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16. Abstract

Infrastructure agencies like TxDOT have a need to cost-effectively implement transportation user services that are required by the federal government and that are expected by TxDOT's customers. A true multi-vendor environment that provides interoperable equipment and systems is a basic building block of such a deployment.

This project evaluates the impact of the National Transportation Communications for ITS Protocol (NTCIP) on the implementation of transportation control systems within TxDOT, including ITS services and devices. The project will also provide implementation recommendations to assist TxDOT in the cost-effective deployment of these systems.

The project work consists of providing technical input into the National NTCIP development effort, coordinating with other standards activities that impact NTCIP, evaluating the NTCIP and developing an NTCIP Implementation Plan.

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EVALUATION AND IMPLEMENTATION OF THE NATIONAL TRANSPORTATION CONTROL ITS COMMUNICATIONS PROTOCOL (NTCIP) AS A STANDARD FOR TXDOT: ANNUAL REPORT

by

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Research Report 1736-1
Research Project Number 0-1736
Research Project Title: Evaluation and Implementation of the National Transportation Control ITS Communications Protocol (NTCIP) as a Standard for TxDOT

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DISCLAIMER

The contents of this report reflect the views of the author who is responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration or the Texas Department of Transportation. This report does not constitute a standard, specification, or regulation, nor is it meant for construction, bidding or permit purposes.

ACKNOWLEDGEMENT

The national standards work performed as a part of this contract on behalf of TxDOT is indicative of the comprehensive perspective of the State towards Intelligent Transportation Systems. The author appreciates the willingness of TxDOT to assist in deriving a deployment solution for devices and systems that can enable a national solution that incorporates regional needs.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1. Background

In the ideal transportation system, hardware and software components communicate seamlessly with other parts of the system. Such an arrangement allows traffic management centers to transfer and share data and, in emergency situations, share the control of transportation system operations with different agencies. Further, when additional or replacement hardware and software is needed, compatible equipment and components will be available from a variety of suppliers.

Developing these scenarios into reality is the focus of the National Transportation Communications for ITS Protocol (NTCIP). The primary objective of the NTCIP is to provide a communications standard that ensures the interoperability and interchangeability of traffic control and intelligent transportation system (ITS) devices. The NTCIP is the first protocol for the transportation industry that provides a communication interface between disparate hardware and software products. The effort to develop this standard not only leverages the existing infrastructure, but it also allows for flexible expansion in the future without reliance on specific equipment vendors or customized software.

For more than 20 years, transportation engineers have been able to use traffic signal field control equipment that met an industry standard sponsored by the National Electrical Manufacturers Association. However, the standards did not define an industry-adopted communications protocol for transmitting the data to control and monitor these devices. Without these standards, each manufacturer developed its own protocol. This variety of protocols has led to situations where replacement devises and ITS functionality cannot be added to systems that use deployed communications infrastructure.

In 1992, transportation manufacturers advanced the idea of a standard communications protocol through the National Electrical Manufacturers Association (NEMA). As the U.S. DOT developed the National ITS Architecture and its associated standards recommendations, this protocol development initiative was expanded to include other services and products. Since the ITS perspective included many services, stakeholders, and manufacturers, a team of Standards Development Organizations (SDOs) collectively formed a Joint Committee to direct the development of NTCIP in 1996. Along with NEMA, the American Association of State Highway and Transportation Officials (AASHTO) and the Institute of Transportation Engineers (ITE) have contributed to the development of the protocol and staffing of the Joint Committee. With funding from the U.S. DOT to expedite development of the standards, these SDOs have sought to ensure that all interests are represented in the NTCIP standards.

NTCIP is a family of rules for moving data (protocols) and of definitions for the data (objects) that are transmitted. The rules are organized into groups called profiles, and the definitions are organized by functional device. Separate standards will be developed for both profiles and object sets. Work to meet the objectives of NTCIP and the expectations of the

ITS community has moved very quickly. AASHTO, ITE, and NEMA are currently balloting recently completed proposed standards that will impact actuated traffic signals and variable message signs.

