Standards Plan for the State of West Virginia

State Project T699-ARC/HI-1

Federal Project CMAQ-2005(016)E

ITS Architecture Development

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Revision History

Filename	Version	Date	Author	Comment
Standards Planv0.03.doc	0.03	06/23/06	M Insignares	QA/QC Review – Delivered to client.
Standards Planv0.04.doc	0.04	0718//06	PChan	Final Draft
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1 Introduction

In January 2006, Consensus Systems Technologies Corp. (ConSysTec), was contracted by West Virginia Department of Transportation (WVDOT), Division of Highways, to provide West Virginia with a comprehensive Statewide ITS Architecture and Strategic ITS Plan that complies with FHWA Rule 940 (and the corresponding FTA Policy on Architecture and Standards). These project outputs will enable the State of West Virginia to deploy and integrate ITS technologies across the state that will assist in the operations and maintenance of the transportation network, and which will support the current transportation planning process.

This document satisfies the requirements for Task 7 of the Scope of Work. For Task 7, 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 in West Virginia. The recommendations are to follow the requirements of FHWA Rule 940.9 and 940.11. In addition, the standards plan was to 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 West Virginia.

1.1 Intended Audience

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

For managers or decision-makers, this Standards Plan document provides the necessary background on ITS Standards and discusses the issues for implementing ITS Standards in the State of West Virginia.

For planners, this Standards Plan document introduces the relationship between ITS Standards and the West Virginia Statewide ITS Architecture. The document also guides 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 shows how the West Virginia Statewide ITS Architecture can be used to determine a list of ITS Standards that may be applicable for a project. The systems engineering analysis for developing projects are introduced as a process for writing specifications. Then, the document shows how to determine if an ITS Standard should be specified , how to specify the ITS Standard selected and how to test the ITS Standards for an ITS project.

For project managers implementing projects, this document introduces the benefits for using a systems engineering analysis to develop ITS projects, and discussing the different types of testing that may be involved in verifying that a project, and the ITS devices and systems it contains, complies with the specifications and conforms with an ITS Standard.

1.2 Purpose

This document is a guide to incorporate ITS Standards into the project development process in the State of West Virginia. This document reviews the life cycle of ITS Standards in the development and deployment of ITS projects in West Virginia, starting with a project's genesis in the 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 then guides 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 many agencies, including WVDOT, already has a project development process in place, regardless of how formal the process is. This document reviews the existing one agency's project development process, and indicates where and how ITS Standards fit into that agency's project development process. The document makes suggestions and recommendations how the existing project development process may be altered to better accommodate and include ITS Standards into the existing process.

What does the document NOT do? This document does not actually alter an agency's project development process. Suggestions and recommendations are made on how to include ITS Standards into their process, but ultimately, each agency must address the suggested changes with other staff within their agency.

This document also does not specify or recommend an ITS Standard for adoption for the State of West Virginia. The selection and adoption of an ITS Standard should be based on an actual analysis of the needs and requirements for the State, the agency, and the project. Once the needs and requirements are determined, an analysis is performed to determine if any ITS Standard meets those needs and requirements and should be 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 Document Organization

This document is separated into seven (7) chapters to support the various audiences 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 Transportation Planning.** Reviews the Federal requirements for ITS systems, the relationship between ITS Standards and ITS Architectures, and how to satisfy the requirements on ITS Standards in the project systems engineering analysis.
- **Chapter 4: ITS Standards in the Project Development Process.** Discusses the role of ITS Standards in the project development process, how to analyze the applicability of ITS Standards for use in projects, and how to specify an ITS Standard.
- **Chapter 6: Testing.** Introduces the types of testing program that should be considered and adopted for testing ITS systems, and ITS Standards. Also reviews the issues related to testing ITS Standards.
- **Chapter 6: Current ITS Activities.** Discusses the current status of relevant ITS Standards and testing activities. Also reviews current West Virginia efforts and contracts in deploying ITS Standards, and provides recommendations on deploying ITS systems.
- **Chapter 7: Performance Measures.** Presents potential measures of performance for evaluating the deployment of various ITS systems.
- **Appendix A: Example Concept of Operations - DMS.** Presents an example Concept of Operations document for operating a dynamic message sign.
- **Appendix B: Example DMS Specification.** Presents an example specification for the functional and NTCIP requirements for a dynamic message sign.
- **Appendix C: Example Center-To-Center Interface Specification.** 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 Chapter 3 to gain a general understanding of the USDOT's requirements for federal funding of ITS projects and skim through Chapter 4 on how ITS Standards fit into an agency's project development process.

Planners should read Chapter 3, which describes the relationship of ITS Standards with the West Virginia Statewide ITS Architecture, and discusses the USDOT requirements for federal funding of ITS projects. Planners may also wish to read Chapter 7, which presents some potential performance measures for calculating the effectiveness of deploying ITS projects.

Project managers and specification writers should read Chapters 4 and 5, which introduces how to write specifications for deploying ITS Standards, and more importantly, how to test ITS Standards. Specification writers should also look at the Appendices, which provide examples of the systems engineering analysis and how to write specifications for ITS Standards. Chapter 6 then reviews the current status of ITS

Standards activities on a national level, and provides additional information about these standards, including current version of the standard, its status, and contact information. Chapter 7 then provides performance measures that may be useful to the project managers.

2 ITS Standards

2.1 Introduction

What are standards? The U.S. National Policy defines standards as a "Prescribed set of rules, conditions or requirements concerning definition of terms and classification of components; specification of materials, performance or operation; definition of procedures; or measurement of quantity and quality in describing materials, products, systems or practices."

There are many types of standards. There are hardware standards, such as an electrical outlet for electricity containing 110 volts of AC power. There are also software standards, performance standards, and standard practices.

What are ITS standards? ITS standards establish a common way in which intelligent transportation 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 such as 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.

ITS Standards are an important tool that will allow efficient implementation of the West Virginia 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 they allow a region to 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. The overall goal of the ITS Standards Program has been to promote the widespread deployment of integrated ITS through robust, non-proprietary standards.

The 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 currently 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)

Through cooperative agreements with these 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 U.S. DOT 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".

However, to date, no standards or interoperability tests have been officially adopted by U.S. DOT. Officially adopting an ITS standard will require a Notice of Proposed Rulemaking, an appropriate comment period, followed by issuance of a rule adopting the standard, and this has not yet occurred. The U.S. DOT 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 (dynamic message signs and traffic signal control). 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 U.S. DOT feels that state and local deployers are not implementing standards that it feels are tested and mature.

2.4 Types of ITS Standards

In general, the ITS Standards program focuses only on information flows between ITS systems. These ITS systems can be categorized into one of four types of subsystems:

- **Centers.** Management center systems, such as traffic management centers, transit management centers, public safety communications centers, etc.

- **Field.** Roadside devices.
- **Vehicles.** Vehicle systems such as mobile data terminals, and,
- **Travelers.** Via devices such as kiosks, PDAs, home computers, etc.

Standards application areas are deployment-oriented categories that focus on information flows, or interfaces, between specific ITS services or systems. The types of interfaces include:

- **C2F - Center-to-Field.** This category of application areas includes those standards that provide communication links between a transportation management center and roadside equipment that regulates or guides the flow of traffic.
- **C2C - Center-to-Center.** This category of application areas includes those standards that facilitate communication between management centers. This category includes communications necessary for transit use and public safety.
- **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. It 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 communication between railroad wayside equipment and highway roadside equipment.

There are other industry-supported ITS standards not related to information flows in the ITS industry, such as hardware standards (NEMA TS-1 and TS-2 traffic signal controllers for example), but these are not supported by the USDOT ITS Standards program and are not discussed here.

Each information flow between ITS systems 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:

- **C - Communications Protocol.** The rules to move information. The protocol may consist of rules regarding data formats, control information coordination, error handling, or timing.
- **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.

An analogy to the above is the written language: the communications protocol defines the language (English) and grammar for sharing the information, the message sets are the sentences that are used to share the information, and the data elements are the words.

2.5 Summary

ITS Standards, as supported by U.S. DOT, are in effect communication standards. ITS Standards are a way to share information between two ITS systems in a consistent manner. These ITS systems may be centers that manage and disseminate information; field devices that control traffic or disseminate information; in-vehicle systems such as mobile data terminals (MDTs), or travelers via personal devices.

ITS Standards can be categorized as one of three types of communications standards: communications protocol (language), message sets (sentences), and data elements (words).

3 ITS Standards in Transportation Planning

3.1 Introduction

In the past, the only basic requirement for federal funding for ITS project was that the ITS project must be on the TIP (Transportation Improvement Plan) at a local or regional level, or on the STIP (Statewide Transportation Improvement Program) at a statewide level. However, with the passage of the TEA-21 in 1997, additional requirements were required to provide federal funding for ITS projects. These requirements were detailed in FHWA Rule 940/FTA Policy on the National ITS Architecture and ITS Standards, which became effective in April, 2001. The requirements are, in summary, that the ITS project must appear in the regional ITS architecture, and a systems engineering process must be used to develop the ITS project.

This chapter reviews the requirements set forth by the FHWA Rule 940/FTA Policy for ITS projects. The chapter summarizes what the requirements are, discusses how to satisfy those requirements, and describes the relationship of ITS Standards with these requirements. The chapter then proposes recommendations on how the transportation agencies can satisfy the FHWA Rule 940/FTA Policy requirements.

Although the discussions in this chapter do not directly impact how ITS Standards are addressed and included in the State's ITS project, they are part of the ITS Standards lifecycle and are included for reference.

3.2 FHWA Rule 940/FTA Policy

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. Concurrently, the Federal Transit Administration (FTA) issued a Final Policy entitled "National ITS Architecture Policy on Transit Projects". This Rule/Policy became effective on April 8, 2001. 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 was to accelerate the deployment of integrated Intelligent Transportation Systems (ITS) by requiring development of a regional, or statewide, ITS architecture. The regional ITS architecture, which is based on the National ITS Architecture but customized to meet a region's or state's particular needs, provides a plan by which a region or state can efficiently deploy ITS systems in a manner allowing for integration of these systems. The Rule/Policy further states that if a region has not yet deployed an ITS project then a regional ITS architecture must be developed within four years of the deployment of the initial ITS project in the region.

The Final Rule/Final Policy also requires that a systems engineering process be used to define and develop ITS projects. A systems engineering process is a structured way of thinking about and defining a system. The process allows us to build systems based on user needs with reliability and stability, and allows us to trace engineering decisions back to user needs. Using a systems engineering process improves the chances of developing a system that satisfies the user needs, and to completing the system on-time and within budget.

Each requirement of the Final Rule/Final Policy is discussed in further detail below.

3.3 ITS Architectures

3.3.1 FHWA Rule 940/FTA Policy on Regional ITS Architectures

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 may 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.

The West Virginia Statewide ITS Architecture developed and delivered by ConSysTec satisfies all 9 requirements of the Final Rule/Final Policy, including the Identification of ITS Standards.

3.3.2 Relationship of ITS Standards to the National ITS Architecture

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 with the ITS Standards. The National ITS Architecture provides a starting point for the standards development activities by identifying the applicable architecture flows and data flows to be standardized and the way in which the information is exchanged across those interfaces. Thus, many architecture flows and data flows in the National ITS Architecture are already mapped to individual ITS standards. Since the architecture flows of the National ITS Architecture form the basis for information exchanges for 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.

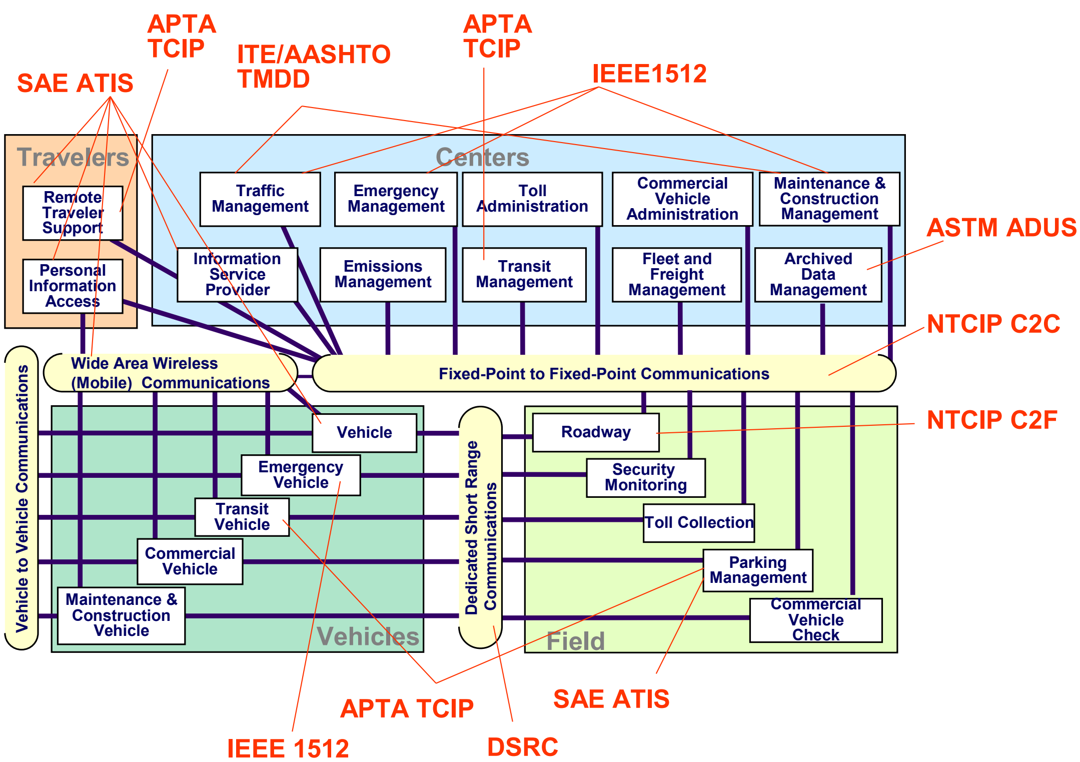

Figure 3-1. Relationship of the National ITS Architecture to ITS Standards

3.3.3 Applicable ITS Standards

As discussed earlier, ITS Standards address the interfaces between ITS systems. These interfaces, and the information flows between the interfaces are identified during the development of the West Virginia Statewide ITS Architecture through the consensus process. Based on the identified data flow and interfaces, the ITS Architecture indicates what standards may be applicable.

The West Virginia Statewide ITS Architecture Document includes a map for each interface and each information flow in the ITS Architecture to applicable ITS Standards (or interim standards), if an ITS Standard exists and may be applicable. 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 a project.

The Turbo Architecture database generated with the West Virginia Statewide ITS Architecture also provides an ITS Standards Report based on all of the architecture flows defined for the State. 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 the State. 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, these reports do not suggest that the ITS Standards listed will support all the functions desired and needed by the State of West Virginia, 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.

Also, 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 an ITS Standard. It is also be possible that no ITS Standard meets the needs and functions desired by the State of West Virginia. The determination of whether to use or adopt an ITS Standard for the State or a region can only made after comparing the needs of the State or region to the functions and capabilities provided by the ITS Standard.

Unfortunately, the West Virginia Statewide ITS Architecture does not provide guidance on whether to adopt an ITS Standard, how to use the standard, or more importantly, how to test the standards. However, these issues are discussed in detail in the next several chapters.

3.4 Systems Engineering Analysis

3.4.1 FHWA Rule 940/FTA Policy on Systems Engineering Analysis

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

The sixth requirement for the project systems engineering analysis, Applicable ITS Standards and Testing Procedures, requires that the project identifies the ITS Standards that may be appropriate, considered or are required for the proposed ITS project, and to indicate how the ITS Standard(s) will be tested.

