **Cost Effectiveness.** How costs have related to the benefit of the transportation network, and if future costs can be avoided due to current ITS deployments.
- **Environmental Quality.** What effect the current ITS deployment has on the environment (as a direct result of the transportation technology).
- **Safety and Security.** What is the effect on the transportation system as it relates to the safety of the users and the security of the system due to the ITS deployment being analyzed.
- **Customer Satisfaction.** How satisfied are the transportation users with the existing transportation system and if the existing ITS deployments have made the transportation system more efficient for all users.

The following sections define the functionality, benefits, and performance measures for various ITS technologies that are either deployed or about to be deployed in the State of Vermont. Each section begins with a brief overview of the corresponding ITS effort including benefits that might be attributed to the ITS effort, then goes on to consider performance measures that would substantiate some of the benefits. For each performance measure, the appropriate criterion (from the list above) that it addresses is identified.

8.1 Roadway Weather Information Systems (RWIS)

Information about the weather has been aiding drivers, maintenance crews, and emergency management personnel for years. The National Weather Service provides weather information to the State of Vermont (and all other states). Unfortunately, this information is more about oncoming storm versus real-time road network conditions. This can lead to huge personnel and maintenance problems when crews are put on standby when there is an approaching storm, or resources are tapped before there really is a need for them. We have historically pre-treated roads for icing versus responding to real-time road conditions.

To illustrate the need for RWIS, we provide the following example: When there is an approaching snowstorm, the VTrans maintenance department is notified and the icing of the surface roadway is remedied with pretreatment of historically problematic areas. It is possible to call this type of treatment a “best-guess”. In addition, these areas are

generally over-treated due to the maintenance crews not knowing how much treatment is sufficient, how long the icy conditions will endure, and to avoid making constant return trips to retreat the area. In today's world, thanks to the ITS systems that have been developed, we are able to treat specific areas that may require it, with the right amount of treatment and at the proper time. In the above example, a weather system may have a camera, a wind sensor, precipitation monitor, and a roadway pavement sensor that measures the surface temperature and chemical content on the roadway surface. Weather systems provide more detailed information for a specific area in order to be able to treat a specific problem. To further the example, a maintenance manager can remotely monitor all sensors and cameras, and is able to determine if the conditions support a roadway section freezing over, such as the surface temperature and if the roadway is dry. This could, essentially, allow the maintenance manager to only call in maintenance crews when needed, and only use the amount of treatment that would be required to treat the roadway for the duration of the weather, and for the projected forecast. This is the promise of RWIS systems. Performance measures can be defined in order to understand if these benefits are being realized.

A suggested set of performance measures relating to RWIS include:

- Amount of road treatment materials used. This measure relates to both Cost Effectiveness and Environmental Quality. Use of RWIS information will allow maintenance crews to better manage the amount of treatment materials used, so that over time a decrease in the overall use of materials will result. Due to the variability of weather conditions from year to year, this measure cannot readily be used for comparison from one winter season to the next, but rather will show trends over several years. The measure could be further refined by monitoring the amount of treatment materials in geographic areas that correspond to where the RWIS stations are set up.
- Maintenance crew hours. This measure relates to Cost Effectiveness. Use of RWIS should provide better information regarding when to treat roads and allow more efficient use of maintenance staff resources. As with the first performance measure this one will fluctuate depending on the severity of a winter season, but should show a long term improvement.
- Response time of crews to treat hazardous road conditions. This measure relates to Safety and Security as well as Mobility. If hazardous (or impending hazardous) road conditions are being detected automatically, then the maintenance crews should require reduced time to respond the situation, which will translate into reduced hazards for the traveling public on the roads. The response time will reduce due to the use of pre-treatment because of monitoring rather than waiting for a call to come in.
- Number of hazardous conditions identified by the devices. This measure relates to Safety and Security as well as Mobility. It would measure the total number (or

possibly the average per RWIS station) of hazardous conditions identified over a winter season. This measure can serve as an indicator of how useful the RWIS stations are at identifying hazardous conditions.

- Number of accidents due to snow or ice on road. This measure relates to Safety and Security as well as Mobility. Quicker identification of hazardous conditions can result in quicker treatment, which can translate into fewer accidents on the roadways. As a way to better quantify this measure, the accident rate (e.g. accidents per mile) could be compared in areas that have RWIS versus those that don't.
- RWIS failure rates. This measure relates to the Cost Effectiveness criterion. With centralized control and monitoring of RWIS, the information about failures can be collected and can provide a basis for maintenance planning and staffing requirements for VTrans.

These measures represent an attempt to quantify the benefits that can be obtained from RWIS deployment. The measures could be collected at a statewide level, or for additional refinement at district level, or even more locally, in order to distinguish those areas that have RWIS monitoring from those that don't.