As a part of this TxDOT Project, Texas has assumed a leadership role in developing the NTCIP standards and has ensured that TxDOT's needs are considered in the development of NTCIP. Dr. Seymour, the TTI Project 0-1736 Principal Investigator, is the Chair of the National AASHTO/ITE/NEMA Joint Committee. In this capacity, he is representing TxDOT and ensuring that the Joint Committee and its subordinate Working Groups develop standards that are in the best interest of TxDOT.

2. FISCAL YEAR ACTIVITIES

2.1. Introduction

The following subsections describe some of the activities of the project that occurred during the fiscal year.

2.2. Task 1: Provide Technical Input in the NTCIP Development Effort

Nature of Task 1

Project 1736 says the following about Task 1.

" . . The NTCIP Steering Group consists of representatives from industry, states, cities and the Department of Transportation. This group meets approximately every six weeks at various locations throughout the United States. . . . This task will provide technical input to the NTCIP Steering Group meetings and activities."

Task 1.a Description

Attend meetings related to the NTCIP Steering Group and provide technical input into the NTCIP development efforts.

Status

Ed Seymour attended six meetings of the Joint AASHTO, ITE, NEMA Committee on the NTCIP as follows.

- in Dallas, Texas in October 1996,
- in Tucson, Arizona in December 1996,
- in Washington, D.C. in February 1997,
- in Denver, Colorado in April 1997,
- in Washington, D.C. in June 1997, and
- in Seattle, Washington in August 1997.

In addition, Ed Seymour attended an NTCIP center-to-center Working Group meeting on March 12, 1997, in Washington, D.C. and one on May 19 and 20, 1997, in Las Vegas. Center-to-center communications is one of the focus areas in which NTCIP is working to develop protocol standards.

Dr. Seymour also attended an RWIS (Road Weather Information System) Working Group meeting in Denver on November 4, 1996. RWIS is also one of the focus areas in which NTCIP is working to develop messages.

Travel costs were paid by AASHTO for these trips.

Task 1.b Description

Make presentations with the Joint Committee regarding NTCIP standards efforts in order to assess the merits of technical choices related to NTCIP.

Status

Dr. Seymour made nine presentations during this reporting period regarding NTCIP on behalf of the Joint Committee. Travel costs were paid by ITE.

2.3. Task 2: Coordinate with Other Standards Activities That Impact NTCIP

Nature of Task 2

Project 1736 says the following about Task 2.

" . . . In addition to the Architecture standards emphasis, there is a Data Dictionary effort sponsored by ITE and an ATC 2070 Steering Group whose activities impact NTCIP. It is important that the needs of TxDOT are represented with all these projects. Through Dr. Seymour, TTI serves on all these committees. It is also likely that other standards activities and meetings will develop as the NTCIP work progresses."

The work effort associated with this task will be developed in conjunction with the TxDOT Research Committee Project Director and could include the following activities:

a. Review and evaluation of other standards documents to assess their impact on TxDOT NTCIP evaluation and implementation efforts.
b. Attend non–NTCIP standards meetings to represent TxDOT interests (e.g., the ITE sponsored ATMS Data Dictionary project) as they relate to NTCIP.

Task 2a Description

Review and evaluation of other standards documents to assess their impact on TxDOT NTCIP evaluation and implementation efforts.

Status

Dr. Seymour is actively reviewing other standards documents related to the NTCIP work. He has submitted to the TxDOT Project Director controller cabinet functionality documents as developed at the November 1996 ATC cabinet meeting held in Washington, D.C. and ATC software "manager" descriptions as defined in the Irvine, California, ATC software meeting held in November 1996. He has also worked with TxDOT, Harris County, Caltrans, and others during the summer of 1997 to further refine the cabinet functionality documents.

Task 2.b Description

Attend non–NTCIP standards meetings to represent TxDOT interests (e.g., the ITE sponsored ATMS Data Dictionary project) as they relate to NTCIP.

Status

Ed Seymour has attended the following meetings related to standards efforts impacting NTCIP. In addition, other TxDOT representatives have been present in some cases. Travel costs have been paid by others.