The Final Rule/Final Policy implies that a systems engineering process must be performed and the analysis must be submitted along with the requests for Federal funding on ITS projects. The ITS project may be purchasing ITS equipment, upgrading or replacing an existing ITS system, or procuring a consultant to design an ITS system. If the Federal representative determines that the project for which funding is requested is an ITS project, the representative may deny the request if the systems engineering analysis is not included with the request.

The information to satisfy this requirement depends on the scope of the ITS project. If the ITS project is to procure a designer to specify the ITS system, listing the appropriate ITS Standards and the types of tests for testing the ITS Standard may be sufficient to satisfy the requirement. Appropriate ITS Standards may be identified based on the project specific architecture flows defined for the project. The actual selection of the ITS Standards for the project, specifying the details of the ITS Standard, and developing the test plans would be performed during the project development process and is described in Chapter 4.

If the ITS project is an actual deployment of an ITS system, actual selection of the ITS Standard(s), including the communications protocol, message sets, and data elements to be supported should be referenced or listed. Procedures to facilitate testing of conformance to the ITS Standards should be included in the project specifications, along with the testing requirements for factory and system acceptance tests, as appropriate.

3.4.2 Completing a Project Systems Engineering Analysis

Information used in a PSEA will be derived from a variety of sources including the West Virginia 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 ITS project. This can be done by conducting a preliminary review of the customized market package diagrams from the West Virginia 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.
2. **Participating Agencies Roles and Responsibilities.** Based on the project specific customized market package diagrams and ITS elements, as well as the operational concepts 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 can be derived from 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 West Virginia 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 may 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 messages to the detailed plan stages of the project development process. A discussion on the procedures to facilitate testing of conformance to the standards specifications and the testing requirements for factory and system acceptance test should be included.
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 ITS system 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, such as the specific roadway sections, transit routes, or geographic areas being considered and project objectives.

3.4.3 Example Systems Engineering Analysis

To illustrate the key points of the requirement for Applicable ITS Standards and Testing Procedures in the project systems engineering analysis, this section will make use of a fictitious project example called the West Virginia Freeway Expansion project, which includes the installation of traffic sensors (WV DOH ITS Field Equipment), CCTV cameras (WV DOH CCTV), and dynamic message signs (WV DOH DMS). This example shows only one possible means to satisfy the PSEA requirements.

3.4.3.1 Example ITS Project

The Statewide ITS Architecture indicates that these ITS field equipment interfaces with the WV DOH Regional TMCs (See Figure 3-2). Table 3-1 summarizes the project specific architecture flows between the WV DOH Regional TMCs and the ITS field equipment.

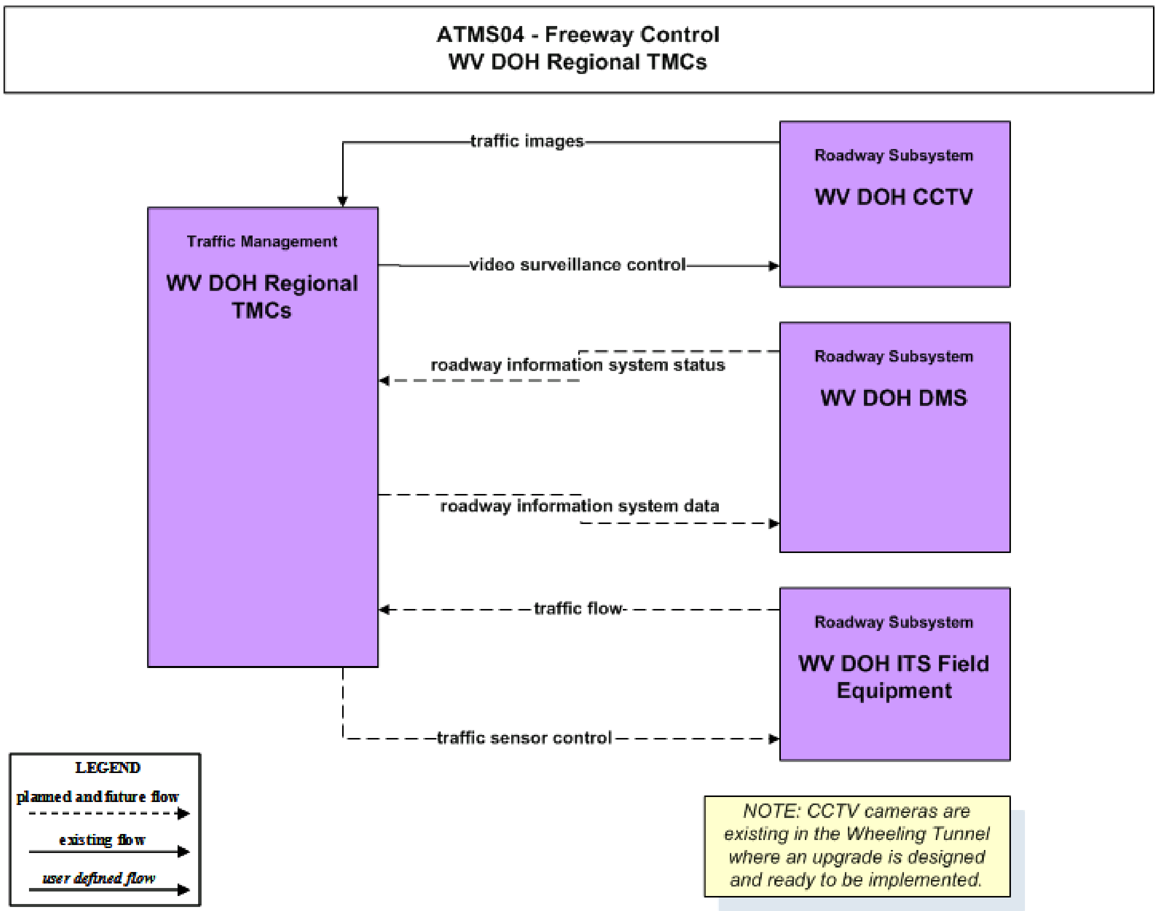

Figure 3-2. ATMS04 – Freeway Control Customized Market Package

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

Project Elements	Direction of Flow	Flow and Definition
WV DOH Regional TMCs → WV DOH DMS	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.
WV DOH DMS → WV Regional TMCs	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.
WV DOH Regional TMCs → WV DOH CCTV	TMC → CCTV	**video surveillance control** - Information used to configure and control video surveillance systems.
WV DOH CCTV → WV Regional TMCs	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.
WV DOH Regional TMCs → WV DOH ITS Field Equipment	TMC → Sensors	**traffic sensor control** - Information used to configure and control traffic sensor systems.
WV DOH ITS Field Equipment → WV Regional TMCs	Sensors → TMC	**traffic flow** - Raw and/or processed traffic detector data which allows derivation of traffic flow variables (e.g., speed, volume, and density measures) and associated information (e.g., congestion, potential incidents).

3.4.3.2 Example List of Applicable ITS Standards

Based on an analysis of the architecture flows and market package selections for the example project, Table 3-2 shows the applicable NTCIP center to field communications standards for the information flows listed in Table 3-1, as derived from the West Virginia Statewide ITS Architecture.

Table 3-2. List of Applicable ITS Communications Standards

Document Number	Document Title Involved	Project Applicability
NTCIP 1101	Simple Transportation Management Framework (STMF)	Yes
NTCIP 1102	Octet Encoding Rules (OER) Base Protocol	Yes
NTCIP 1103	Transportation Management Protocols (TMP)	No
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	No
NTCIP 1209	Data Element Definitions for Transportation Sensor Systems	Yes
NTCIP 2101	Point to Multi Point Protocol (PMPP) Using RS-232 Sub network Profile	Yes

Document Number	Document Title Involved	Project Applicability
NTCIP 2102	Point to Multi-Point Protocol Using FSK Modem Subnetwork Profile	No
NTCIP 2103	Point-to-Point Protocol (PPP) Over RS-232 Sub network Profile	Yes
NTCIP 2104	Ethernet Subnetwork 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
NTCIP 2302	Trivial File Transfer Protocol (TFTP) Application Profile	No
NTCIP 2303	File Transfer Protocol (FTP) Application Profile	No

If funding for the ITS project includes or is limited to the design of the ITS system, the above list of applicable ITS Standards may be sufficient (without the column marked “Project Applicability”) for the purposes of the systems engineering analysis. However, if the design of the ITS system is complete, and the ITS project is only the deployment of the ITS system, the analysis should indicate what ITS Standards are being specified (list only those ITS Standards where “Project Applicability” is “Yes”), if any, and what optional portions of the ITS Standards are being implemented (i.e., which communications protocol, message sets and/or data elements are required).

3.4.3.3 Example Testing Procedures

The second part of the ITS Standards requirement of the project systems engineering analysis is to list the applicable Testing Procedures. This part should outline what should be tested, and what system tests may be included (if the ITS Project includes design) or is included (if the ITS Project is deployment only) in the final Plans, Specifications, and Estimates (PS&E).

The testing program for the deployment of ITS system should be part of an overall testing philosophy. A testing program for the deployment of ITS Systems is discussed in detail in Chapter 6, but for the purposes of the project systems engineering analysis, an example set of system testing considerations for the West Virginia Freeway Expansion project is included below. In this example, ITS Standards have been specified for the project:

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

- **Design Tests.** These tests will be performed in a laboratory or controlled environment and will be used to verify that the design of the ITS System meets the requirements in the specifications. These tests shall include:
    - **Mechanical Tests.**
    - **Functional Testing.**

  - **Conformance Testing.** Verification that the ITS System conforms to the specified ITS Standards.

- **Field Tests.** These tests will be performed for each unit after installation of the equipment in the field.
  - **Design Verification Tests.** Verification that the equipment is properly installed as indicated in the approved plans.
  - **Power-On Tests.** Verification that the unit and all furnished equipment properly boots up, and has the correct communications address.
  - **Stand-alone Tests.** Verification that the unit and installed field equipment functions properly, and properly performs the functions required in the specifications.
  - **Systems Interface Test.** Verification that the unit and installed field equipment properly communicates with the central (computer) system. Conformance with the specified ITS Standards shall also be demonstrated. Status information, command information, and control of the unit and installed ancillary equipment from the central computer system shall be exercised and properly executed, using the specified ITS Standards.
  - **Integration Test.** Verification of the (entire) ITS system shall be exercised and demonstrated, including proper control and monitoring of all ITS field equipment from the central computer system.
  - **Burn-In Test.** Upon successful completion of the Integration Test, the (entire) ITS system shall be subject to a 60-day Burn-In Period. During this period, the ITS system shall be used and operated by WVDOT. Any anomalies or problems reported by WVDOT shall be recorded and reported to the Contractor, and the Contractor shall investigate and "fix" the problem at no cost to WVDOT. Upon "fixing" the problem, WVDOT may elect to start a new 60-day burn-in period. Burn-in Test is successfully completed after 60 consecutive days without a problem.

3.5 Recommendations

The FHWA Rule 940/FTA Policy sets forth the requirements for federal funding of ITS projects. The requirements are, in summary, that the ITS project must appear in the regional ITS architecture, and that a systems engineering process must be used to develop the ITS project.

The West Virginia Statewide ITS Architecture developed by ConSysTec is a Rule 940/FTA Policy-compliant architecture and satisfies all the requirements for a regional ITS architecture. One of the requirements is to identify the applicable ITS Standards for the region, or in this case, the State of West Virginia. This is documented in the West Virginia Statewide ITS Architecture Document.

Although ConSysTec has made efforts to document all planned ITS projects in the West Virginia Statewide ITS Architecture, it is possible that a future ITS project does not appear in the architecture. Thus, it is recommended that a step be included in all transportation planning processes in the state, whether it is WVDOT's or an MPO's planning process, to check if an ITS project is included in the West Virginia Statewide ITS Architecture. This check should be performed whether federal funding is requested or not for consistency.

It is also recommended that agencies adopt a process for performing systems engineering analysis on ITS projects. One possible method to perform the systems engineering analysis is included in this document in Section 3.4. Each agency may adopt its own systems engineering analysis process, or the state may develop a process that all agencies may use.

It is recommended that the WVDOT develop and issue guidelines on developing a systems engineering analysis that all agencies and organizations can use to develop ITS projects. By issuing guidelines, there will be some consistency with the various systems engineering analyses performed throughout the State, while allowing agencies flexibility to adopt a systems engineering process that works well with the agency's own transportation planning and project development process. The guidelines should indicate that the effort to perform the systems engineering analysis be commensurate with the size of the ITS project. For smaller ITS projects, a short analysis is sufficient, while a more comprehensive systems engineering analysis should be performed for larger ITS projects.

4 ITS Standards in the Project Development Process

4.1 Introduction

Once funding has been identified and allocated for an ITS project, the next step in the deployment of ITS systems is the development of design documents and procurement specifications. Many transportation agencies in the state, including WVDOT, already has an established project development process for creating these project documents, and ultimately, the plans, specification, and estimates (PS&E).

This chapter will review West Virginia Division Of Highway's (WV DOH) current project development process, and using that same existing process, how it can be used to review and consider the inclusion of ITS Standards for ITS projects. WV DOH's project development process is used in this chapter only for illustrative purposes, to demonstrate how each agency can adopt the concepts discussed to include ITS Standards when developing ITS projects. Some best practices for reviewing and specifying ITS Standards will be discussed, including the systems engineering process. These best practices will assist West Virginia transportation agencies in developing specifications that are thorough, meets the needs of the agencies and their customers, and that are testable.

4.2 Systems Engineering Process

As discussed earlier, the systems engineering process is structured way of thinking and defining a system. The process allows us to build systems based on user needs with reliability and stability, and allows us to trace engineering decisions back to user needs. Using a systems engineering process improves the chances of developing a system that meets the user needs, and to completing the system time and within budget.

The use of a systems engineering process is recommended for the development of ITS systems. Even if the use of systems engineering process was not a requirement by FHWA Rule 940/FTA Policy, it is a best practice for the industry. Technology projects, such as ITS systems, consists of complex relationships between hardware components, software, and the users of the system, and managing the relationships of these systems is made easier by using the systems engineering process.

This section will review the FHWA systems engineering process and compare it to WV DOH's current project development process. The section will show that there is a strong mapping between the systems engineering process and the existing WV DOH project development process. This will allow WV DOH to easily include and adopt the concepts of the systems engineering process without significantly altering the WV DOH project development process.

4.2.1 FHWA Systems Engineering Process

FHWA's recommended systems engineering process for developing ITS project is shown in Figure 4-1.