8.2 Dynamic Message Signs

One of the most common deployments of ITS technologies is Dynamic Message Signs (DMS). These signs, which can be either portable or stationary, relay a variety of messages and information to travelers as they drive or ride on the transportation network. They are fundamentally traveler information devices, providing information to travelers that is helpful in a variety of ways including determining which routes to travel based on congestion and/or determining which mode of transportation to take due to congestion, ridership, or ozone days.

When considering performance measures for these systems, analysis most often focuses on the travelers and the decisions they make as a result of the information displayed. Do travelers change their routes based on information displayed? Do they follow directions given to them on the signs? In addition, traveler perceptions about the information on the signs is sometimes solicited - is the information accurate, timely, or useful to travelers. All of these performance measures are usually measured by performing traveler surveys through any of a variety of means (via the VTrans website, mailings, or in-person interviews). As such, they are not ongoing measurements, but happen at specific intervals when traveler surveys are funded and implemented. From a criteria standpoint these surveys relate primarily to Customer Satisfaction. Are there any measures that can be identified that could be derived from operational data (the kind that might be archived and then analyzed)? The following is a suggested measure that would get at the usefulness and effectiveness of the signs.

- What are the number (or frequency) of key advisory messages? This measure relates to Mobility/ Accessibility and also somewhat to Cost Effectiveness. In measuring this information the different types of advisory messages could be distinguished (e.g. weather advisory, incident advisory, route change advisory). The actual number of messages of each type could be determined (based on DMS logs) and then converted into a message rate (e.g. so many advisory messages per day). The information could be organized by fixed sign location. When organized in this way it will identify how useful each sign is for its intended purpose. This information can serve as an input to the siting of additional signs throughout the network. Information for portable signs could also be collected but should probably be lumped together into a single result (or split by district).
- DMS failure rates. This measure relates to the Cost Effectiveness criterion. With centralized operations of dynamic message signs, the information about failures can be collected and can provide a basis for maintenance planning and staffing requirements for VTrans.

8.3 CCTV

Closed Circuit Television (CCTV) is used for a variety of functions including detecting incidents (which may include weather conditions), incident management, and for monitoring traffic movements or roadside assistance needs. For detecting incidents, CCTVs are able to pinpoint the location of incidents, give an accurate account of the incident scene, and (in most cases) allow the traffic operator (and sometimes the emergency dispatch) to pan, tilt, and zoom in on the incident. The added effect of knowing what the incident will entail would be helpful to determine what kind of equipment would be needed to remedy the incident before first responders are dispatched. In addition, CCTVs allow the emergency management personnel to verify the location of the incident (i.e. what side of the highway it is on) and how best to arrive on the scene.

In the same fashion, CCTVs can monitor the road network for traffic so that information can be reported to other agencies or displayed in DMS signs for the traveling public. In this way, CCTVs can be the eyes of the roadways relaying a variety of information back to the transportation center and to the emergency operations center (in most cases).

In reviewing performance measures that can be associated with CCTV, one most often sees measures for incident management, such as reduction in incident response time. Two performance measures that could be attached to the CCTV systems themselves are:

- Number of incidents detected or verified. This measure relates to the Safety and Security criterion. Since one of the primary uses of CCTV is for incident detection and verification, measuring how often this happens gives a measure of

the usefulness of individual cameras, or of the system of cameras as a whole. The measure could be calculated as a rate (e.g. incidents per week) and could also be calculated by individual camera location, or aggregated with all cameras in the system. This measure could be used to support the deployment of additional cameras.

- Reduction in incident detection and verification time. This measure relates to the Safety and Security criterion. The state has a current approach to incident detection and verification (based on not having CCTVs deployed). The detection might come from traveler cell phone calls, or from public safety services. The verification most likely is done by public safety or VTrans personnel arriving on the scene. Once CCTV is deployed, the time an incident is detected with CCTV can be compared with the time detection comes from other means to provide a measure of what improvement, if any, can be attributed to the CCTV. In the same way, the time an incident and type of incident is verified using CCTV can be compared to the time that first responders arrive at the scene to give a measure of the improvement in verification time.
- CCTV failure rates. This measure relates to the Cost Effectiveness criterion. With centralized control and monitoring of CCTV, the information about failures can be collected and can provide a basis for maintenance planning and staffing requirements for VTrans.

8.4 Traffic Signals

Traffic signalization has significant positive (or negative) impact on users of the transportation system. Two ways that ITS can provide improvements are through reduction in the response time when faults occur and in improvements (or reduction) in delays at intersections due to improved signal plans. Without a communications network between traffic signals and a TMC, problems with a traffic signal are not detected until a call comes in from the public, or during a normal maintenance cycle. If a traffic signal suffers a “fault”, the only way it is reported is by the general public, an emergency provider, or VTrans personnel who happen to notice. With coordinated traffic signal systems (including communications to a central monitoring system), the traffic signal is constantly monitored and faults are detected much quicker and remedied much faster. This may have a direct result on traffic by decreasing the delays and hazards associated with the faulty traffic signal.