- Five ATMS Data Dictionary meetings.
- Six ATC cabinet meetings.
- Two ATMS Operating and Maintenance recommended practices meetings sponsored by ITE.

2.3 Calendar

The following list in table 1 identifies the status of each of the NTCIP standards as they exist in August 1997. The priorities of the Joint Committee and the current status of the standards are a result of the consensus building led by Dr. Seymour and of the teamwork of those involved.

Table 1 - NTCIP Deployment Calendar

Standard	Status
Simple Transportation Management Framework, TS 3.2	Published & approved by NEMA. AASHTO & ITE are balloting.
Class B Profile, TS 3.3	Published & approved by NEMA. AASHTO & ITE are balloting.
Global Object Definitions, TS 3.4	Published & approved by NEMA. AASHTO & ITE are balloting.
Actuated Traffic Signal Controller Units, TS 3.5	Published & approved by NEMA. AASHTO & ITE are balloting.
Object Definitions for Dynamic Message Signs, TS 3.6	Projected to be a standard in 3rd Qtr 97. AASHTO, ITE, and NEMA are balloting.
Object Definitions for Environmental Sensor Stations, TS 3.ESS	Projected to be a standard in 4th Qtr 97. AASHTO, ITE, and NEMA are balloting.
Object Definitions for Highway Advisory Radio Stations, TS 3.HAR	Projected to be a standard in FY 98.
Class E Profile for Center-to-Center Communications, TS 3.CLE	Projected to be a standard in FY 98.
Object Definitions for Ramp Meter Control, TS 3.RMC	Projected to be a standard in FY 98.
Object Definitions for Advanced Sensor Objects, TS 3.SEN	Projected to be a standard in FY 98.
Object Definitions for Data Collection and Monitoring Devices, TS 3.DCM	Projected to be a standard in FY 98.
Class C Profile, TS 3.CLC	Projected to be a standard in FY 98.
Class A Profile, TS 3.CLA	Projected to be a standard in FY 98.

Table 1 - NTCIP Deployment Calendar - continued

Standard	Status
Transit Communications Interface Protocols, TS 3.TCIP	Projected to be a standard in FY 98.
Class D Profile, TS 3.CLD	Projected to be a standard in FY 99.
Object Definitions for Video Camera Control, TS 3.VCC	Projected to be a standard in FY 99.

3. IMPLEMENTATION

3.1. Introduction

As can be seen from table 1, NTCIP is a rapidly developing standard that is eminently deployable. Some portions of NTCIP are nearing the completion of the balloting process and are ready for deployment. These include the actuated traffic signal controller (ASC) standard, the dynamic message sign (DMS) standard, and the environmental sensor station (ESS) standard. Even though no products have been built to these standards and deployed, it should be noted that the vendor community has been actively involved along with the user community in authoring the standards. The deployment issue to consider is not "whether" vendor products will be available to meet NTCIP standards but "when" vendors will be able to deliver compliant products. As of August 1997, no vendors have come forward and promised exact delivery schedules.

Other NTCIP standards are likely candidates for approval during the fiscal year ending 1998. These include center-to-center communications, ramp metering objects, and data collection device objects. Current procurements for these devices should contain wording to allow the reconfiguration of the devices to NTCIP compliance.

Potential federal rulemaking authority further illustrates the need to provide NTCIP standards compliance. In August 1997, the FHWA issued a "brief" outlining a plan to require formal adoption of ITS standards for the U.S. Department of Transportation. The brief that describes the potential rulemaking included the following quotation.

> "The published elements of NTCIP which are currently being considered for endorsement with AASHTO and ITE will likely be the first standards to be proposed for adoption through the federal rulemaking process. Further information would be published as a Federal Register notice sometime in late 1997." (1)

This rulemaking authority is likely to tie the use of FHWA transportation funds to compliance with the NTCIP standards.

3.2. General Implementation Guidance

NTCIP and non-NTCIP devices cannot be mixed on the same communications channel. Therefore, all devices sharing a channel must be upgraded simultaneously. A management station (e.g., a local field master or a central system) that communicates with both NTCIP and non-NTCIP devices will need to use a different communications port for NTCIP devices and for non-NTCIP devices, and will need to support both protocols.