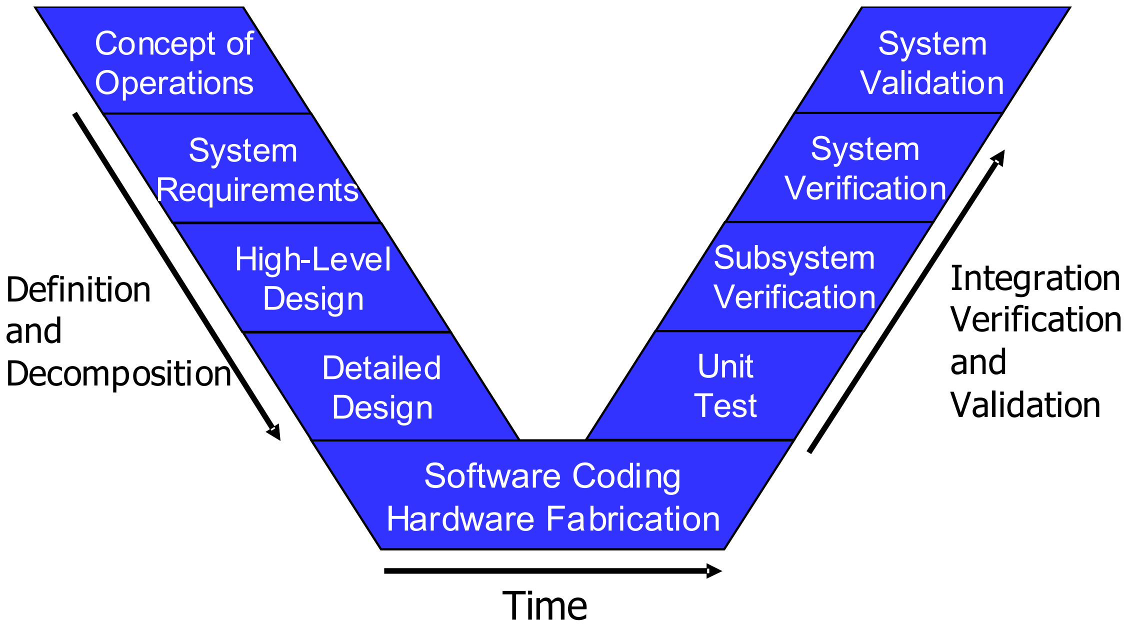

Figure 4-3. FHWA Systems Engineering Process

This systems engineering process consists of the following components:

- **Concepts of Operation.** Defines the transportation problem being solved through the implementation of the system. In addition, the concept of operation should define the relationship between the system and the organization(s), the roles and responsibilities of each organization and describes how the ITS "systems" will be used (its operational characteristics, practices and procedures).
- **System Requirements.** Something that governs what, how well, and under what conditions a product or a system will achieve a given purpose. Defines WHAT and not HOW. Should be based on concept of operations.
- **High-Level Design.** Defines from What to How. Design is the technical information resulting from translating requirements for a product into a complete description of the product. Preparation of the specification that describe the design. This step is the transition between requirements and detailed design.
- **Detailed Design.** Appropriate selection of system components and their interconnections so as to meet the defined requirements. Completes the description of the product or system. Includes hardware, software, and testing specifications.

- **Implementation.** The construction and deployment of the system.
- **Unit Test.** These tests check that the individual units that comprise the system comply with the design specifications.
- **Subsystem Verification.** Checks that the various subsystems that comprise the system comply with the design specifications.
- **System Verification.** Checks that the system meets and satisfies the project requirements.
- **System Validation.** Checks that the system match the user's needs. Also serves as a check that the systems requirements are correct.

But why is the systems engineering process important to ITS?

For ITS projects, the WV DOH project development process has proven effective when deploying common roadside field devices such as signs or lampposts. However, the same process is difficult to use when deploying technology systems such as ITS systems. The reasons for this are because ITS systems involve complex interrelationships between various systems and devices, and because ITS systems involve computers, communications, and software.

With ITS systems, project specification writers must spend more time identifying the problem, addressing user needs for operations, and defining what functionality will be needed to address that vision and the users needs, all before the system design is started. Based on this definition, ITS systems involves designing, integration, and testing, then starting over again. Deploying ITS systems is often an iterative development, unlike traditional infrastructure design and construction. Extensive testing (verification) is needed to assure what that the user needs and requirements are met, built, and works!

Thus for ITS projects, a slightly different approach or view of the WV DOH project development process is required.

4.2.2 WV DOH's Project Development Process

WV DOH's existing project development process is as follows:

- **Concept Development.** The purpose of this step is to develop and describe a candidate project. Project information includes a description of the problem, project needs and objectives, a preliminary schedule, and cost estimate. Once the project is approved by the Program Administration, a request is made for federal funding, if applicable.
- **Design Report.** Prepare preliminary design. Obtain consensus on the objectives and verify that the project needs have been well-defined. Focus includes the design criteria, the range of alternatives, outlining alignments, and a preliminary cost estimate.

- **Detailed Design.** Approximate to a 30% design, also known as the field performance review. Preliminary plans showing the boundaries of the project and the existing structures, profiles, etc.
- **Final Field Review.** Approximate to a 70% design. The purpose is to provide a review of the detailed plans and specifications by the various field and regional offices. Review may also be submitted to the quality control unit and to local agencies and organizations with jurisdiction over the project facility.
- **Final Office Review.** Submittal for review of the nearly complete detailed plans and specifications by the Main Office functional units.
- **Final PS&E Submission.** Final Plans, Specifications, and Estimates, or bid documents, for contract letting. After approval, submit authorization for money for construction.
- **Construction.** Actual deployment and installation of the system. Includes testing and acceptance of the system.
- **Operation and Maintenance.** The project is completed and turned over to WV DOH for everyday use and maintenance.

Figure 4-2 is a diagram comparing the USDOT recommended systems engineering process with the existing WV DOH's project deployment process. Looking at the figure, the major steps and components of the system engineering process has a direct correlation to the WV DOH project development process.

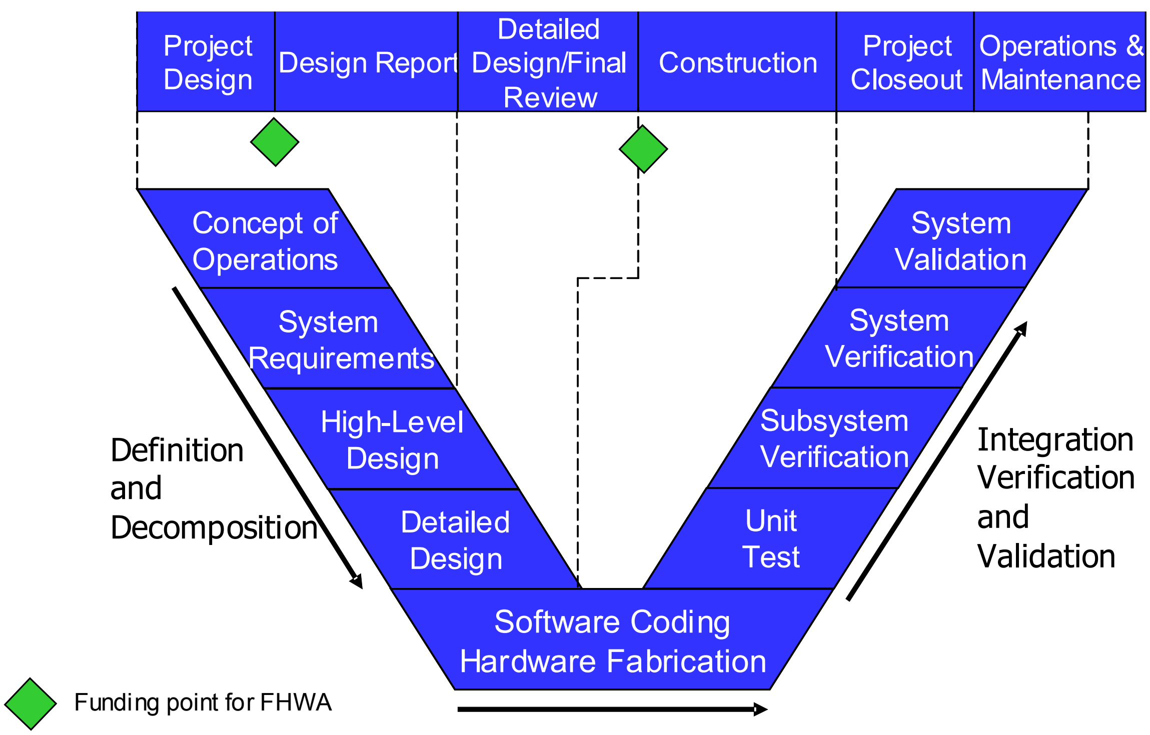

Figure 4-4. FHWA ITS Systems Engineering Process

This strong correlation allows WV DOH to easily incorporate and adopt the FHWA systems engineering process when developing ITS projects.

Table 4-1 shows the relationship the WVDOT project development process has to the FHWA system engineering process.

Table 4-3. WVDOT Project Development Process to FHWA System Engineering Process

West Virginia DOT Project Development Process	Relation	System Engineering Process
Project Design	→	Concept of Operations
Design Report	→	High Level Requirements
		Detailed Requirements
Detailed Design	→	High Level Design
Final Field Review / Final Office Review	→	Detailed Design
Construction*		Implementation
Integration/Testing		Integration & Test
System Verification	→	Subsystem Verification
Subsystem Verification		System Verification
Operation and Maintenance	→	Operations & Maintenance
Note: * - Implementation step is not shown because the completion of construction a project is presumed to be implemented.		

The remainder of this chapter reviews each step of the WVDOT project development process, discusses how the corresponding systems engineering component can be incorporated, and how ITS Standards fits into the process.

4.3 Project Design

4.3.1 WV DOH Project Design

Project design for WV DOH begins after the project has been approved by the Program Administration (Program Review Committee) of WV DOH with a schedule, which includes the funding and the time table. This is also the point when WV DOH requests federal funding for project design, if applicable.

Project design begins with the development of a project scope, or a statement of what the project is trying to accomplish. Although the project scope should be 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. The project scope meeting is either performed in-house, or with the consultant/contractor.

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 West Virginia Statewide ITS

Architecture. This level of detail can be found by finding the customized market package diagrams that the project encompasses, then reviewing the market package descriptions, which can be found on the West Virginia Statewide ITS Architecture website.

4.3.2 Systems Engineering - Concepts of Operation

The similar step to the WV DOH Project Design phase in the systems engineering process is the development of a Concept of Operations.

The Concept of Operation (ConOps) document defines the relationship between the ITS system and the organization, and the roles and responsibilities of each organization that will operate and/or maintain the system. Put differently, the Concept of Operation describes how the ITS "system" will be used (its operational characteristics) and what transportation problem is being solved through the implementation of the system. The Concept of Operations should be developed to clearly define the user needs and operational context for the functions that the ITS system will support, and the roles and responsibilities.

The ConOps should be developed using easy-to-use understand terms and as a stand-alone section. The ConOps should also be developed with participation from all the stakeholders and users of the ITS System, including those stakeholders that are expected to operate, maintain, or be directly affected by the system.

Information belonging in a Concept of Operations document may include:

- **Identification of Stakeholders**. 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; or "non-normal" conditions, including when parts of the system fail.

- **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.

Development of a Concept of Operations (ConOps) document is highly recommended. The ConOps will be used to develop the system functional requirements, based on the needs and operational concepts identified in the Concept of Operations.

From an ITS Standards point-of-view, the ConOps 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.

4.3.3 ITS Standards in the Project Design Phase

Earlier, it was recommended that the level of detail for the project definition and scope be what is contained in the West Virginia Statewide ITS Architecture. Expanding on that recommendation, it is recommended that at this stage of the project development process, a list of ITS Standards that may be applicable to the project be developed.

This list can be derived directly from the West Virginia Statewide ITS Architecture. Based on the project definition and scope and those parts of the Statewide ITS Architecture that the project scope includes, a list of applicable architecture flows that are part of the project can be created. Each of these architecture flows may have ITS Standards associated with them.

Using the example in Section 3.4.3.1, the list of applicable ITS Standards for that example project can be found in Table 3-2.

From the WVDOT Statewide ITS Architecture website, the list of applicable ITS Standards can be found by clicking on ***ITS Inventory*** from the menu on the left, scrolling down and clicking on one of the elements included in the project. For demonstration purposes, use ***WV DOH Regional TMCs***. A table will appear, which includes a list of other ITS elements that WV DOH Regional TMCs interfaces with. Click on one of the other ITS elements included in the project that WV DOH Regional TMCs interface with, for example, ***WV DOH DMS***. Another table appear, listing the architecture flows that exist in the Statewide ITS Architecture between these two ITS elements. Click on one of the architecture flows that are included in the project scope, for example, ***roadway***

information system status. Several tables will appear, providing a definition of the architecture flow, and a list of the potentially applicable ITS Standards for that architecture flow.

4.4 Design Report

4.4.1 WVDOT Design Report

The next phase of the WV DOH project development process is the design report. The design report includes an analysis of existing conditions and explains what will be designed and reviews alternate design options. It focuses on the major decisions that need to be made to allow design to proceed efficiently.

The design report should include a summary of findings based upon the initial investigation activities and field verification work incorporating an overview and history of existing conditions. For "normal" construction projects, these conditions may include architectural and structural elements, and an overview of mechanical and electrical systems. For ITS projects, this may include an overview of the existing capacity of electrical power, availability of an communications infrastructure, and a traffic engineering analysis for projects that involve field equipment and devices. Alternative design solutions and technologies should be developed and analyzed, and one design solution should be selected.

Graphical illustrations may be included to show location plans, site plans, and site plans, including architectural plans depicting space in control or dispatch centers for new computers and communications equipment.

4.4.2 Systems Engineering – High-Level and Detailed Requirements

The similar step to the WV DOH Design Report in the systems engineering process is the development of requirements. Requirements are statements of "what" a system should do, "when" it should do the "what," and for whom the "what" should be done. However, they do not define the manner in which the system should do it.

Requirements should be traceable back to the Concept of Operations document. This is the first step of traceability. Traceability is the ability to explain why every system function is specified by tracing it back to its origin. Traceability is a key component of the success of the systems engineering process. With traceability, project managers can determine if the system "solves" the problems it is intended for, performs the functions required, and is testable.

Using a dynamic message sign as an example, the high level requirements for a dynamic message sign might be:

- What a system does (functions) – provides traveler information
- Expected outcomes – displays traveler information to drivers so travelers can make informed decisions

- Expected interfaces – Interface with control computer, display boards above or adjacent to the roadway, drivers
- Performance objectives – Ability to change, download and display messages within 5 minutes, able to display 6 lines of text, up to 20 characters of text per line in 10 seconds.

Until requirements have been determined, development of the contract drawings and specifications should not begin.

4.4.3 ITS Standards Considerations for the Design Report

For the design report, review the list of applicable ITS Standards that was created in the first step and make an initial determination of which ITS Standards may be applicable to the project. The initial determination should minimally consider the following factors:

- **Maturity of the ITS Standard(s).** How mature is the ITS Standard(s), is the standard(s) widely supported, and has the Standard been tested are major questions. Although it is certainly possible to still use the ITS Standard(s) if the answer is in the negative, it is important to be aware of the increased risks (and probably costs) involved with specifying the ITS Standard. Section 6.2 of this document reviews the current status and maturity of the existing ITS Standards.
- **Ability of the ITS Standard to Meet the Requirements.** Does the ITS Standard satisfy or support the requirements of the project? By now, the project requirements should be developed. Compare the project requirements to the functional capabilities supported by the ITS Standard(s) that are being considered. Are they compatible? If the ITS Standards only support a very small subset of the capabilities required by the project, it may not be cost effective to specify the ITS Standard.
- **Effect of Deploying ITS Standards on Existing Software.** The previously developed central software may be based on non-standard or proprietary protocols of the manufacturers. To integrate ITS Standards, modifications to any existing software may be required. 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 support the ITS Standards.

A review of the ITS Standards and the functions or messages supported by those ITS Standards can also assist in determining what requirements may be desired and/or overlooked for the ITS project. Each ITS Standard supports the more common functions and/or messages currently required or available in the ITS industry.

4.4.3.1 Requirements for Center to Field Communications

The requirements for an ITS system using Center to Field Communications should include discussion of the following:

- **Normal Operations.** Based on the Concept of Operation document, the requirements should include how the field and central control system should operate under normal conditions, and what must happen during that operation. 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.
- **Exception Operations.** Based on the Concept of Operation document, the requirements should include what the field equipment and central control system should do under abnormal conditions, such as during equipment or power failures.
- **Control Modes.** Based on the Concept of Operation document, the requirements should discuss the different control modes, functions, and what operations are available during which control modes, if applicable.
- **Monitoring.** Based on the Concept of Operation document, the requirements should outline how the system will perform status monitoring, event logging, and diagnostics.

If the ITS Standards that are being considered do not support a majority of the above requirements, specifying those ITS Standards should not be considered for the project.