Traditional performance measures for signalized intersections are described in the Highway Capacity Manual. The primary measure of effectiveness is control delay, which is directly related to level of service. These measures are certainly applicable to traffic signal systems that include interconnected signals, centralized monitoring of signals, or adaptive signal patterns - all ITS aspects of traffic signals. Several additional measures can be identified for these ITS type applications.

- Traffic signal system failure rates. This measure relates to the Cost Effectiveness criterion. With centralized monitoring of signals this information for individual intersections (or aggregated for networks of signals) is readily available and can provide a basis for maintenance planning and staffing requirements for VTrans.
- Response time for signal faults. This measure relates to the Cost Effectiveness criterion. The time from first detection of a signal fault to its repair can be measured using and compared with response times for VTrans operated signalized intersections that are not under centralized control and monitoring. This measure can provide a quantification of the improvement in response time which can support deployment of additional ITS equipped systems.
- Intersection queue lengths. This measure relates to the Mobility/ Accessibility and Reliability criterion. Development of advanced signal systems that measure queue length (and may use this for adaptive signal timing), provide the opportunity to monitor queue lengths and use this to better assess the operation of the system.
- Travel time along a corridor. This measure relates to the Mobility/ Accessibility and Reliability criterion. The interconnection of signals along a corridor can be used to improve travel times through the corridor. Using detection techniques, either traditional speed/volume or some of the newer probe vehicle detection capabilities can allow estimation of travel time along the corridor. This can be contrasted to travel times measured before interconnected systems were implemented.

8.5 Weigh in Motion

Weigh in Motion (WIM) sensors systems are usually deployed in conjunction with commercial vehicle operations deployments such as electronic clearance or safety screening. As such they contribute to performance measures for these overall systems that include reduction in delay for commercial vehicles at the roadside facilities. When considered as individual “systems” there are two performance measures that might be assigned to them:

- System failure rate. This measure relates to the Cost Effectiveness criterion. Because WIM systems can have the capability of providing status or fault information, it is possible to determine their failure rate. Additional parameters such as mean time between failure and mean time to repair could be calculated.
- Number of over-weight vehicles. This measure relates to the Safety and Security criterion. As the purpose of the WIM is to identify over-weight vehicles, measuring how many are found can be a measure of the “success” of the system in accomplishing its goal. Related measures to this could be the ratio of

overweight to legal weight vehicles or the rate overweight vehicles are identified (e.g. number per week).

8.6 Coordination between Centers

Dependable communication and coordination between traffic, transit, and public safety centers can result in improvements in both operations of the individual agency and in areas requiring joint operations, such as incident response. Many of the benefits and hence performance measures of this interagency coordination are difficult to define, but one measure that relates to the coordination of traffic and public safety agencies is:

- Incident response time. This measure relates to the Safety and Security criterion. Improved coordination (including creation of a link for data sharing) between traffic and public safety agencies can speed the overall incident response time by providing better information in a more timely fashion to the responding agencies. When VTrans has deployed centralized traffic management capabilities (e.g. the Statewide TOC or the Rutland TOC), they will have the capability of monitoring incident response and can initially determine time from incident detection to arrival of first responders. As coordination capabilities with VSP or other public safety agencies are added, this identification of response time could be refined based on information obtained from the public safety agency.

8.7 Next Steps

The performance measures suggested in the previous sections represent an initial step in defining the performance of various current or near term ITS deployments planned by VTrans. In order to establish a set of performance measures that are collected and documented (and through continued review refined) additional steps must be considered:

- Review recommended measures with affected departments (or districts) within VTrans. In order to accomplish this, a working group for performance measures for the state may need to be established.
- Finalize initial measures on both a statewide and regional or district level. Once a working group is established, local and regional transportation professionals should weigh-in on the performance measures in order to establish an initial set of recommendations for the state, and smaller regions within the state.
- Review data and availability to obtain data for processing. Once the initial recommendations are documented, each region must be able to review them and assess their ability to support reporting the measures on the following criteria: data availability, frequency, quality, and timeliness of reporting.