One approach to the introduction of the NTCIP standard is to operate two totally separate management systems, one NTCIP and one non-NTCIP, during a transition period. (It should be noted that this approach does not exclude a deployment configuration where both

management systems operate on the same multitasking hardware platform.) With this approach, field devices can gradually be switched over from one system to the other as they are replaced or their software is upgraded. This may be the only choice if the current system is old and upgrading it in one project is not practical.

Even if a system continues to use a proprietary protocol, it should include NTCIP support as an optional bid item. Some vendors will support both their existing protocols and the NTCIP in the same software package. Others will require a change of software or hardware to switch from one protocol to the other. Regardless of how it is done, the operating agency should ensure that NTCIP support is available for future use even if it is not needed immediately. This will maximize the useful life of the new equipment and enable introduction of the NTCIP at any time in the future without further upgrades. It also maximizes options and competition when choosing new equipment since different vendors equipment can be mixed in an NTCIP environment if needed.

General TxDOT implementation guidance for procuring and activating NTCIP compliant devices in the month of September 1997 falls into the following categories.

1. If intended for a new system, a new communications "path" (communications channel) on an existing system, or a communications channel that will be upgraded, then:
    1.1. For devices and protocols where NTCIP standards are in the balloting process and approved by at least one of the standards development organizations, TxDOT should require NTCIP compliance with the standard at the time of delivery. This applies to the Class B Profile, actuated traffic signal controllers (ASC), dynamic message signs (DMS), and environmental sensor stations (ESS) as appropriate.
    1.2 For devices that are likely to be balloted in fiscal year ending 1998, TxDOT should require the capability to upgrade the NTCIP standard when it is available. This applies to highway advisory radio (HAR), center-to-center communications, ramp meter controls, and advanced sensor stations.
2. If intended for an existing system where there is no immediate plan for conversion of the entire communications channel, then:
    2.1. For devices and protocols where NTCIP standards are in the balloting process and approved by at least one of the standards development organizations, TxDOT should require compliance with the proprietary standard at the time of delivery. But they should also require delivery of the firmware or components that allow the product to be upgraded to NTCIP compliance. This applies to the Class B Profile, actuated traffic signal controllers (ASC), dynamic message signs (DMS), and environmental sensor stations (ESS).

2.2 For devices that are likely to be balloted in fiscal year ending 1998, TxDOT should require the capability to upgrade the NTCIP standard when it is available. This applies to highway advisory radio (HAR), center-to-center communications, ramp meter controls, and advanced sensor stations.

Having made those recommendations, it should be noted that the cost of alternative 2.1 might offset the cost of upgrading the communications channel and central system. If so, TxDOT should perform the communications channel and associated central system upgrade, and then elect alternative 1 above.

3.2 Procurement Specification Model Wording for NTCIP Compliance

The procurement wording for an NTCIP compliant device can be organized along the following structure.

1. Identify which NTCIP protocol profiles standards apply
   - 1.1 Identify which NTCIP object standards apply
   - 1.2 Identify which objects apply
   - 1.3 Identify applicable ranges for the objects
2. Identify impact of manufacturer-specific objects
3. Identify documentation requirements

The following subsections further discuss this structure.

3.2.1 Identify Which NTCIP Protocol Profiles Standards Apply

The AASHTO/ITE/NEMA Joint Committee document titled "National Transportation Communications for ITS Protocol (NTCIP) Guide" contains the following "model wording" for procurements using NTCIP as shown in figure 1. (2) The structure of this section of a specification is fairly straightforward: first name the device(s) that apply, state whether the protocol should be resident in the unit when installed or at a future specific date, indicate which protocol documents are applicable, and finally describe the protocol(s) that apply to the unit's physical communications connections.

An operating agency that uses this approach to specify compliance with the NTCIP at a future date, should consider their transition from the units as first delivered to the fully compliant NTCIP device. The agency might, for example, require the delivery of alternate computer firmware chips that could be used to upgrade communications capability to NTCIP compliance at a later date after initial delivery.