4.4.3.2 Requirements for Center to Center Communications

The requirements for Center to Center Communications should include the following:

- **Normal Operations.** Based on the Concept of Operation document, the requirements should indicate what functions are the centers able to perform. The centers will minimally consist of a local center, and one or more remote centers.
- **Dialogs.** Based on the Concept of Operation document, the requirements should include what information is to be exchanged between the centers under normal operations. Ideally, the requirements should include a detailed description of what information will be exchanged including the data elements, under what conditions will exchanges be initiated, and the proper response when specific information is received.
- **Message Types.** Message types may include: control messages, inventory messages, request messages, response messages, status messages, and subscription messages.

  A brief review of the candidate message set standards and list of messages should also be included in the design report. 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.

If the ITS Standards that are being considered do not support a majority of the above requirements, specifying those ITS Standards should not be considered for the project.

4.5 Detailed Design

4.5.1 WV DOH Detailed Design

Upon completion of the design report, the next step in the WV DOH project development process is the preliminary and detailed design. Based on the selected design alternative, the design should be expanded upon and shall include preliminary calculations and assumptions, and preliminary design drawings including architectural, structural, electrical, and mechanical drawings as necessary. Specifications should be outlined and developed, using available standard specifications as a starting point. For ITS projects involving field equipment, site plans with sight lines should also be developed.

4.5.2 System Engineering – High-Level Design

High level design is the transitional step between WHAT the system does and HOW the system will be implemented to meet the system requirements. For ITS projects, the high level design defines the sub-systems to be built, internal and external interfaces to be developed and identifies the ITS Standards that are applicable.

The high level design process also defines the division of the system into sub-systems, and where the sub-system requirements are developed. Sub-systems may exist for a variety of reasons, including parts that may need to be developed or procured separately, parts that are deployed in different locations, or parts that perform different, specific functions.

Alternative designs are also evaluated and reviewed in more detail in this step, including determining the relative importance of the various selection criteria. Evaluation criteria may include functionality, performance, and costs for each type of technology.

4.5.3 ITS Standards Consideration in Detailed Design

If an ITS Standard can support the project requirements, then adoption of such a standard for the project eases the design work. With ITS Standards, certain aspects of the design have already been defined by the standard, such as the communications protocol (how will they talk), the message format (what is the structure for sending information), and the data element formats. 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. Using the ITS Standard and its benefits may be as simple as referencing the standard in the specifications. Without the ITS Standards, each aspect of the communications will need to be defined, described and detailed in the project specifications.

However, rarely will an agency need all the functions and messages that an ITS standard supports. The ITS Standards generally “support” the most common functions for a field device or the most common messages between centers. However, each project may not necessarily require all the functions or messages supported by the ITS Standard. Conversely, there is also a possibility that an ITS Standard does not support all the user and functional requirements that have been defined earlier in the project development phase.

Thus the project specifications should specify only those data objects (center-to-field) or messages (center-to-center) that are required for the project. Some data objects and messages will already be required by the ITS Standard (mandatory) but many are considered optional by the ITS Standard.

Note the difference, to be in conformance with an ITS Standard, the implementation of the ITS Standard in the project MUST support the mandatory portions of the standard but it does NOT have to support the optional portions to remain in conformance. However, if an optional portion of the ITS Standard is a requirement for the project, that requirement should be included in the project specifications.

If an ITS Standard does not support all the user requirements, agency-specific data objects or messages may be needed. The ITS Standards recognize that they can only define and support only the more common functions and messages, thus they allow agencies to create and define agency-specific data elements and messages. Most ITS Standards provide guidelines on creating such agency-specific data elements and messages. If any agency does create agency-specific data elements and messages, it is important that the agency “owns” and maintains the right to them, so the agency can reuse those data elements and messages for future projects.

4.5.3.1 Center to Field Communications in Detailed Design

Some of the newer center-to-field ITS Standards have a Protocol Requirements List (PRL) that maps user requirements to functional requirements to solutions that are defined in the ITS Standards. This makes it easy for specification writers 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. Tailoring the PRL for use in a specification makes it a Protocol Implementation Conformance Specification (PICS). A completed PICS can be included as part of the project specifications. An example of a PICS can be found in Appendix B.

Ultimately, an agency may have a state agency MIB (management information base) for certain field devices. These MIBs are specifications, in a specific format, containing and describing the definitions of the data objects supported by the field devices and software. MIBs can be machine-read, so software can easily determine what objects are supported by the central software and/or field devices.

4.5.3.2 Center to Center Communications in Detailed Design

The design for center-to-center communications should 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

The design of the center-to-center communication should also include:

- **Monitoring.** Outline the behavior of the system during status monitoring, event logging, and diagnostics.
- **Installation/Testing.** Outline what testing is required under various times/conditions. For example, during installation, routine maintenance, and failure.
- **Exception Operations.** Outline what the central control system should do under abnormal conditions, such as during equipment or power failures.

4.6 Final Review

4.6.1 WV DOH Final Review

Final review consists of a field review and office review. Upon acceptance of the detailed design, the drawings and specifications shall be updated. All items of the design should have been started by now.

For the field review, the level of detail work shall be such that the details allow the reviewers to comprehend the general direction of the design shown. Drawings may include architectural plans with equipment and utility locations, communications and wiring drawings, electrical drawings and mechanical drawings, both in the field and within the centers. Specifications should include specifications of all materials and equipment to be used, details of specification requirements, and specifications of all tests to be performed, including acceptance criteria. For ITS projects, detailed functional capabilities of all equipment should be included.

Office review occurs after acceptance of the field review. The design drawings and specifications should be completed for the office review. Contents of the drawings and specifications should be complementary to the bid and contract documents, ready for advertisement, and the cost estimates and estimated quantities should be complete.

4.6.2 Systems Engineering – Detailed Design

The detailed design specification defines HOW the system will be built. It is the build-to design of the hardware and software products. For software development, this is also the step where the software documentation is being prepared for coding. Enough detail should be available so the software programmers can write the individual software modules. An incomplete design at this point leads to increased technical risk and increased cost.

4.6.3 ITS Standards in the Final Review

For Final Review, all details for the project specification should be completed. These details should include:

- **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.
- **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. Testing is discussed in more detail in Section 5.

In addition, several paragraphs should be included in the specifications to reduce the risk for the procuring agency and the vendor. Although there may be an inclination not to protect a vendor's interest in a specification, when vendors review a specification, they also evaluate the potential risks to them and will price their products and services accordingly. Thus, if a specification provides some protection for a vendor's risk, the pricing may be better.

Paragraphs that should be included in a specification are:

- **Specifying the Version.** When specifying an ITS Standard, clearly indicate what version of the ITS Standard is to be deployed for the project. This will eliminate any misunderstanding with the vendor and clarify the risks involved to the agency and the vendor. If a version of an ITS Standard is not yet approved but is still desired because it has new, required functionality, that version of the ITS Standard can be used, but the risks must be recognized by the agency, and allowances for changes to the ITS Standard (between the draft version and the final approved version) must be made.

- **Documentation.** The manufacturer should always provide NTCIP and MIB documentation in electronic form. Statements similar to the following should be included.

  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, the manufacturer specific version of the 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.

- **ITS Standard Interpretation Resolution.** Finally, a statement that reflects what will be done in the event of a conflict in interpreting the ITS Standard 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 ITS Standard Working Group for resolution. If the Working Group fails to respond within 90 days, the project shall develop an interpretation of the specification.

4.6.3.1 Center to Field Communications in the Final Review

In addition to the above, a specification for center to field communications should include the following:

- **Specify Values.** The ITS Standards for center-to-field communications generally support a range of values for each data object. If the project requirements need only support a subset of the available values supported by the standard, require only those values in the specifications because it may decrease costs. For example, although the NTCIP 1203, Object Definitions for Dynamic Message Signs supports up to 65,535 messages, if only 8 messages are required, indicate support for a minimum of 8 messages in the project specifications. The DMS vendor will properly size the amount of memory required for 8 messages instead of enough memory for 65,535 messages. Often, the vendor will provide more than required in the project specifications because it may be part of their standard products.

- **Example MIB**. Optionally, if the procuring agency already has an agency MIB from a prior project, and that MIB is still relevant, the agency should include the MIB in the specifications.
- **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.

4.6.3.2 Center to Center Communications for Final Review

In addition to the above, a specification for center to center communications should cover the following:

- **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 West Virginia, 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**. This 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.
- **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.

4.7 Recommendations

It is recommended that agencies expecting to deploy multiple ITS projects update and formalize their project development process to incorporate systems engineering concepts. Existing agency project development processes have proven effective for roadway design and devices, but do not consider the complexities involved with ITS systems. ITS systems involve complex interrelationships between different systems and subsystems, such as roadway devices and between centers. ITS systems also involve designing software, which is generally a more iterative process and involves significant development time determining the user problem, user needs, and user requirements BEFORE the system design begins.

The systems engineering process is better suited to the different needs of software and systems development and design. The concepts and relationships described in this chapter are intended for developing ITS projects, but can also be applied to other technology projects.

Based on the West Virginia Statewide ITS Architecture, a list of applicable ITS Standards is available. The ITS Standards and the functionality and messages supported by the ITS Standard should be reviewed during the project development. Selection of an ITS Standard for an ITS project should be based on three factors, the maturity of the ITS Standard, the effect on existing software and systems, and most importantly, the ability of the ITS Standard to satisfy the project requirements. If the ITS Standard does not support the project requirements, it is not cost effective to require support for the ITS Standard.

Otherwise, use of the ITS Standard is recommended because many aspects of the communications design will already be defined by the standard. There is a temptation to require that the vendor support the full spectrum of the functions and messages supported by an ITS Standard. The recommendation is not to arbitrarily require support for all the functions or messages, only require what is needed for the project as defined by the project. Requiring all the functions and messages supported by a standard may be costly.

Finally, the specifications should include discussions on software and integration support, how testing of the ITS Standard will occur, documentation, and how to resolve interpretation issues.

Additional information that may warrant further consideration with regard to ITS Standards implementation include:

- 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, WVDOT 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).
- While manufacturers advertise that their products are NTCIP conformant, this does not mean that WVDOT 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.
- A statement that reflects what will be done in the event of a conflict in interpreting the ITS Standard. This may include submitting the issue to the appropriate ITS Standard working group.

4.8 Summary

Many transportation agencies already has an established project development process. However, this project development process may be ineffective for ITS projects, which include complex interrelationships between elements such as field devices and centers and software development.

The inclusion of systems engineering concepts into the project development process will assist the agency to write better and more complete project specifications for ITS projects. For example, the various steps of the FHWA ITS system engineering process has a strong correlation to the WV DOH project development process, allowing for easy adoption of the systems engineering process.

When developing ITS projects using the systems engineering analysis, there are certain aspects of ITS Standards to consider at each step of the process. For example, in the case of the WV DOH project development process, during project design, a list of applicable ITS Standards should be extracted from the West Virginia Statewide ITS Architecture. During the design report, selection of ITS Standards for the project should occur. During detailed design, optional message, data elements, and other optional portions of the standard should be selected and included in the project specification. Finally, other information regarding the ITS Standard, including test procedures and documentation should be added to the specification.

5 Testing

5.1 Introduction

After the design of the ITS project is completed, the next step is to build and deploy the ITS system. As the ITS system is deployed, it is important to systematically test each component of the ITS system and the ITS system as a whole to ensure that it complies with the specifications, meets the requirements and satisfies the user needs. If an ITS Standard is specified, the ITS system should be tested for conformance to the ITS Standard.

Testing is important in the deployment of technology projects, such as ITS, because it serves as validation and confirmation that an implementation is correct. For ITS 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 center-to-field standards, but many of the philosophies discussed are applicable to the other ITS Standards.

5.2 Testing Philosophy

Testing of devices to determine NTCIP compliance to a project specification has been a subject of debate since the initial draft release of an NTCIP Standard in 1995 by NEMA. There are different philosophies to testing and 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.

5.2.1 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. The ITS 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 ITS Standards simply specify a consistent manner that information is transferred between components of a system, such as a center and field devices. They do NOT explicitly 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 Center-To-Field 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.

For example, NTCIP 1203, Objects for Dynamic Message Signs, has an object (element) called *dmsIllumManLevel*, which is defined as the object for manually setting the brightness of the dynamic message sign. The NTCIP 1203 standard states that to manually set the brightness level for the dynamic message sign, this data object shall be used and in the format prescribed to send the information from a central system to the field device. However, "supporting" or acknowledging this object implies that the dynamic message sign is capable of understanding the object, and is thus capable of changing its brightness level to the one defined in the object. Understanding and accepting the object in the prescribed format (and ONLY in the prescribed format) is "explicitly" required by the NTCIP 1203 standard, but the ability to actually to perform the function is "implicitly" required.

Put differently, 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 NTCIP Standard does not explicitly require that the field device do something after receiving and interpreting the data elements, the Standard "assumes" that the device will perform the function.

Because of this confusion, many users equate the test for conformance to the standard, correctly or incorrectly, as a test for compliance to the 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. 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).

Recognizing the confusion between conformance to ITS Standards and the lack of functional and performance requirements, NEMA has sponsored several on-going activities to define functional requirements for traffic signal controllers (TS-1, TS-2), dynamic message signs (TS-4), and environmental sensor stations (TS-5x – In Development).

5.2.2 Compliance Testing

The focus of this document is on ITS Standards. Although testing for compliance to specification is important, particularly to the procuring agency, it is not the primary focus of this section. However, it is important to distinguish the difference between the two types of tests, compliance to specifications and conformance to standards, to facilitate the discussion on conformance.

As stated, conformance (to ITS Standards) testing should only be part of an overall testing program for ITS Systems. For the overall ITS system, several types of tests should be performed at different stages of the procurement process to verify that the system and subsystems meet the overall requirements of the specifications. The specifications may include different types of requirements, including functional, electrical, environmental, mechanical, structural, and performance. Each of these requirements should be tested. 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).

5.2.3 Testing Program

In addition to these individual compliance tests and conformance tests, it is important to recall that the purpose for this section is the testing of ITS *systems*. Systems consists of different components that must work together in unison to perform a function or set of functions. Thus, the testing program should consider different tests at the different stages of the procurement. The following tests should be considered as part of an overall testing program.

- **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 each device or component 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 component 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.

5.2.4 Compliance Testing Requirements

The following are recommended statements for compliance testing that should be considered for inclusion in the specifications. These statements serve two purposes, to clarify how testing is to be performed, and to protect the interests of the procuring agency and the contractor.

5.2.4.1 Test Procedure Approval

The Contractor shall be responsible for developing detailed test procedures for each type of equipment and for conducting the specified acceptance test to verify satisfactory operation of the equipment. The test procedures shall be submitted to the Engineer for approval prior to the tests. Only approved test procedures shall be used for the test. Unless otherwise specified, a minimum of XX days shall be allowed for the Engineer's review and approval of the test procedures.

5.2.4.2 Test Schedule

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.

5.3 Conformance Testing

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. There is generally two methods to obtaining conformance, the procuring agency may wish to test each component of the standard and verify through a battery of tests that the implementation "conforms" to the standard, or it may allow the vendor to self-certify that its implementation "conforms" to the standard.

The decision on which method to use for a procurement is most likely a financial one. If the procurement is a small project, but the cost for testing "conformance" is estimated to add, say 20% to the cost of the project, a decision may be made to allow the vendor to self-certify conformance, particularly if the vendor can demonstrate it has implemented the standard before (in other projects). For large procurements, it is probably desirable to at least test some subset of the implementation for conformance to the standard, since it is a significant investment, even if the vendor has a history of demonstrating conformance in other projects. Minimally, the procuring agency will obtain a better understanding (experience) of how the ITS system works by performing the conformance test.

But what is conformance to a 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 ALL the mandatory components and requirements identified in the referenced standards.

Optional components, are just that, optional. Optional components are not required to be supported in the implementation to be conformant to the standard. However, if the optional component is supported by the implementation, that optional component must be provided in the manner dictated by the standard to remain conformant to the referenced standard. This is true regardless if the optional component is required or not by the specifications.

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 the standards did support all the possible functions that an agency may need, the standard 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 is 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.