- Reach consensus on recommended measures and plan for data collection. After regions have concluded if and how they can support the reporting measures defined above, they must establish agreements to collect and share collected data (with the agency responsible for data processing) and they must begin to collect data.
- Data collection. Methods need to be developed to collect and store the data necessary to make judgments about the performance of any one ITS element. These methods may just be utilizing an existing data source, or they may be more cutting edge as we try to collect information about new technologies. Nevertheless, all information gathered must be stored and processed, which leads into the final step.
- Prepare final recommendations report. Once the data has been collected, and sent to the appropriate data warehouse, it can be processed and developed into reportable findings. Once these findings are determined, reports can be formulated and the outcomes of the transportation network, as it related to our six principles mentioned above, can be determined. Then, and only then, can we have results on a quantitative and qualitative level about the performance of ITS elements in the transportation system.

9 Asset Management

Asset management is a strategic approach to managing transportation infrastructure assets. There are many definitions of asset management, but Federal Highway Administration, in association with AASHTO has developed the following definition:

"Asset management is a systematic process of maintaining, upgrading, and operating physical assets cost-effectively. It combines engineering principles with sound business practices and economic theory, and it provides tools to facilitate a more organized, logical approach to decision-making. Thus, asset management provides a framework for handling both short- and long-range planning."[2]

VTrans has been developing their asset management capabilities, partly in response to the passage in 2001 by the General Assembly of Vermont of Sections 24 and 25 of Act No. 64, which required the Vermont Agency of Transportation (VTrans) to submit information on its assets to the House and Senate Committees on Transportation. In response to this legislation, VTrans conducted a study, entitled Vermont Asset Management Vision and Work Plan. The objectives of this study were to document a vision for asset management at VTrans and to develop an asset management work plan. In addition to these objectives the study compared VTrans current asset management practices against a benchmark state of the art and identified the state of compliance of VTrans asset management practice with the Sections 24 and 25.

This project will address issues of asset management as they relate to ITS deployments in the state. This involves tracking key information about each ITS asset, measuring the performance of the assets (through performance measures as described in the previous section) and then using the performance data in the ongoing programming and planning for asset deployment, maintenance, replacement, or retirement.

In the arena of tracking the ITS assets, VTrans has been using an existing departmental system, the Fixed Assets Management System (FAMS), to track ITS assets currently in place. This system, which is designed to manage any asset over $5,000, keeps track of details such as serial numbers, location, and who has responsibility for the equipment. Since most ITS systems are fixed assets, the current system is well suited to track the key information for the ITS assets. However, some ITS assets, such as portable dynamic message signs, are not fixed. These assets are typically "owned" by one VTrans district, but can also be used by other districts. For this reason these mobile assets have additional management requirements relating to their real time location and near term scheduling. Currently this type of "real time" tracking cannot be handled in

[2] Asset Management: Advancing the State of the Art Into the 21st Century Through Public-Private Dialogue. Federal Highway Administration and the American Association of State Highway and Transportation Officials, 1996, page 3.

FAMS, but will be handled via a simple spreadsheet that is updated as often as needed as accessible in a read only version to all affected stakeholders.

In the tracking of maintenance assets, specifically maintenance vehicles, VTrans has been using the MCMS system (a widely used mainframe based system). This system tracks usage, repairs, parts, and costs. The department has plans to upgrade this to the web based M5 system (from the same company as the old system). This system will continue to be used for asset management of the maintenance vehicles. It may also be used for asset management of wheeled ITS assets such as portable Dynamic Message Signs.

How should the agency collect and manage performance measurement data, and how should the agency relate this performance measurement to the assets being tracked (in FAMS or M5)? A logical recommendation is to use the VTrans Data Warehouse to collect and analyze the data resulting from performance measurement, to provide access to FAMS and M5 from the data warehouse, and to use the warehouse to correlate between performance measurement and the asset information from FAMS and M5. This will require creation of interfaces between the systems so that data can be automatically transferred.

Appendix A – Example Concept of Operations - DMS

Introduction

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

The intent of this document is to present:

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

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

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

Physical Features

Type of Sign

The Dynamic Message Sign for this project will be a *line matrix sign*, capable of displaying *3* lines of *460-mm* (18-inch) character text. Each line is a minimum of *7 pixels* high and *165* pixels wide. (Note: the width is calculated assuming 21 characters, 5 pixels wide per character, 3 pixel spacing between characters). The horizontal pitch between pixels shall be *2.6 ± .15* mm, and the vertical pitch between pixels shall be at *2.6 ±.15* mm. (Note: The pitch is the distance between pixels. The smaller the pitch, the more fluid the lines look. Final value would be determined based on the size of the DMS.)

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

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

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

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

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

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

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

Other
This DMS does not support the following:

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

Normal Operations

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

Sign Display Behavior After Bootup

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

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

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

Sign Display After a Momentary Power Loss

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

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

Sign Display Behavior During Communications Loss

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

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

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

Sign Display After End Duration

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

Sign Display After Controller Reset

If the controller is reset (software), the DMS can be set to display a specific message after the reset. *This parameter is optional* and assumes that the DMS controller can differentiate between a power loss and controller reset. The default message to be displayed can be a blank message, a specific defined message, the last message commanded before the DMS was reset. The current default message to be displayed after a Controller Reset should be a ***blank message***. The DMS will continue to display this message until a valid message is commanded.