The

- field device
  and/or
- controller

software shall comply with the referenced National Transportation Communications for ITS Protocol (NTCIP) Standards

- when installed
  or
- prior to DATE.

The software shall comply with the versions of the relevant NTCIP standards that are current at the date of this document, or a later version.
The software shall comply with NEMA TS 3.2 the Simple Transportation Management Framework, and shall meet the requirements for Compliance Level

- 1
  or
- 2.

The software shall comply with NEMA TS 3.3 the Class B Profile, and shall include an

- EIA/TIA 232-E
  and/or
- FSK modem

interface for NTCIP based communications.

Figure 1 - Guide Document Model Wording for Standards Reference

3.2.2 Identify Which NTCIP Object Standards Apply

3.2.2.1 Identify Which Objects Apply

This section of a procurement document indicates which object standards, which conformance groups, and which optional objects are to be implemented.

Typically, object standards include both mandatory and optional conformance groups. The mandatory groups represent those objects that are applicable to all applications of the device. Optional conformance groups contain objects that may not be used in all applications. Therefore, an agency must evaluate and identify those conformance groups and optional objects that are applicable in their specific deployment.

For example, in the case of a traffic signal, an optional conformance group is "traffic signal coordination." If an agency wanted to exclusively operate a traffic signal in a fully actuated, isolated mode, they might specify that coordination is optional in a procurement specification. However if the traffic signals were to operate near each other, the agency would likely require delivery of units that provide coordination capability.

The AASHTO/ITE/NEMA Joint Committee document titled "National Transportation Communications for ITS Protocol (NTCIP) Guide" contains the following "model wording" for procurements using NTCIP as shown in figure 2. (3)

The software shall implement all mandatory objects of all mandatory conformance groups as defined in

- Global Object Definitions, NEMA TS 3.4

and

- Actuated Signal Controller Object Definitions, NEMA TS 3.5

or

- Dynamic Message Sign Object Definitions, NEMA TS 3.6

(NOTE: The following sentences are optional within any one specification)

The software shall also implement all mandatory objects of the following optional conformance groups as defined in

- Global Object Definitions, NEMA TS 3.4
  - * *Reports*
  - * *STMP objects*

and/or

- Actuated Signal Controller Object Definitions, NEMA TS 3.5
  - * *Generic*
  - . . . .
  - * *TS2 (if desired)*

or

- Dynamic Message Sign Object Definitions, NEMA TS 3.6
  - * *<To be determined>*.

The software shall also implement the following optional objects as defined in the

- Global Object Definitions, NEMA TS3.4
  - * *<To be determined>*

and/or

- Actuated Signal Controller Object Definitions, NEMA TS 3.5
  - * *phaseCarsBeforeReduction*
  - . . . . . .
  - * *eventClassTableor*

Figure 2 - Guide Document Model Wording for Object Identification

3.2.2.2 Identify Applicable Ranges for the Objects

Just as field deployment applications dictate which objects are mandatory and which are optional, applications also dictate the permissible range values for objects. Therefore, a procurement specification should identify the object range values for devices, taking into account the agencys intended application.

The AASHTO, ITE, NEMA Joint Committee document titled "National Transportation Communications for ITS Protocol (NTCIP) Guide" contains the following "model wording" for procurements using NTCIP as shown in figure 3. (4)

All objects required by these procurement specifications shall support all values within its standardized range, unless otherwise approved by the PROJECT ENGINEER. The standardized range is defined by a size, range, or enumerated listing indicated in the object's SYNTAX field and/or through descriptive text in the object's DESCRIPTION field of the relevant standard. The following provides the current listing of known variances for this project.