5.4 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.

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 devices perform the functions required as intended by the procuring agency.

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 the conformance test 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.

5.5 Recommendations

Each agency that deploys an ITS project using ITS Standards should develop and adopt a testing philosophy appropriate to their agency and their agency’s resources. The philosophy should recognize and distinguish the different types of ITS system testing, and the different manner that vendors can achieve conformance to an ITS Standard.

For example, a large agency that has available resources may wish to develop and adopt their own conformance tests; while a smaller agency may just wish to adopt another agency's conformance test. The conformance test should clearly indicate how the vendor is to demonstrate that it conforms to an ITS Standard.

Regardless, each agency should formalize their testing requirements, terminology, and testing program for ITS projects. These requirements and program may include factory acceptance testing, stand-alone test, conformance tests, systems integration test, etc. Each agency may have their own test plans or MIBs that a vendor must conform to; or perhaps a vendor must produce a new test plan or MIB for the ITS system.

In addition, several testing tools exist that can be used to demonstrate conformance to ITS Standards. Some testing tools are generic in nature, such as a protocol analyzer. Other tools have been developed specifically for ITS Standards testing, such as the NTCIP Exerciser or Device Tester. If a testing tool is preferred by an agency, the specifications should indicate which testing tools will be used and a statement similar to the following should be included:

- The acceptance test shall use the xxx Testing Unit or other testing tool for testing conformance.
- The manufacturer will submit an <<ITS Standards>> test plan a minimum of 90 days prior to <<ITS Standards>> acceptance testing. <<ITS Standards>> 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.

6 Current ITS Standards Activities

6.1 Introduction

This section reviews the current status of relevant ITS Standards and ITS Standards testing activities on a national level.

This section also review current West Virginia efforts and contracts in deploying ITS Standards. This includes dynamic message signs, environmental sensors, and traffic signal controllers.

6.2 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 ITS Standards Program encompasses five key areas of standards activity: Development, Testing, Deployment, Technical Assistance, and Training and Outreach.

- 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
- Deployment Activities

  - Provide tools that help state and local deployers implement standards-based ITS, including experience-based deployment guidance, such as lessons learned.
  - Provide platforms that allow state and local deployers to exchange ideas and to discuss standards deployment-related issues
- 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
- 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
  - Provide up-to-date information about ITS standards development, testing, deployment, and training activities, mainly through the ITS Standards Program website.

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 April 2006, the U.S. DOT reported the following statistics on standards development:

Table 6-4. U.S. DOT ITS Standards Status Levels

Status Level	Status Level Description
81 – Published	Standards that are available for purchase.
12 – Approved	Standards that have passed all necessary ballots and have been approved by a standards development organization, but not yet published.
7 – Ballot	Standards that are being voted upon by a committee or working group, or are undergoing other SDO procedures.
10 - 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. Many 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.

From the beginning, US DOT 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 following sections will provide details of the individual standards efforts, grouped by SDOs. Only those ITS Standards that may be applicable to West Virginia public agencies, including highway agencies, transit agencies, public safety agencies, and transportation planning organizations, are summarized here.

6.2.1 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.

6.2.1.1 NTCIP 1101 – NTCIP Simple Transportation Management Framework

A set of rules and protocols for organizing, describing and exchanging transportation management information between transportation management applications and transportation equipment such that they interoperate with each other.

Status: TS3.2, Amendment 1 - Published. To be replaced by NTCIP 1102, NTCIP 1103, and NTCIP 8004

Contact: Robert De Roche, Robert De Roche Consulting

Issues : To be replaced.

Implementations : Many.

6.2.1.2 NTCIP 1102 - Octet Encoding Rules (OER)

A set of encoding/decoding rules to prepare data for transmission or to decode data before sending it to the application. Developed as a derivative of the Basic Encoding Rules (BER), as defined in ISO 8825-1. Within the NTCIP suites of protocols, OER is to be used in conjunction with NTCIP-STMF and NTCIP-DATEX ASN. Serves as a replacement for part of NTCIP 1101 (STMF), but also defines additional features.

Status: Version 1.12 - Approved.

Contact: Robert De Roche, Robert De Roche Consulting

Issues : None.

Implementations : No known implementation.

6.2.1.3 NTCIP 1103 – Transportation Management Protocol (TMP)

Specifies a set of rules and procedures for exchanging information with a minimum of overhead to provide an interoperability standard for transportation-related devices that operate over bandwidth-limited communications links. Includes STMP (NTCIP 1101) with additional definitions.

Status: Version 1.26a - Approved. Version 2 – Under Development and will define trap management.

Contact: Robert De Roche, Robert De Roche Consulting

Issues : None.

Implementations : No known implementation.

6.2.1.4 NTCIP 1104 – CORBA Naming Convention Specification

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.

Status: Version 1.08c - Approved.

Contact: Manny Insignares, ConSysTec

Issues : CORBA implementations of center-to-center communications is no longer supported.

Implementations :

6.2.1.5 NTCIP 1201 – Global Object Definitions

Defines the pieces of data that are likely to be used in multiple device types, such as device identification, time management, schedules, report generation, and event logs. Version 2 adds auxiliary I/O support and UML diagrams to explain interrelationships.

Status: Version 1, Amendment 1 – Published. Version 2 – Approved.

Contact: Ken Vaughn, Trevilon Corp.

Issues : None.

Implementations : Many.

6.2.1.6 NTCIP 1202 – Object Definitions for Actuated Traffic Signal Controller Units

Defines the data that are frequently found in actuated traffic signal controllers. Version 2 adds BLOCK object data to decrease communications overhead.

Status: Version 1, Amendment 1 – Published. Version 2 – Approved.

Contact: Peter Ragsdale – US Traffic Corporation; Beth Ramirez, City of Dallas.

Issues :

Implementations : Many.

6.2.1.7 NTCIP 1203 – Object Definitions for Dynamic Message Signs

Defines the data that are found in dynamic message signs, including blank-out signs, changeable message signs, and variable message signs. Version 2 adds default values to many objects, improves support for graphics and multiple colors, and expands error reporting status, including support for multiple climate control devices.

Status: Version 1, Amendment 1 – Approved. Version 2 (v02.31a) – Balloting.

Contact: Mark Morse, Washington State DOT.

Issues :

Implementations : Many.

6.2.1.8 NTCIP 1204 – Object Definitions for Environmental Sensor Stations

Defines the data that are found in road weather information stations and air quality sensors, including fog sensors, pavement sensors, and (camera) snapshots.

Status: Version 1, Amendment 1 – Published. Version 2 (v02.22) – In Balloting.

Contact: Gene Martin, Virginia DOT

Issues : Time periods defining “Average” and “Peak” measurements are fixed (Average = 2 minute period, Peak = 10 minute period).

Implementations : Several.

6.2.1.9 NTCIP 1205 – Object Definitions for Closed Circuit Television Camera Control

Defines the data that are used to control video camera. Amendment 1 includes additional functionality, including privacy zones and queries.

Status: Version 1 – Jointly Approved. Version 1, Amendment 1 – Under Development.

Contact: Michael Forbis, Washington State DOT

Issues : Increased costs, PTZ control may not be as responsive, some values (zoom, focus and iris limits and position values) are arbitrary and may prevent interoperability unless clearly defined.

Implementations : Florida DOT

6.2.1.10 NTCIP 1206 – Object Definitions for Data Collection

Defines the data that are stored in roadside count stations. Supports data collection by Binned studies, per vehicle records (PVR), and event studies (e.g., time-stamped events). Data may include speed, length, axles, height, and weight.

Status: Version 1 (v01.22b) – Approved.

Contact: Rick Stalowski, Peek Traffic Systems, Inc.

Issues : High communications overhead.

Implementations : No known implementations.

6.2.1.11 NTCIP 1207 – Object Definitions for Ramp Meter Control

Defines the data that are found in ramp meters. Version 2 to incorporate responses to the Battelle test report, and add support for block objects.

Status: Version 1 – Approved. Version 2 – In Development.

Contact: Mark Morse, Washington State DOT

Issues : Interoperability and interchangeability cannot be guaranteed without a more restrictive approach in defining objects.

Implementations : Utah DOT.

6.2.1.12 NTCIP 1208 – Object Definitions for Video Switches

Defines the data to control a video switch to enable multiple monitors to view multiple video feeds.

Status: Version 1 – Approved.

Contact: Michael Forbis, Washington State DOT

Issues : Increased costs.

Implementations : No known implementations.

6.2.1.13 NTCIP 1209 – Object Definitions for Transportation Sensor Systems

Deals with the data collected by various types of detectors used by real-time management systems.

Status: Version 1 – Approved. Version 2 – In Development.

Contact:

Issues : Increased costs.

Implementations : No known implementations.

6.2.1.14 NTCIP 1210 – Field Management Stations (FMS) - Part 1: Object Definitions for Signal System Masters

Deals with the data used to control a field master.

Status: Version 1 – In Development.

Contact: Richard Denney, Iteris, Inc.

Issues : Increased costs.

Implementations : No implementations yet.

6.2.1.15 NTCIP 1211 – Object Definitions for Signal Control and Prioritization

Defines the data for controlling traffic signal systems in priority applications. Includes management of multiple requests and preferential treatment of different vehicle classes (e.g., transit vehicles versus first-responder vehicles). Coordinates with NTCIP 1202.

Status: Version 1 – Approved.

Contact: Ronald Atherley, King County DOT – Metro Transit

Issues :

Implementations : Testing by King County Metro (Seattle, WA).

6.2.1.16 NTCIP 1212 – Object Definitions for Network Camera Operations

Defines the data that are used with digital image cameras.

Status: In Development.

Contact: Michael Forbis, Washington State DOT

Issues :

Implementations : No known implementations.

6.2.1.17 NTCIP 1213 – Object Definitions for Electrical and Lighting Management Systems

Defines the data for roadside electrical and lighting management systems.

Status: Version 1 – In Development.

Contact: Karl Burkett, Texas DOT.

Issues :

Implementations : No known implementations.

6.2.1.18 NTCIP 2001 – Class B Profile

Defines the low bandwidth NTCIP communications protocol.

Status: Version 1, Amendment 1. To be rescinded by NTCIP 2201, NTCIP 2301, NTCIP 2101, and NTCIP 2102.

Contact: Robert De Roche, Robert De Roche Consulting

Issues : None.

Implementations : Many.

6.2.1.19 NTCIP 2002 – Class A and Class C Profile

Withdrawn.

Status: Withdrawn.

Contact: Robert De Roche, Robert De Roche Consulting

Issues : None.

Implementations : Various.

6.2.1.20 NTCIP 2101 – Point-to-Multipoint Protocol/RS232 Subnetwork Profile

Defines how to communicate over a multi-drop serial communications link.

Status: Version 1 – Published.

Contact: Robert De Roche, Robert De Roche Consulting.

Issues : None.

Implementations : Many.

6.2.1.21 NTCIP 2102 – Point-to-Multipoint Protocol/FSK Subnetwork Profile

Defines how to communicate over twisted wire using FSK modems.

Status: Version 1 – Published.

Contact: Robert De Roche, Robert De Roche Consulting.

Issues : None.

Implementations : Several.

6.2.1.22 NTCIP 2103 – Point-to-Point Protocol/RS232 Subnetwork Profile

Defines how to communicate over a dial-up link or other serial point-to-point link. Version 2 adds support and information for modems and telephone numbers.

Status: Version 2 – Published.

Contact: Robert De Roche, Robert De Roche Consulting.

Issues : None.

Implementations : Many.

6.2.1.23 NTCIP 2104 – Ethernet Subnetwork Profile

Defines how to communicate over ethernet links.

Status: Version 1 – Published.

Contact: Robert De Roche, Robert De Roche Consulting.

Issues : None.

Implementations : Various.

6.2.1.24 NTCIP 2201 – NTCIP Transport Profile

Defines a bandwidth efficient mechanism to transit data when the subject devices are directly connected and do not require network services.

Status: Version 1 – Published.

Contact: Robert De Roche, Robert De Roche Consulting.

Issues : None.

Implementations : Various.

6.2.1.25 NTCIP 2202 – Internet (TCP/IP & UDP/IP) Transport Profiles

A set of transport and network layer protocols to provide connectionless and connection-oriented transport services.

Status: Version 1 – Published.

Contact: Robert De Roche, Robert De Roche Consulting.

Issues : None.

Implementations : Various.

6.2.1.26 NTCIP 2301 – Simple Transportation Management Framework - Application Profile

A set of application, presentation, and session layer protocols to provide simple information management services. Version 2 includes changes required by NTCIP 1101 Amendment 1, NTCIP 1103, and NTCIP 8003.

Status: Version 1 – Published. Version 2 – In Development.

Contact: Robert De Roche, Robert De Roche Consulting.

Issues : None.

Implementations : Various.

6.2.1.27 NTCIP 2302 – Trivial File Transfer Protocol - Application Profile

Defines how to use the Trivial File Transfer Protocol within transportation networks. Provides connectionless file transfer services.

Status: Version 1 – Published.

Contact: Robert De Roche, Robert De Roche Consulting.

Issues : None.

Implementations : Few.

6.2.1.28 NTCIP 2303 – File Transfer Protocol - Application Profile

Defines how to use the File Transfer Protocol within transportation networks. Provides connectionless file transfer services.

Status: Version 1 – Published.

Contact: Robert De Roche, Robert De Roche Consulting.

Issues : None.

Implementations : Few.

6.2.1.29 NTCIP 2304 – Data Exchange (DATEX) - Application Profile

Defines how to use the DATEX-ASN protocol within US-based transportation networks.

Status: Version 1 – Published.

Contact: Manny Insignares, ConSysTec.

Issues : New implementations will likely use XML instead of DATEX.

Implementations : Various.

6.2.1.30 NTCIP 2305 – CORBA - Application Profile

Defines how to use the Common Object Request Broker Architecture protocol within US-based transportation networks.

Status: Version 1 - Development on hold.

Contact: Manny Insignares, ConSysTec.

Issues : CORBA is no longer supported.

Implementations : Few.

6.2.1.31 NTCIP 2306 – Application Profiles for XML Message Encoding and Transport in ITS Center to Center Communications

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.

Status: Version 1 - Approved.

Contact: Manny Insignares, ConSysTec.

Issues : None.

Implementations : Various.

6.2.1.32 NTCIP 7001 – InP-DATEX

Defines what services are required within DATEX centers to determine what messages and data the center supports.

Status: Development on hold.

Contact: Manny Insignares, ConSysTec.

Issues : New implementations will likely use XML instead of DATEX.

Implementations : None.

6.2.1.33 NTCIP 7002 – InP-CORBA

Defines what CORBA services are required in ITS systems.

Status: Development on hold.

Contact: Manny Insignares, ConSysTec.

Issues : None.

Implementations : CORBA is no longer supported.

6.2.1.34 NTCIP 2801 – SEP for Communications Profile

Defines the systems engineering process content for the NTCIP subnetwork and transport profiles.

Status: Version 1 – In Development.

Contact: Robert De Roche, Robert De Roche Consulting.

Issues : None.

Implementations : CORBA is no longer supported.

6.2.1.35 NTCIP 8004 – Information Report – Structure and Identification of Management Information.

Defines how NTCIP defines and registers its data, including how the SNMP MIB information is mapped into the ITS Data Registry.

Status: Version 1 – In Balloting.

Contact: Robert De Roche, Robert De Roche Consulting.

Issues : None.

Implementations : Not Applicable.

6.2.1.36 NTCIP 8007 – Information Report – Testing Guide for Users.

Defines the rules and guidelines to be used by the other NTCIP working groups when they produce NTCIP test documentation. This document is not intended for use directly by manufacturers or public agencies that may procure NTCIP equipment; rather, it is intended to promote a consistent look and feel of NTCIP testing documentation throughout the various NTCIP standards.

Status: Version 1 – In Balloting.