ATMS Software

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

The ATMS software provides the following functions:

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

Polling

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

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

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

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

Selecting Messages

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

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

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

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

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

Activate Messages

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

Exception Operations

ATMS Software

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

- For maintenance purposes – use of the manufacturer-provided software at the AGENCY STATEWIDE TOC or a laptop at DMS controller

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

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

Control Modes

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

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

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

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

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

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

Unfortunately, the user may forget to release the sign from Local Mode when their work is complete. Thus, it may be necessary to send a Central Override command from the

ATMS software or the manufacturer-provided software at the AGENCY STATEWIDE TOC. The DMS will then transition from Local Mode, temporarily to Central Override Mode, then back to Central Mode. (Note: verify that the ATMS software supports Central Override).

Monitoring

Monitoring Status

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

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

Event History

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

Diagnostics

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

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

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

Installation/Testing

Testing

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

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

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

Workstation

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

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

A *technician's laptop computer* will be provided with the sign. The technician's laptop computer will be used to maintain or control the DMS sign at the DMS cabinet for maintenance purposes or in the event there is no communications between the traffic

management center and the DMS sign. The technician's laptop computer shall be environmentally hardened. The laptop computer shall be provided with the manufacturer's software, *Microsoft Windows* operating system, and the necessary cables to connect to the DMS sign's laptop *RS-232* port.

Appendix B – Example DMS Specification

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

General NTCIP Requirements

Definitions

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

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

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

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

References

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

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

Conformance

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

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

Property Rights

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

Physical and Functional Requirements

Type of Sign

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

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

LEDs

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

Communications Ports

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

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

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

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

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

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

Fonts

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

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

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

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

Photosensors

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

Protocol Implementation Conformance Specification

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

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

Requirements ID	Functional Requirement	Project Requirement
1.0	Manage the DMS Configuration	

Requirements ID	Functional Requirement	Project Requirement
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.	

Requirements ID	Functional Requirement	Project Requirement
2.5.4	Switch Brightness Control Modes - The DMS shall allow a management station to switch between the defined brightness control modes. NOTE: See Requirement ID 3.4.2 for Supplemental Requirements related to brightness control modes.	
2.6	Manage the Exercise of Pixels - The DMS shall allow a management station to manage frequency and duration of the exercise of each pixel's physical actuation mechanism.	
3.0	Monitor the Status of the DMS - Requirements for monitoring the status of the DMS are provided in the following subclauses.	
3.1	Perform Diagnostics - Requirements for performing diagnostic functions on the DMS are provided in the following subclauses.	
3.1.1	Test Operational Status of DMS Components - Requirements for activating tests are provided in the following subclauses.	
3.1.1.2	Execute Pixel Testing - The DMS shall allow a management station to initiate a pixel test.	Default values: vmsPixelServiceFrequency(1440) vmsPixelServiceTime(181)
3.1.1.3	Execute Fan Equipment Testing - The DMS shall allow a management station to initiate an equipment test of the fan system.	
3.1.2	Provide General DMS Error Status Information - The DMS shall allow a management station to retrieve a high-level overview of the operational status of the DMS that includes an indication of the following error and warning conditions: 1. Communications Error 2. Power Error 3. Pixel Error 4. Light Sensor Error 5. Message Error 6. Controller Error 7. Temperature Warning 8. Fan Error	
3.1.3	Identify Problem Subsystem - Requirements for identifying the component within a subsystem that is causing an error or warning are provided in the following subclauses.	
3.1.3.1	Monitor Power Errors - The DMS shall allow a management system to determine the status of the power supply and the power source.	
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.	

3.4.3.1	Automatically Control Brightness - The DMS shall automatically manage the light sensor-driven light output of the display when this mode is enabled.	
3.4.3.2	Inhibit Flickering of Message Brightness - The DMS shall allow the Light Output Algorithm to include overlapping values, which shall enable the Light Output Algorithm to avoid flickering of the light output due to small changes in the measured ambient light conditions.	
3.4.4	Supplemental Requirements for Control Modes - Supplemental requirements for allowing different entities to control the DMS are provided in the following subclauses.	
3.4.4.1	Support Central Control Mode A DMS shall allow an operator to control the sign from a remote location (e.g., from central).	
3.4.4.2	Support Local Control Mode - The DMS shall allow an operator to control the sign through a local interface. NOTE: A 'local' interface may include any of the following: a touch panel on the sign controller, a laptop connected directly to a 'local' port on the sign controller, any other mounted or unmounted panel that can be used to select a message for display.	
3.4.4.3	Support Central Override Control Mode - The DMS shall allow the central system to override the local control mode.	
3.4.4.4	Processing Requests from Multiple Sources - The DMS shall only allow a single source to control the sign at any one time.	
3.4.5	Supplemental Requirements for Message Activation Request - Supplemental requirements for activating a message for display on the sign face based on an external request are provided in the following subclauses.	
3.4.5.1	Supplemental Requirements for Internal or External Message Activation - Supplemental requirements for activating a message for display on the sign face (whether generated by an internal or external request) are provided in the following subclauses.	
3.4.5.1.1	Activate Any Message - The DMS shall allow the activation of any valid message that is stored in the sign controller.	
3.4.5.1.2	Preserve Message Integrity - The DMS shall prohibit the display of a message that uses memory objects such as fonts or graphics that were altered after the message was composed and saved within the sign's local message library.	
3.4.5.1.3	Ensure Proper Message Content - The DMS shall ensure that the contents of the message are the same as what the requester requests.	
3.4.5.2	Indicate Message Display Duration - Each message activation shall be associated with a duration for the sign controller to display the message. If the request is validated, the DMS shall display the associated message for the indicated duration.	
3.4.5.3	Indicate Message Display Requester ID - Each message activation shall be associated with an indication of the entity that requested the display. The DMS shall store this information while the message is displayed.	

3.4.5.4	Supplemental Requirements for Message Activation Priority - The DMS shall only activate the newly requested message if the activation priority is higher than the runtime priority of the currently displayed message.	
3.4.6	Supplemental Requirements for Message Definition - Supplemental requirements for defining user-defined messages (i.e., volatile and changeable messages) are provided in the following subclauses.	
3.4.6.1	Identify Message to Define - Each message stored in the sign controller shall be associated with a unique identifier.	
3.4.6.2	Define Message Content - Supplemental requirements for defining the message content are provided in the following subclauses.	
3.4.6.2.1	Support Multi-Page Messages - The DMS shall allow the message to contain the number of distinct page displays as defined by the specification. If the specification does not define the number of distinct page displays that must be supported, the DMS shall support at least one page per message.	
3.4.6.2.2	Support Page Justification - Supplemental requirements for supporting vertical justification of the message on the display are provided in the specification text related to Requirement ID 2.3.2.6 and the following subclauses.	
3.4.6.2.2.1	Support for One Page Justification within a Message - The DMS shall allow the message content to specify a single vertical (page) justification, which shall apply to all pages of the message.	
3.4.6.2.2.2	Support for Multiple Page Justifications within a Message - The DMS shall allow the message content to specify vertical (page) justification on a page-by-page basis.	
3.4.6.2.3	Support Multiple Line Messages - The DMS shall allow each page of the message to contain up to the number of lines as defined by the specification. If the specification does not define the number of lines that must be supported, the DMS shall support at least one line per page.	
3.4.6.2.4	Support Line Justification - Supplemental requirements for horizontal (line) justification are provided in the specifications related to Clause 3.4.2.3.2.5 and the following subclauses.	
3.4.6.2.4.1	Support for a Single Line Justification within a Message - The DMS shall allow the message content to specify a single line justification, which shall be used for each line within the message.	
3.4.6.2.4.2	Support Line Justification on a Page-by-Page Basis - The DMS shall allow the message content to specify the line justification on a page-by-page basis.	
3.4.6.2.4.3	Support Line Justification on a Line-by-Line Basis - The DMS shall allow the message content to specify the line justification on a line-by-line basis.	
3.4.6.2.6	Support Font Commands - Supplemental requirements for supporting font commands within a message are provided in the specification related to Clause 3.4.2.3.2.4 and the following subclauses.	
3.4.6.2.6.1	Support One Font within a Message - The DMS shall allow the message content to specify a single font, which shall apply to the entire message.	