Contact: Steve Dellenback, SWRI; Joe Stapleton, URS Corp.

Issues : None.

Implementations : Not Applicable.

6.2.1.37 NTCIP 9001 – NTCIP Guide

Provides an overview of NTCIP. The various chapters of the Guide provide various levels of detail, from the high level view to the implementer's perspective.

Status: Version 2 – Published. Version 3 – In Development.

Contact: NTCIP Coordinator – Bruce Schopp, NEMA.

Issues : Focus is primarily on center to field communications.

Implementations : Not Applicable.

6.2.1.38 NTCIP 9010 – Information Report – Using XML in Center-to-Center Communications

General information report describing future XML-based standards development efforts.

Status: Version 1 – Published.

Contact: Manny Insignares, ConSysTec.

Issues : None.

Implementations : Not Applicable.

6.2.1.39 NTCIP 9012 – Information Report – Testing Guide for Users.

A User's Guide to help an Agency define a testing process that will assist in the testing of devices that incorporate the NTCIP standards.

Status: Version 1 – In Development.

Contact: Steve Dellenback, SWRI; Joe Stapleton, URS Corp.

Issues : None.

Implementations : Not Applicable.

6.2.2 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).

6.2.2.1 ANSI TS284 – Commercial Vehicle Safety Reports

An electronic data interchange (EDI) transaction set to allow authorized parties to electronically request and send reports on information related to the safe operation of commercial road vehicles, such as inspection reports, safety and compliance review reports, and hazardous material incident reports.

Status: Published.

Contact: The John Hopkins University Applied Physics Laboratory

Issues :

6.2.2.2 ANSI TS285 – Commercial Vehicle Safety and Credentials Information Exchange

An electronic data interchange (EDI) transaction set to permit enforcement officials, government administrators and other authorized parties to retrieve information electronically on the safety performance, regulatory compliance, and credentials status of commercial motor vehicles, carriers, and drivers.

Status: Published.

Contact: The John Hopkins University Applied Physics Laboratory

Issues :

6.2.2.3 ANSI TS286 – Commercial Vehicle Credential

An electronic data interchange (EDI) transaction set that can be used by owners, leasers, and drivers of commercial motor vehicles to apply electronically for credentials necessary to legally operate those vehicles, and by authorizing jurisdictions to electronically transmit credential data to applicants and other authorized entities.

Status: Published.

Contact: The John Hopkins University Applied Physics Laboratory

Issues :

6.2.3 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.

6.2.3.1 Transit Communications Interface Profiles (TCIP)

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. These dialogs allow TCIP components to exchange information using standardized mechanisms.

The TCIP profile is divided into 10 business areas as follows:

1. Common Public Transport
2. Scheduling
3. Passenger Information
4. Incident Management
5. TCIP Tool Support
6. On-board Systems
7. Control Center
8. Fare Collection
9. Spatial Representation
10. Transit Signal Priority

Status: Version 2.8 in ballot.

Contact: Richard Ayers, ARINC

Issues :

Implementation: South Korea, limited in the US.

6.2.3.2 UFTS-xxx – Universal Transit Farecard Standard

Defines the interfaces needed to support regional fare cards.

Status: Under development.

Contact: Tom Parker, BART

Issues :

Implementation: No known implementations.

6.2.4 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.

6.2.4.1 ASTM WK7604 – Standard Specification for Archiving ITS-Related Traffic Monitoring Data

Specifies a data dictionary for archiving traffic data. Provides definitions of the data elements to be archived from ITS traffic management systems, their interrelationships, and the procedures and methodologies for collection and calculation of traffic statistics. Specifies the rules and definitions for moving that data from the traffic systems to the ADMS. In addition, specifies the logical database schema of the ADMS to support integration of ITS-generated data with conventional traffic count data.

Status: Version 1 – In development.

Contact: Rich Margiotta, Cambridge Systematics

Issues :

Implementation: No known implementations.

6.2.4.2 E2158-01 – Standard Specification for Dedicated Short Range Communications (DSRC) Physical Layer Using Microwave in the 902-928 Mhz Band

Specification for the RF characteristics (physical layer) for DSRC operating in the range of 902-928 MHz. Comprises the requirements for the physical (i.e., electrical and mechanical) interfaces and the transmission medium (i.e., air) in the 902 to 928 MHz location and monitoring service (LMS) band. This standard provides information for onboard equipment based on both active and backscatter technologies and allows for interoperability between systems based on either of these technologies.

Status: Published Standard

Contact: Dan Smith, ASTM

Issues :

Implementation: No known implementations.

6.2.4.3 E2213-03 - Standard Specification for Telecommunications and Information Exchange Between Roadside and Vehicle Systems - 5 GHz Band Dedicated Short Range Communications (DSRC) Medium Access Control (MAC) and Physical Layer (PHY) Specifications

A medium access control layer (MAC) and physical layer (PHY) specification for wireless connectivity using dedicated short-range communications (DSRC) services. This standard defines the operating parameters required to implement a high-speed data transfer service in the 5.9-GHz Intelligent Transportation Systems Radio Service (ITS-RS) band.

Status: Published Standard.

Contact: Dan Smith, ASTM

Issues :

Implementation: No known implementations.

6.2.4.4 E2259-03 – Standard Guide for Archiving and Retrieving ITS-Generated Data

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.

Status: Published.

Contact: Rich Margiotta, Cambridge Systematics

Issues :

Implementation: Not Applicable.

6.2.4.5 E2468-05 – Standard Practice for Metadata to Support Archived Data Management Systems

Establishes the recommended metadata framework for archived data management systems and provide additional commentary and examples to assist ADMS developers and users. Using metadata to organize the flood of information that could potentially be archived from ITS systems helps users understand which data applies to them and whether it is appropriate for their particular application or analysis.

Status: Published.

Contact: Rich Margiotta, Cambridge Systematics

Issues :

Implementation: Not Applicable.

6.2.5 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.

6.2.5.1 EIA-794 – Data Radio Channel (DARC) System

Specifies the DARC FM Subcarrier waveform for the delivery of traveler information, messages and data services to mobile, portable and fixed receivers.

Status: Published.

Contact: Jean Johnson, CEA

Issues :

Implementation: No known implementations.

6.2.5.2 EIA-795 – Subcarrier Traffic Information Channel (STIC) System

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. Supports ATIS message sets (SAE J2359), emergency alert system messages defined by CFR Title 47, Part 11; and Retransmission of Radio Broadcast Data System data.

Status: Published.

Contact: Jean Johnson, CEA

Issues :

Implementation: No known implementations.

6.2.6 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.

6.2.6.1 IEEE SH94633-SH94638 – The Survey and Analysis of Existing Standards and those Under Development Applicable to the Needs of the ITS Communications Technologies

The survey and analysis of existing standards (and those under development) that include requirements for both wireline and wireless transmissions.

Status: Published.

Contact: Patricia Gerdon, IEEE

6.2.6.2 P1609.1 – Standard for Wireless Access in Vehicular Environments (WAVE) - Resource Manager

The WAVE standards define an architecture and a complementary, standardized set of services and interfaces that collectively enable secure vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) wireless communications. Together these standards provide the foundation for a broad range of applications in the transportation environment, including vehicle safety, automated tolling, enhanced navigation, traffic management and many others.

The P1609.1 standard describes a resource manager that arbitrates requests for transponder usage. It specifies the services and interfaces of the WAVE Resource Manager application. It describes the key components of the WAVE system architecture and defines data flows and resources at all points. It also defines command message formats and data storage formats that must be used by applications to communicate between architecture components, and specifies the types of devices that may be supported by the On Board Unit (OBU) resident on the vehicle or mobile platform.

Status: In Ballot.

Contact: Tom Kurihara, TKstd Management

6.2.6.3 P1609.2 – Standard for Wireless Access in Vehicular Environments (WAVE) - Application Layer

Describes an application layer standard to be used for 5.9 GHz DSRC. Defines secure message formats and processing, and the circumstances for using secure message exchanges and how those messages should be processed based upon the purpose of the exchange.

Status: In Ballot.

Contact: Tom Kurihara, TKstd Management

6.2.6.4 P1609.3 – Standard for Wireless Access in Vehicular Environments (WAVE) – Networking Services

Describes standard that supports higher layer communication stacks, including TCP/IP. Defines network and transport layer services, including addressing and routing, in support of secure WAVE data exchange. It also defines Wave Short Messages, providing an efficient WAVE-specific alternative to IPv6 (Internet Protocol version 6) that can be directly supported by applications. Further, this standard defines the Management Information Base (MIB) for the WAVE protocol stack.

Status: In Ballot.

Contact: Tom Kurihara, TKstd Management

6.2.6.5 P1609.4 – Standard for Wireless Access in Vehicular Environments (WAVE) – Multi-Channel Operations

Describes various standard message formats for DSRC applications at 5.9 GHz. It provides enhancements to the IEEE 802.11 Media Access Control (MAC) to support WAVE operations.

Status: In Ballot.

Contact: Tom Kurihara, TKstd Management

6.2.6.6 Std 1455-1999 – Standard for Message Sets for Vehicle/Roadside Communications

Standard messages for commercial vehicle, electronic toll, and traffic management applications. Provides the basis for interoperable, non-interfering DSRC implementations using equipment from multiple vendors.

Status: Published.

Contact: Patricia Gerdon, IEEE

6.2.6.7 Std 1488-2000 – Standard for Message Set Template for Intelligent Transportation Systems

A standard for an ITS message set template. This message set template standard provides the basic structure, or framework, and syntax for specifying message sets.

Status: Published.

Contact: Patricia Gerdon, IEEE

6.2.6.8 Std 1489-1999 – Standard for Data Dictionaries for Intelligent Transportation Systems - Part 1 Functional Area Data Dictionaries

Establishes a national standard for defining data concepts, allowing transportation systems to interoperate. 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.

Status: Published.

Contact: Patricia Gerdon, IEEE

6.2.6.9 Std 1512-Base –Common Incident Management Message Sets for use by Emergency Management Centers

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).

Status: Version 1 - Published. Version 2 – In Ballot.

Contact: Ann Lorscheider, NCDOT

Implementations:

6.2.6.10 Std 1512.1 –Traffic Incident Management Message Sets for Use by Emergency Management Centers

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.

Status: Version 1 - Published. Version 2 – In Ballot.

Contact: Ann Lorscheider, NCDOT

Implementations:

6.2.6.11 Std 1512.2 – Public Safety Incident Management Message Sets for Use by Emergency Management Centers

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.

Status: Version 1 - Published.

Contact: Ann Lorscheider, NCDOT

Implementations:

6.2.6.12 Std 1512.3 –Hazardous Material Incident Management Message Sets for Use by Emergency Management Centers

Enables consistent standardized communications among incident management centers, HAZMAT teams, police, local government, special emergency and emergency management centers.

Status: Version 1 - Published. Version 2 – In Ballot.

Contact: Ann Lorscheider, NCDOT

Implementations:

6.2.6.13 Std 1512.4 –Common Traffic Incident Management Message Sets for Use in Entities External to Centers

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.

Status: In Ballot.

Contact: Ann Lorscheider, NCDOT

Implementations:

6.2.6.14 Std 1570-2002 – Standard for the Interface Between the Rail Subsystem and the Highway Subsystem at a Highway Rail Intersection

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.

Status: Published.

Contact: Patricia Gerdon, IEEE

Implementations:

6.2.7 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.

6.2.7.1 9603-1 – Application Program Interface (API) Standard for the Advanced Transportation Controller (ATC)

An advanced transportation controller (ATC) software application program interfaces (APIs) that support ITS data flows and standards enabling the deployment of ITS functions.

Status: In Development.

Contact:

Implementations:

6.2.7.2 9603-2 – Advanced Transportation Controller (ATC) Cabinet

Functional physical design requirements for an advanced transportation controller (ATC) cabinet that supports the deployment of multiple ITS functions in a single cabinet.

Status: Version 1 - Published. Amendment 1 – In Ballot.

Contact:

Implementations:

6.2.7.3 9603-3 – Advanced Transportation Controller (ATC)

Standard for advanced transportation controller (ATC) devices to support ITS data flows and standards that enable deployment of ITS. Capable of operating in the ATC cabinet and using the ATC application program interfaces.

Status: In Ballot.

Contact:

Implementations:

6.2.7.4 TM 2.1 – Standards for Traffic Management Center to Center Communications

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.

Status: Version 2.1 - Approved. Version 3.0 – In Development.

Contact: Robert G. Rausch, TransCore

Implementations:

6.2.8 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.

6.2.8.1 SAE-J1663 – Truth-in-Labeling Standard for Navigation Map Databases

This standard defines consistent terminology, metrics, and tests for describing the content and quality of navigable map databases. Supports the navigation applications that automotive manufacturers and suppliers are currently developing for marketplace delivery.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.2 SAE-J1708 – Serial Data Comm. Between MicroComputer Systems in Heavy-Duty Vehicle Applications

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.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.3 SAE-J1746 – ISP-Vehicle Location Referencing 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).

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.4 SAE-J1757 – Standard Metrology for Vehicular Displays

Provides methods to determine display optical performance in all typical automotive ambient light illumination, including indoor measurements and simulated outdoor lighting. Provides recommended threshold values for automotive compliance as reference.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.5 SAE-J1760 – ITS Data Bus Data Security Services

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.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.6 SAE-J1761 – Information Report on ITS Terms and Definitions

A dictionary of terminology in the ITS field, with a focus on the vehicle and interfaces to the vehicle.

Status: Published Standard.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.7 SAE-J1763 – A Conceptual ITS Architecture: An ATIS Perspective

This Information Report describes a general reference architecture for integration of multiple advanced traveler information system (ATIS) devices.

Status: Published Standard.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.8 SAE-J2266 – Location Referencing Message Specification (LRMS)

Standardizes location referencing for ITS applications that require the communication of spatial data references between databases. ITS databases may reside in central sites, vehicles, or devices on or off roads or other transportation links. The LRMS is applicable to both homogeneous (same database) and mixed database environments that may be implemented on wireless or landline networks. While developed for ITS applications, the

LRMS may be used for non-ITS applications as well within the field of geographic information processing.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.9 SAE-J2313 – On-Board Land Vehicle Mayday Reporting Interface

A general specification that prescribes protocol methods which enable vendors with different communication methods to communicate with response agencies in a standard format. Intended for use by private industries (e.g., manufacturers) and public safety and emergency response agencies (at primary safety answering points (PSAPs)).

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.10 SAE-J2352 – Mayday Industry Survey Information Report

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.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.11 SAE-J2353 – Data Dictionary for Advanced Traveler Information Systems (ATIS)

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.

Status: Published. Folded into SAE J2354.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.12 SAE-J2354 – Message Set for Advanced Traveler Information System (ATIS)

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. The standard provides two basic types of ATIS, based on whether or not the traveler (data consumer) interacts with the traveler information provider (data provider). One-way communication of traveler information includes predefined information broadcast to travelers, such as radio and TV broadcasts and some web pages. Two-way, transactional traveler information includes all means whereby the traveler makes specific, personalized requests and receives customized information.