3.4.6.2.7	Support Moving Text - The DMS shall allow the message content to include a 'window' that contains moving text at a defined speed and direction.	*Not required.*
3.4.6.2.8	Support Character Spacing - The DMS shall allow the message content to specify the spacing between characters in a text string or between text and a graphic on a character-by-character basis.	
3.4.6.2.9	Support Customizable Page Display Times in a Message - The DMS shall allow the message content to specify the time to display each page and the time to blank the sign face between each page when displaying a multi-page message. The allowed range for the display time and the blank time shall be identical to the range identified in the specification for Requirement ID 2.3.2.7.	
3.4.6.2.10	Support Customizable Flashing Times within a Message - The DMS shall allow the message content to specify the time to display and the time to blank each section of flashing text. The allowed range for the display time and the blank time shall be identical to the range identified in the specification for Requirement ID 2.3.2.3.	
3.4.6.2.11	Support Flashing - Supplemental requirements for flashing text are provided in the following subclauses.	
3.4.6.2.11.1	Support Character-by-Character Flashing - The DMS shall allow the message content to identify portions of text (and/or graphics) to be flashed on a character-by-character basis.	
3.4.6.2.11.2	Support Line-by-Line Flashing - The DMS shall allow the message content to identify portions of text (and/or graphics) to be flashed on a line-by-line basis.	
3.4.6.2.11.3	Support Page-by-Page Flashing - The DMS shall allow the message content to identify portions of text (and/or graphics) to be flashed on a page-by-page basis.	
3.4.6.2.13	Support Message Data Fields - Supplemental requirements for defining a message that includes fields that display dynamic data are provided in the following subclauses.	
3.4.6.2.13.1	Support Current Time Field - The DMS shall allow the message content to include field(s) indicating the current time.	*Not required.*
3.4.6.2.13.2	Support Current Date Field - The DMS shall allow the message content to include field(s) indicating the current date.	*Not required.*
3.4.6.2.13.3	Support Current Temperature Field - A DMS shall allow the message content to include field(s) indicating the current ambient air temperature.	*Not required.*
3.4.6.2.13.4	Support Detected Vehicle Speed Field - The DMS shall allow the message content to include field(s) indicating the current reading from the attached speed detector.	*Not required.*
3.4.6.2.13.5	Support Current Day of Week Field - The DMS shall allow the message content to include field(s) indicating the current day of the week.	*Not required.*
3.4.6.2.13.6	Support Current Day of Month Field - The DMS shall allow the message content to include field(s) indicating the current date of the month.	*Not required.*

3.4.6.2.13.7	Support Current Month of Year Field - The DMS shall allow the message content to include field(s) indicating the current month of the year.	*Not required.*
3.4.6.2.13.8	Support Current Year Field - The DMS shall allow the message content to include field(s) indicating the current year.	*Not required.*
3.4.6.2.13.9	Support Current Time with uppercase AM/PM Field - The DMS shall allow the message content to include field(s) indicating the current time with uppercase AM/PM after.	*Not required.*
3.4.6.2.13.10	Support Current Time with lowercase am/pm - The DMS shall allow the message content to include field(s) indicating the current time with lowercase am/pm after.	*Not required.*
3.4.6.2.13.12	Data Field Refresh Rate - Each field shall be updated at least once every 60 seconds.	
3.4.6.2.15	Specify Location of Message Display - A DMS shall allow the message content to specify the starting position of text *and graphics* on the sign face at a one-pixel resolution.	
3.4.6.2.16	Support of Text - Supplemental requirements for including text characters in a message are provided in the following subclauses.	
3.4.6.2.16.1	Support of Textual Content - The DMS shall allow the message content to include any character supported by the DMS in any order.	
3.4.6.2.16.2	Support of Message Lengths Compatible with Sign Face - The DMS shall allow the message to contain any number of characters per page for each page, up to the physical limits of the sign face.	
3.4.6.3	Identify Message Owner - Each message stored in the sign controller shall be associated with an owner name.	
3.4.6.4	Priority to Maintain a Message - Each message stored in the sign controller shall be associated with a run-time priority.	
3.4.6.5	Beacon Activation Flag - Each message stored in a sign controller library shall indicate whether any existing attached beacons are to flash while this message is displayed.	*Not required.*
3.4.6.6	Pixel Service Flag - Each message stored in a sign controller library shall indicate whether a pixel service can be executed while the message is displayed.	
3.4.6.7	Message Status - Each message stored in the sign controller shall be associated with a status to indicate if it is valid for display, being modified, etc.	
3.4.6.8	Identify Message Name - Each message stored in the sign controller shall be associated with a message name.	
3.4.7	Supplemental Requirements for Locally Stored Messages Supplemental requirements for storing local messages are provided in the following subclauses.	
3.4.7.1	Support Permanent Messages	The DMS shall minimally support one permanent message, blank message.
3.4.7.2	Support Changeable Messages	The DMS shall minimally support x changeable messages.

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

3.4.12	Supplemental Requirements for Page Justification - Supplemental requirements for page justification are provided in the following subclauses.	
3.4.12.1	Support top Page Justification - The DMS shall support top page justification.	
3.4.12.2	Support middle Page Justification The DMS shall support middle page justification.	
3.4.12.3	Support bottom Page Justification - The DMS shall support bottom page justification.	
3.4.13	Supplemental Requirements for Line Justification	
3.4.13.1	Support left Line Justification - The DMS shall support left line justification.	
3.4.13.2	Support center Line Justification - The DMS shall support center line justification.	
3.4.13.3	Support right Line Justification - The DMS shall support right line justification.	
3.4.13.4	Support full Line Justification - The DMS shall support full line justification.	