Status: Version 2 - Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.13 SAE-J2355 – ITS Data Bus Architecture Reference Model Information Report

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.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.14 SAE-J2365 – Calculation of the Time to Complete In-Vehicle Navigation and Route Guidance Tasks

Guidelines for the implementation of specific man-machine interface transactions and classes of transactions.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.15 SAE-J2366-2 – ITS Data Bus Protocol - Link Layer

Requirements for the link layer (layer 7 of the OSI model) for the ITS data bus.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.16 SAE-J2366/1 – ITS Data Bus Protocol - Physical Layer

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.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.17 SAE-J2366/1L – ITS Data Bus Protocol – Low Impedance Stereo Audio

Describes the Low Impedance Stereo Audio (LISA) bus, which may be used in conjunction with the Physical Layer of the IDB-C, as described in SAE J2366-1. The audio arbitration messages used to control access to the LISA bus are specified in SAE J2366-7. The IDB-C is a non-proprietary virtual token passing bus, designed to allow disparate consumer, vehicle, and commercial electronic components to communicate and share information.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.18 SAE-J2366/4 – ITS Data Bus Protocol – Thin Transport Layer

Requirements for the thin transport layer (Layer 4 of the OSI model) for the ITS data bus.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.19 SAE-J2366/7 – ITS Data Bus Protocol – Application Layer

Requirements for the application layer (Layer 7 of the OSI model) for the ITS data bus.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.20 SAE-J2369 – Standard for ATIS Message Sets Delivered Over Reduced Bandwidth Media

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.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.21 SAE-J2372 – Field Test Analysis Information Report

This information report presents the results of field tests on location-referencing standards.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations: Not Applicable.

6.2.8.22 SAE-J2373 – Stakeholders Workshop Information Report

Results of workshops to solicit and discuss stakeholder requirements for location referencing standardization.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations: Not Applicable.

6.2.8.23 SAE-J2374 – Location Referencing Message Specification (LRMS)

A basis for location referencing standardization activities by various application communities and SDOs. Intended to provide a practical approach to standardization for location referencing within a mixed data set environment, i.e., where more than one kind of spatial data set exists, and where spatial references between these data sets must be made.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.24 SAE-J2395 – ITS In-Vehicle Message Priority

Specifies orderly temporal and spatial presentation of ITS information to the driver.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.25 SAE-J2396 – Definitions and Experimental Measures Related to the Specification of Driver Visual Behavior Using Video Based Techniques

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.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.26 SAE-J2399 – Adaptive Cruise Control: Operating Characteristics and User Interface

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.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.27 SAE-J2400 – Forward Collision Warning: Operating Characteristics and User Interface

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.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.28 SAE-J2529 – Rules for Standardizing Street Names and Route IDs

Specifies the rules for standardizing street names for use in ATIS and other ITS applications.

Status: Approved.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.29 SAE-J2539 – Comparison of GATS Messages to SAE ATIS Standards Information Report

An overview and comparison of Global Automotive Telematics Standard (GATS) messages developed for use on global system mobile (GSM) cellular phone systems (European).

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.30 SAE-J2540 – Messages for Handling Strings and Look-Up Tables in ATIS Standards

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.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.31 SAE-J2540/1 – RDS (Radio Data System) Phrase List

Provides a table of textual messages meeting the requirements for expressing "Radio Data Systems" (RDS) phrases commonly used in the ITS industry. They can be used both over the RDS subcarrier transmission media as part of a 37-bit long "Group 8a message" as well as being used to provide a common content list of phrases used in a wide number of other media and applications.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.32 SAE-J2540/2 – ITIS (International Traveler Information Systems) Phrase Lists

Provides a table of textual messages meeting the requirements for expressing "International Traveler Information Systems" (ITIS) phrases commonly used in the ITS industry. The tables provided herein follow the rules of SAE J2540 and therefore allow a local representation in various different languages, media expressions etc., to allow true international use of these phrases. The phrases are predominantly intended for use in the description of traffic related events of interest to travelers and other traffic practitioners.

Status: Version 1, Amendment 1 - Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.33 SAE-J2540/3 – National Names Phrase List

This SAE Standard provides a table of textual messages meeting the requirements for expressing the names of street and roads and some basic building blocks for phrases commonly used in the ITS industry.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.34 SAE-J2630 – Converting ATIS Message Standards from ASN.1 to XML

Presents a set of rules for transforming an Abstract Syntax Notation (ASN.1) message set definition into an eXtensible Markup Language (XML) schema. The result is intended to be a stand-alone XML Schema that is fully consistent with an existing ASN.1 information model.

Status: Published.

Contact: Jack Pokrzywa, SAE

Implementations:

6.2.8.35 SAE-J2735 – Standard for Data Dictionary and Message Sets for DSRC

This standard will assure that DSRC applications will be interoperable. Applications such as collision avoidance, emergency vehicle warnings, and signage require this standard before they can be effective.

Status: In Development.

Contact: Jack Pokrzywa, SAE

Implementations:

6.3 National ITS Standards Testing Activities

This section summarizes some of the activities that are on-going in the area of standards testing. It provides a review of the current status of FHWA's ITS Standards Testing activities, standards testing activities by the SDOs, and activities by other groups.

6.3.1 FHWA 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.

6.3.1.1 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 produces 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.

Three testing evaluations of ITS Standards were completed:

- NTCIP 1203 - Dynamic Message Sign (DMS) implementation (formerly NTCIP TS3.6), with variable message signs from two different sign vendors
- NTCIP 1204 – Environmental Sensor Station (ESS) implementation
- NTCIP 1207 – Ramp Metering control

The full test reports for NTCIP 1203 and NTCIP 1204 are available at the US DOT Standards web site. The test report for NTCIP 1207 is not available to the public yet.

6.3.1.2 Test Report Summary – Dynamic Message Signs

During this evaluation, Battelle examined an implementation of NTCIP 1203 in March 2000, with two (2) different vendors. Battelle reviewed 19 core functions and features in the NTCIP 1203 Standard and 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. Since the test report, an amendment (Amendment 1) to the NTCIP 1203 has been approved since the time of the report, which clarifies the ambiguity of the scheduler functions and several other functions.

6.3.1.3 Test Report Summary - Environmental Sensor Stations

In this evaluation, Battelle 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. Amendment 1 and Version 2 of the NTCIP 1204 has been approved since the time of the report.

6.3.1.4 Test Report Summary - Ramp Metering

Examined an implementation of NTCIP 1207 in June 2005.

The conclusion of the test team is that NTCIP 1207 is suitable and effective. However, the test report did note that interoperability and interchangeability using the standard cannot be guaranteed without a more restrictive approach in defining objects. The NTCIP Working Group for the standard has evaluated the report and is updating the standard.

6.3.2 Testing and Conformity Assessment (TCA) NTCIP Working Group

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 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 9012 – Information Report – NTCIP Testing Guide for Users

6.3.2.1 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 document defines the process, the rules, and the guidelines for completing that activity. This document is currently in balloting.

6.3.2.2 NTCIP 9012 – NTCIP Testing Guide for Users

This document is a guide for testing ITS Standards as part of an overall testing program. The document considers issues such as types of testing, testing requirements, testing extended functionality, and testing documentation. This document is currently in development, but a user comment draft is available.

6.4 West Virginia ITS Standards Activities

This section reviews current West Virginia efforts and contracts in deploying ITS systems.

In reviewing the available information, we have identified three current efforts and projects that can be standards-based. These efforts and projects are:

- Traffic Signal Controllers
- Portable Dynamic Message Signs
- Fog Sensors

6.4.1 Traffic Signal Controllers

West Virginia Division of Highways currently operates and/or maintains approximately 3,000 traffic signal controllers in the State. These traffic signal controllers consists of various closed-loop systems, and isolated intersections. Traffic signal controllers are mostly Eagle and Econolite NEMA TS-1 controllers, using each manufacturer's respective, proprietary communications protocols. Most controller cabinets are also NEMA TS-1 cabinets, although there are some NEMA TS-2 cabinets. WV DOH is continuously replacing and adding new traffic signal controllers as the need warrants it.

Communications from traffic management centers to the field masters and the traffic signal controllers are generally via dial-up telephone lines, with some using frequency-shift key (FSK) modems.

Both Eagle Traffic Control Systems and Econolite Control Products offer NEMA TS controllers (generally NEMA TS-2) that support both their respective proprietary communications protocols and the NTCIP protocols. Selection of the protocol to be used involves changing the firmware that is installed on the controller, allowing a controller to initially use the manufacturer's proprietary protocol, then with a firmware change, allows the controller to use the NTCIP protocol.

Several ITS standards may be applicable for the communications between these traffic signal controllers and traffic control centers. These ITS standards include:

- NTCIP 2102 – NTCIP Subnetwork Profile – PMPP/FSK, Version 1.

- NTCIP 2103 – NTCIP Subnetwork Profile – PPP/RS232, Version 2.
- NTCIP 2201 – NTCIP Transport Profile – Transportation Transport Profile, Version 1.
- NTCIP 2301 – NTCIP Application Profile - Simple Transportation Management Framework (STMF), Version 1. Version 2 if approved.
- NTCIP 1201 – Global Objects Definition, Version 2.
- NTCIP 1202 – Object Definitions for Actuated Signal Controllers, Version 2.
- NTCIP 1210 – Object Definitions for Signal System Masters, Version (Draft).

6.4.2 Portable Dynamic Message Signs

WV DOH currently owns and operates several portable dynamic message signs throughout the state. These portable message signs are usually deployed in construction work zones. Communications with a central computer, if any, is usually via a wireless dial-up modem.

Several ITS standards may be applicable for the communications between these portable dynamic message signs and traffic control centers. These ITS standards include:

- NTCIP 2103 – NTCIP Subnetwork Profile – PPP/RS232, Version 2.
- NTCIP 2201 – NTCIP Transport Profile – Transportation Transport Profile, Version 1.
- NTCIP 2301 – NTCIP Application Profile - Simple Transportation Management Framework (STMF), Version 1. Version 2 if approved.
- NTCIP 1201 – Global Objects Definition, Version 2.
- NTCIP 1203 – Object Definitions for Dynamic Message Signs, Version 1, Amendment 1.

For permanent dynamic message signs, the following ITS standards may also be considered in addition to the above ITS standards:

- NTCIP 2101 – NTCIP Subnetwork Profile – PMPP/RS232, Version 1.
- NTCIP 2104 – NTCIP Subnetwork Profile – Ethernet, Version 1.
- NTCIP 2202 – NTCIP Transport Profile – Internet (TCP/IP & UDP/IP), Version 1.

6.4.3 Fog Sensors

WV DOH is currently evaluating a fog sensor system. Communications is expected to initially be wireless communications.

Several ITS standards may be applicable for the communications between a fog system and traffic control centers. These ITS standards include:

- NTCIP 2101 – NTCIP Subnetwork Profile – PMPP/RS232, Version 1.
- NTCIP 2103 – NTCIP Subnetwork Profile – PPP/RS232, Version 2.
- NTCIP 2104 – NTCIP Subnetwork Profile – Ethernet, Version 1.
- NTCIP 2201 – NTCIP Transport Profile – Transportation Transport Profile, Version 1.
- NTCIP 2202 – NTCIP Transport Profile – Internet (TCP/IP & UDP/IP), Version 1.
- NTCIP 2301 – NTCIP Application Profile - Simple Transportation Management Framework (STMF), Version 1. Version 2 if approved.
- NTCIP 1201 – Global Objects Definition, Version 2.
- NTCIP 1204 – Object Definitions for Environmental Sensor Stations, Version 1, Amendment 1.

6.4.4 CCTV Cameras

WV DOH is planning to procure CCTV cameras to monitor its roadway network. There are several key factors in the design of the CCTV camera system. They include:

- If pan, tilt, zoom capabilities are needed
- If color images are needed
- The available communications bandwidth to transmit back images.

Each of these contribute to the cost of the CCTV camera network. Only the pan, tilt, and zoom, and other functional capabilities determine if a standards-based CCTV system should be used.

Several ITS standards may be applicable for the communications between CCTV cameras and traffic control centers. These ITS standards include:

- NTCIP 2101 – NTCIP Subnetwork Profile – PMPP/RS232, Version 1.
- NTCIP 2103 – NTCIP Subnetwork Profile – PPP/RS232, Version 2.
- NTCIP 2104 – NTCIP Subnetwork Profile – Ethernet, Version 1.
- NTCIP 2201 – NTCIP Transport Profile – Transportation Transport Profile, Version 1.
- NTCIP 2202 – NTCIP Transport Profile – Internet (TCP/IP & UDP/IP), Version 1.
- NTCIP 2301 – NTCIP Application Profile - Simple Transportation Management Framework (STMF), Version 1. Version 2 if approved.

- NTCIP 1201 – Global Objects Definition, Version 2.
- NTCIP 1204 – Object Definitions for CCTV Camera Control, Version 1.
- NTCIP 1212 – Object Definitions for Network Camera Operations.

6.5 Recommendations

It is recommended that WVDOT actively participate in one of the standards working groups that it is interested in. By its active participation, WVDOT can make its needs known to the working groups that develop the standards, and help shape the standards so that it supports WVDOT's needs.

USDOT recognizes that public agency is involvement is important to the standards development process, particularly in defining its needs. Thus, USDOT has provided funds for public sector employees to attend and participate in the standards development groups.

In addition, it is recommended that WVDOT communicate the contact person for any ITS Standard that it may be interested in. Many of the standards maintain a list server that inform interested parties, by e-mail, of the progress and developments for the standard, including upcoming teleconferences and meetings.

USDOT also provides technical assistance and training and outreach to states and regions, including several courses, that can be provided to the state. More information about these activities can found on the USDOT standards website, at http://www.standards.its.dot.gov/default.asp.

At the appropriate time, WVDOT should contact US DOT for training in applicable areas. Because of certain requirements regarding costs and class size, WVDOT may wish to share the costs and logistics of these costs with a neighboring state.

The remainder of this section provides specific recommendations in areas where there are specific WVDOT activities.

6.5.1 Traffic Signal Control Systems

ITS Standards for traffic signal control systems are relatively mature. Several implementations do exist throughout the United States, and most, if not all, major vendors do support the ITS Standards. Admittedly, interoperability, the ability to operate traffic signal controllers from different vendors on the same system, has been difficult to achieve, but is possible.

It is recommended that WV DOH develop a plan to test and migrate their existing and new proprietary traffic control systems to a system that supports the ITS Standards. Several current factors regarding WV DOH's business processes and configuration makes this a realistic possibility.

- WV DOH operates and maintains several isolated traffic control systems and signalized intersections throughout the state. This allows small and controllable initial testing and implementation of standards-based systems without affecting other signal systems.

- Manufacturers now offer traffic signal controllers that support both their proprietary communications protocol and the standards-based (NTCIP) protocols. Thus, controllers can be deployed with the proprietary protocol, and remain controlled by the existing traffic control software, then simultaneously switched over to the standards-based protocol when the other controllers (in the system or area) with the standards-based protocol are deployed.
- WV DOH is slowly adding new and replacing existing traffic control systems and traffic controllers anyway. Since this is part of their normal maintenance and operations anyway, purchasing traffic signal controllers that support the vendor-proprietary and standards-based protocols is an incremental cost.
- WV DOH is considering building a 24/7 Statewide traffic operations center that would ultimately monitor and operate all WV DOH traffic signal control systems during nights and weekends. This consideration increases the benefit value of using standards-based products, since this would decrease the number of (different) traffic control systems the operations center must support.

Some of the benefits of migrating to standards-based traffic control systems include:

- WV DOH would not be "married" to a particular vendor or vendors. Once a traffic control system, particularly closed-loop systems, using a proprietary communications protocol is in place, WV DOH must use that same vendor when adding or replacing signal controllers to that system. With a standards-based system, signal controllers from different vendors can be added to that system. This can ultimately lead to favorable pricing for WV DOH.
- With a standards-based traffic control system, support for only one communications protocol is needed to operate and monitor traffic control systems. Otherwise, support for multiple (proprietary) communications protocols is needed at an operations center that operates multiple traffic control systems or signalized intersections, making design of the traffic operations center more complex.

Some barriers to successful implementation of the ITS Standards for traffic signal control systems include:

- Initially more expensive. Currently, standards-based products may be more expensive than proprietary systems, particularly products that must support both proprietary protocols and standards-based protocols. With standards-based products, purchasing agencies are also buying some functionality that are required by the standards, which the agency may never use or need. There is also the additional expense of buying new software and equipment to test, operate, and maintain the new products.

- Learning curve. As with any new products, there is a learning curve involved to properly test, operate and maintain the product. Because of the availability of isolated traffic control systems and signalized intersections, WV DOH can carefully test, operate and maintain the new products at a measured pace without little fear of affecting a larger area.
- The standard for Signal System Masters is not available yet. Thus, closed loop systems that uses a field master cannot be replaced with a standards-based system at this time.

Despite these barriers, it is still recommended that WV DOH develop a plan to test and transition to the use of standards-based traffic signal control systems. The ITS Standards that may be applicable for WV DOH for traffic signal control systems has been listed in Section 6.4.1.

WV DOH is also considering installing its own optical fiber network. If traffic signal controllers may use this optical fiber network for communications, and ethernet communications is considered, the traffic signal control system should also support the following ITS Standards:

- NTCIP 2104 – NTCIP Subnetwork Profile – Ethernet, Version 1.
- NTCIP 2201 – NTCIP Transport Profile – Internet (TCP/IP & UDP/IP), Version 1.

6.5.2 Portable Dynamic Message Signs

ITS Standards for dynamic message signs, which includes portable signs, are probably the most mature of all the ITS Standards. There are many implementation of dynamic message signs throughout the United States, including several outside the United States also. All the major vendors support the standards, and interoperability, the ability to control multiple vendor's signs using the same software, has met with some success.

WV DOH is planning to deploy dynamic message signs throughout the state in the near future. It is recommended that WV DOH procure only standards-based dynamic message signs, beginning with the portable dynamic message signs.

The benefits of using standards-based dynamic message signs is similar to that of using standards-based traffic control systems. They include:

- WV DOH would not be "married" to a particular vendor or vendors.
- With standards-based dynamic message signs, support for only one communications protocol is needed to operate and monitor dynamic message signs.

In addition, there is less risk involved with deploying the standards for DMS than traffic signal control systems because:

- Standards for dynamic message signs is more mature

- Many successful implementations exist
- Support for these standards is more widespread
- No existing permanent dynamic message signs in the state, so there are no current operations or maintenance that have to be changed, nor are there existing implementations that have to be simultaneously supported.

The main dis-benefit for procuring standards-based dynamic message signs is that initially the costs will be slightly higher than proprietary-based dynamic message signs. However, it is expected that the benefits will outweigh the initial additional costs.

It is recommended that WV DOH begins its experience with standards-based dynamic message signs by procuring standards-based portable dynamic message signs. Starting with portable dynamic message signs has the following advantages:

- WV DOH is already purchasing portable dynamic message signs. Thus, it has experience with what the needs are, and a process for procuring is in place.
- Portable dynamic message signs generally require only a subset of functionality that are available by full-size, fixed dynamic message signs. Thus, WV DOH can gain its experience with standards-based dynamic message signs with using and supporting only the core functions of the full ITS standards for dynamic message signs, without worrying about the additional functions that may be required by the permanent, full-size dynamic message signs.

The ITS Standards that may be applicable for WV DOH for dynamic message signs has been listed in Section 6.4.2.

6.5.3 Fog Systems

Fog sensors, or the ability to detect fog, are supported by the ITS Standards for roadway weather information systems (RWIS). Visibility is one of the functions supported by RWIS systems, in addition to weather condition detection, and roadway pavement measurements. There are several implementations of roadway weather information systems throughout the United States, and most of the major vendors support the standards. There are no known implementations where an agency operate multiple vendor's RWIS systems using the same communications channel.

Since WV DOH is considering deploying fog sensors, it is recommended that WV DOH consider using standards-based communications if it deploys fog sensors. The benefits of using a standards-based fog system include:

- WV DOH would not be "married" to a particular vendor or vendors.
- With a standards-based fog system, specifically RWIS systems, support for only one communications protocol is needed to operate and monitor RWIS field equipment.

- The communications system is a significant cost when deploying ITS systems, particularly for WV DOH, where many field devices will be remotely located. Using the ITS Standards, communications costs can be decreased because the NTCIP standard allows multiple devices using NTCIP communications to use and share the same communications channel. So, only one communications drop is needed for a field cabinet that contains both a fog system and another device using NTCIP, for example, a CCTV camera or dynamic message sign.
- Related to the communications costs is the expandability of using the RWIS standard. The RWIS standard provides support for other devices, including monitoring roadway pavement sensors, monitoring weather sensors (precipitation, temperature, wind, etc.), taking and sending snapshots (images), and auxiliary outputs that can activate other systems (such as a de-icing spray or a dynamic message sign that may display the message "Low Visibility"). Thus, these devices can be added to the fog system without additional communications costs.

The barriers to successful implementation of a standards-based fog system include:

- Initially more expensive, including potentially increased costs for hardware equipment that allows expandability, e.g., a larger cabinet.
- Additional software costs to support or to add support for expandability. When specifying the ITS Standards, software costs must be considered for future, additional device support. That is, software to support the fog system will be provided with the fog system, but additional costs for the software to support future expansion, such as image capture capabilities or to activate auxiliary devices must be included up-front, or in the future, if needed.

WV DOH should also consider how the fog system will be used and maintained. If verification of fog is important, or if the fog system is to be used to inform motorists of low visibility, support for capabilities such as image capture (snapshots) or activation of a dynamic message sign should be included in the specification, even if the equipment is not purchased until a later time.

6.5.4 CCTV Camera System

ITS Standards for CCTV camera control are available today, but the number of implementations have been recent and limited. The cost-benefit analysis for deploying standards-based CCTV systems is not as obvious as other traffic systems. The benefits for deploying standards-based CCTV systems is the same as for other standards-based traffic systems:

- WVDOT would not be "married" to a particular vendor or vendors.
- With a standards-based CCTV system, support for only one communications protocol is needed to operate and monitor CCTV camera equipment.

- Reduction in communications cost if the CCTV camera is co-located with other standards-based traffic systems. Using the ITS Standards, communications costs can be decreased because the NTCIP standard allows multiple devices using NTCIP communications to use and share the same communications channel. So, only one communications drop is needed for a field cabinet that contains both a CCTV camera and another device using NTCIP, for example, a dynamic message sign.

The barriers to deploying standards-based CCTV systems include the following:

- Initially more expensive. Standards-based CCTV cameras may be initially more expensive because additional processing power is generally required to process the higher (communications) overheard associated with the standards.
- CCTV control may be less responsive. This also is related to the higher overhead associated with using standards-based communications protocols.
- Potential additional costs to develop software that supports the ITS Standards. Proprietary communications protocols for CCTV camera control are relatively simple, since there is generally a limited number of commands between the field device and the control software. Software to support a standards-based CCTV camera system may be significantly more expensive then changing software to support multiple proprietary protocols.

It is recommended that WV DOH perform a cost-benefit analysis on using standards-based CCTV camera systems after its needs are identified, and a preliminary design on where CCTV cameras are needed is determined. For example, if PTZ controls is not a requirement for the system, communications to control the camera may not be needed. Similarly, if the CCTV cameras will be co-located with other field equipment that uses the NTCIP standard, a standards-based system may be desired to reduce communications costs.

6.5.5 Center-To-Center

ITS Standards for center-to-center communications have been deployed throughout the United States. However, most of the existing implementations have been CORBA-based or DATEX-based implementations. Implementations using XML is more recent and is not considered proven or mature. However, it is expected that center-to-center communications using XML will be successful after some initial growing pains and some implementations are complete.

It is recommended that WVDOT use an XML, standards-based center-to-center communications protocol for communications between their traffic operations centers. There are several advantages to using a standards-based center-to-center communications protocol. They include:

- Wide-spread support. Many state DOTs are evaluating XML-based center-to-center standards, and several states have begun implementing them, including Arizona, Texas, New York, and Florida. It is expected that many more states will begin using these standards. Thus, the knowledge and experience for support will be available. In addition, XML is commonly used in the business and Internet (world wide web) industries, so knowledge of XML concepts is becoming more common.
- Flexibility. XML provides flexibility. Support for new messages can be easily added when using XML. When the center-to-center communications protocol is first deployed, it is expected only certain basic messages will be needed and supported. As more needs are identified and experienced gained, support for new messages can be added.
- Interoperability. If an XML, standards-based center-to-center protocol is used, new traffic operations centers can be easily added to the communications network. This includes traffic operations centers in other states that also use and support the same standards and message sets.

It is expected that WVDOT will not begin designing or implementing communications for another 2 to 5 years. By then, there should be sufficient experiences and lessons learned in the ITS industry for WVDOT to begin developing its XML-based center-to-center communications network with minimal risk.

6.6 Summary

US DOT is continuously supporting the development and deployment of ITS Standards through one of seven Standards Development Organizations. US DOT provides supports standards activities in several areas: development activities, testing activities, deployment, technical assistance, and training and outreach.

USDOT is currently supporting approximately 110 ITS Standards. Some of these standards are mature, and are widely deployed. Other standards are still under development.

The decision on whether to use a standard should be made during the project development process.

7 Performance Measures

This section of the West Virginia 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.

WVDOT 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 West Virginia. 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)
- Traffic 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 West Virginia. The performance measures listed in the following sections relate 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:

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

- **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 affect 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 West Virginia. 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.

7.1 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 West Virginia (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 WVDOT 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 WVDOT.

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, to distinguish those areas that have RWIS monitoring from those that don't.

7.2 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 WVDOT 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 WVDOT.

7.3 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 WVDOT 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 WVDOT.

7.4 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 WVDOT 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 WVDOT.

- 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 WVDOT 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.

7.5 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).

7.6 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 WVDOT 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.

7.7 Recommendations

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 WVDOT. 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 WVDOT. 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.

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

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

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

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

Requirements ID	Functional Requirement	Project Requirement
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.	
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.	

Requirements ID	Functional Requirement	Project Requirement
2.3.5.1.1	Configure Message for Short Power Loss Recovery Event - The DMS shall allow a management station to define which message to display upon recovery from a short power loss.	*dmsShortPowerRecoveryMessage(currentBuffer).* *dmsShortPowerLossTime(1 – 1 second)*
2.3.5.1.2	Configure Message for Long Power Loss Recovery Event - The DMS shall allow a management station to define which message to display upon recovery from a long power loss. This message will remain until a new valid message is commanded.	*dmsLongPowerRecoveryMessage(to be determined)*
2.3.5.1.4	Configure Message for Controller Reset Event - The DMS shall allow a management station to define which message to display upon the DMS controller being reset. This message will remain until a new valid message is commanded.	*Value to be Determined*
2.3.5.1.5	Configure Message for Communications Loss Event - The DMS shall allow a management station to define which message to display upon the detection of a loss of communications to the management station. Loss of communications is defined as no detection of a valid NTCIP message. This message will remain until a new valid message is commanded.	*dmsTimeCommLoss (To be Determined)* *dmsCommunicationsLossMessage(to be determined).*
2.3.5.1.6	Configure Message for End Message Display Duration Event - The DMS shall allow a management station to define which message to display upon the expiration of the message display duration. NOTE: Every message is associated with a duration when it is activated, which may be infinite. If the duration expires, the message referenced by this configuration parameter defines the message to display next.	*Value to be determined*
2.5	Control Sign Brightness - Requirements for controlling the brightness of the message on the sign face are provided in the following subclauses.	
2.5.1	Determine Number of Brightness Levels - The DMS shall allow a management station to determine the maximum number of (settable) brightness levels. The DMS shall support the number of brightness levels as specified in the specification. If the specification does not define the number of brightness levels, the DMS shall support at least 3 brightness levels.	The DMS shall be capable of supporting 9 brightness levels, each level equivalent to 1/8 of the maximum allowable output of the LEDs (0, 12.5%, 25%, 37.5%, 50%, 62.5%, 75%, 87.5%, and 100%).
2.5.2	Determine Current Photocell Readings - The DMS shall allow a management station to determine the current photocell readings.	
2.5.3	Manually Control Brightness - The DMS shall allow a management station to manually control the light output of the display.	
2.5.4	Switch Brightness Control Modes - The DMS shall allow a management station to switch between the defined brightness control modes. NOTE: See Requirement ID 3.4.2 for Supplemental Requirements related to brightness control modes.	
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.	

Requirements ID	Functional Requirement	Project Requirement
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).	
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).	

Requirements ID	Functional Requirement	Project Requirement
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 hysteresis.*
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.	
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.	

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

Requirements ID	Functional Requirement	Project Requirement
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 hysteresis 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 WV DOH 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.

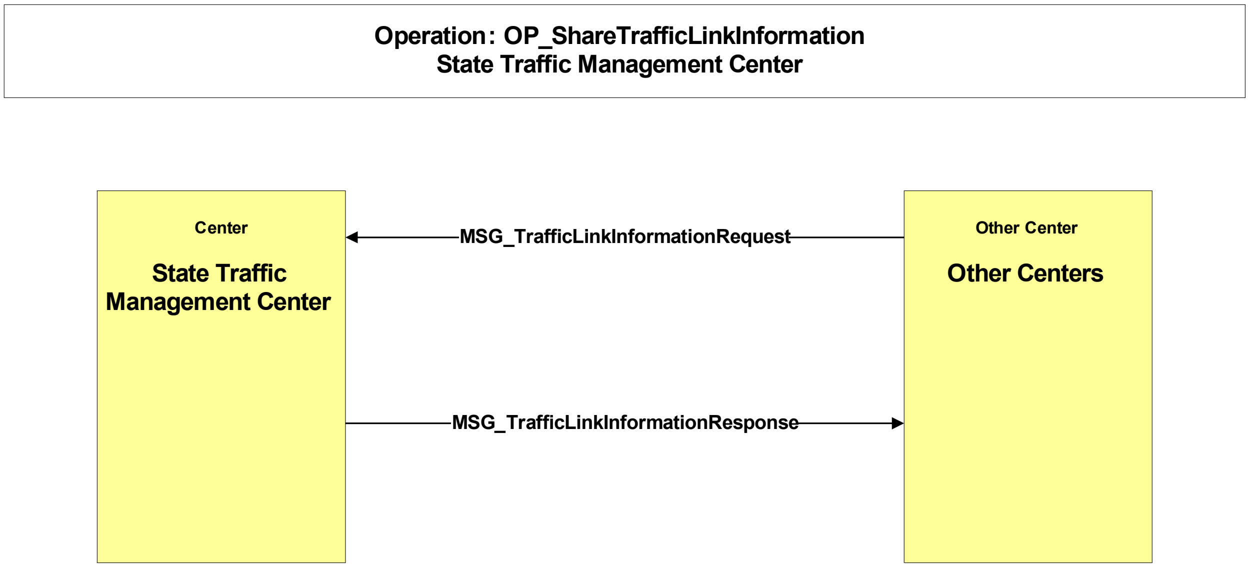

Figure C-7-5. OP_ShareTrafficLinkInformation Operation Message Exchange Diagram

Center Interface Definition Worksheet

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

Table C-7-5. 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 WV DOH 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-7-6. 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**				
	a) WSDL Request Only (XML Direct)		**M**		**N**
	- WSDL General	6.1	M		N

Profile Requirements List (PRL)		NTCIP 2306 Section	NTCIP 2306 Mandatory / Optional	NTCIP 2306 Profile Require-ment	Project Require-ment
	- 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
	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				

Profile Requirements List (PRL)		NTCIP 2306 Section	NTCIP 2306 Mandatory / Optional	NTCIP 2306 Profile Requirement	Project Requirement
	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-7-6. 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 WV DOH Freeway Expansion Project shall accept and generate messages that validate against the following schemas:

Table C-7-7. 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 WV DOH 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-7-8. 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-7-7. 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  <!-- West Virginia -->
							</stateFIPS>
						</adminAreas>
					</areaLocation>
				</location>
			</location>
			<dataTypes>
				<roads>
					0 <!-- all -->
				</roads>
			</dataTypes>
		</filter>
	</informationRequest>
</atisMessage>
```


Figure C-7-8. Sample MSG_TrafficLinkInformationResponse Message


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

```
                    <lastName>
                        WVDOT 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>
```