Software and Integration Support

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

Software

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

Integration Support

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

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

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

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

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

Testing

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

- The Factory Acceptance Test (FAT) shall include all labor and material necessary to verify conformance of the field equipment with the performance, mechanical, electrical and environmental requirements specified.
- The Visual Inspection Test shall include all labor and material necessary to perform a visual inspection after the complete installation of the DMS equipment to check for manufacturing and installation defects.
- The Startup Tests shall include all labor and material necessary to verify the setup and configuration of the DMS.
- The Stand-alone Tests shall include all labor and material necessary to demonstrate that the required functionality and capabilities of the DMS are functioning properly, including subsystem check tests on all installed equipment and operation and monitoring of the DMS.

- The Operational Tests shall include all labor and material necessary to support the AGENCY over a 60-day period during which the DMS System will be utilized by the AGENCY in daily operations.
- The Integration Tests shall include all labor and material necessary to transfer control and monitoring of the DMS from the manufacturer-supplied software to the ATMS software.

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

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

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

Factory Tests

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

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

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

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

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

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

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

Visual Inspection Test

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

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

The visual inspection checklist shall include, at a minimum:

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

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

Startup Tests

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

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

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

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

- space on the checklist for each item for the AGENCY's or its representative's initials
- verify that all global objects values have been properly set (Configuration, Database Management, Time Management, Report, STMF, and PMPP Conformance Groups), and record the information.

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

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

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

Stand-alone Tests

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

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

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

- space on the checklist for each item for the AGENCY's or its representative's initials
- conduct of subsystem check tests on all installed equipment, including communications equipment. Include equipment checkout tests for each system component, including provisions for testing all internal and external system interfaces.
- Proper operation of every pixel, including uniform brightness at all brightness levels and proper current consumption.

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

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

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

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

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

Operational Tests

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

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

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

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

The following conditions apply to the observation period:

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

problems which restricted system operation have been corrected, and no new problems have resulted from the changes.

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

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

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

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

Integration Tests

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

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

Documentation

The component shall be supplied with full documentation, including 3.5" floppy disk(s) and a CD-ROM containing ASCII versions of the following Management Information Base (MIB) files in Abstract Syntax Notation 1 (ASN.1) format:

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

Warranties

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

Interpretation Resolution

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

Workstation

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

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

for at least *15* minutes. *A laser printer* will be provided with each workstation to allow printing of reports and logs.

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

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

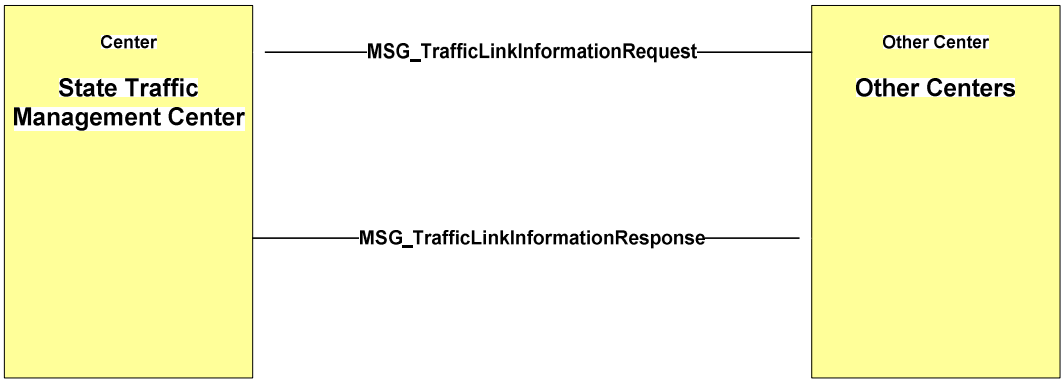

Table C-1. Center Interface Definition Worksheet

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
2.0	**XML over HTTP**				

Profile Requirements List (PRL)		NTCIP 2306 Section	NTCIP 2306 Mandatory / Optional	NTCIP 2306 Profile Require-ment	Project Require-ment
	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
	- Binding (Transport)	9.1.3	M	PR 4.4.2b	N
	- Service (Transport)	9.1.4	M	PR 4.4.2b	N

Profile Requirements List (PRL)		NTCIP 2306 Section	NTCIP 2306 Mandatory / Optional	NTCIP 2306 Profile Require-ment	Project Require-ment
	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 NTCIP C2CXML. WSDL for the subject project is shown below.

Figure C-2. 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

Xpath	Data Concept Name	Data Frame (DF) or Data Element (DE)	Mandatory (M) or Optional (O)	May Repeat	Max Occurrences
//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
//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-3. 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-4. 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>
```