TABLE 2.1

Object Range Values For Actuated Signal Controllers

Object	Minimum Project Requirements
TS 3.4-1996	
MaxTimeBaseScheduleEntries	15
MaxDayPlans	15
MaxDayPlanEvents	15

Figure 3 – Guide Document Model Wording for Object Ranges

3.2.2.3 Identify Impact of Manufacturer-Specific Objects

In this section of the procurement, the agency should state their position with regard to vendor specific functionality. The specification should state whether manufacturer-specific objects are allowed and, if they are not allowed, whether the vendor is permitted to provide functionality that cannot be remotely configured and controlled (perhaps the functionality is only programmable in the field through a front panel). Figure 4 contains model wording from the NTCIP Guide. (5)

Additionally, the software shall

- not support any objects not standardized and approved by NEMA

or

- be supplied with full documentation, including
  * *3.5in. floppy disk(s)*

  and/or
  * *CD-ROM*

  containing ASCII versions of any and all manufacturer-specific objects supported by the device in ASN.1 format in a manufacturer-specific MIB with accurate and meaningful DESCRIPTION fields and supported ranges indicated in the SYNTAX field of the OBJECT-TYPE macros.

Figure 4 -Guide Document Model Wording for Manufacturer-Specific Objects

3.2.3 Identify Documentation Requirements

In many applications, device functionality will be dependent on implementing a group of associated NTCIP objects. It may not make sense and/or it may not be safe to implement only a component of the functionality. An analogy can be drawn with a traffic signal. For instance, it would not be appropriate to attempt operation of a traffic signal without programming a complete set of signal timing parameters that include amber clearances.

NTCIP has a mechanism to accomplish the transmission of associated objects and then subsequently to act on them. These associated objects can be controlled through the "Global Database Management Node" defined in Section 2.3 of NEMA TS 3.4, Global Object Definitions. Global database management objects modify the behavior of the device by causing all SET commands to be buffered and by postponing the editing and validation of the SET operations until a "commit" command is issued. That is, an associated set of NTCIP objects can be kept in buffered memory without any action being performed. Later, when the complete set of associated objects has been transmitted, a "commit" command is issued to initiate the device's updating of the objects.

For the purpose of programming a management station (e.g., a central computer system), it is important to know which objects should typically be associated in a group for the purpose of achieving functionality. *Therefore, a supplier should provide documentation describing typical groupings of objects and corresponding functionality.*

It is also important to note that NTCIP is not a functional or procedural standard. Therefore, procedures and object data relationships are not explicitly defined for each function. This is especially true for vendor-supplied functionality not required in procurement specifications.

Table 2 illustrates this concept. A specific function X might be dependent on the value of an object T. For example, if the value of object T is greater than 0, the action of function X might be to set (send) objects Y and Z. Therefore, for the purpose of programming a management station (e.g., a central computer system), it is important to know object relationships pertaining to functionality. *Therefore, a supplier should provide documentation describing objects and associated implementation procedures for each function.*

Table 2 - Example Object and Procedure Relationships for Functions

Function	Objects	Implementation Procedures
Example: Function X	Object T Object Y Object Z	Get object T, then send objects Y and Z if T > 0.

The AASHTO, ITE, NEMA Joint Committee document titled "National Transportation Communications for ITS Protocol (NTCIP) Guide" contains the following "model wording" for procurements using NTCIP as shown in figure 5. (6)

The software shall be supplied with full documentation, including a

- 3.5in. floppy disk(s)

and/or

- CD-ROM

containing ASCII versions of the following MIB files in ASN.1 format:

- the relevant version of each official NEMA Standard MIB Module referenced by the device functionality

and

- if the device does not support the full range of any given object within a NEMA Standard MIB Module, a manufacturer-specific version of the official NEMA Standard MIB Module with the supported range indicated in ASN.1 format in the SYNTAX field of the OBJECT-TYPE macro. The filename of this file shall be the same as the standard MIB filename with the extension ".man".

Additionally, the software shall

- not support any objects not standardized and approved by NEMA

or

- be supplied with full documentation, including
  - * *3.5in. floppy disk(s)*

  and/or

  - * *CD-ROM*

  containing ASCII versions of any and all manufacturer-specific objects supported by the device in ASN.1 format in a manufacturer-specific MIB with accurate and meaningful DESCRIPTION fields and supported ranges indicated in the SYNTAX field of the OBJECT-TYPE macros.

The Manufacturer shall

- not place any restrictions as to the passage of any and all of this documentation to any third party.

or

- allow the use of any and all of this documentation by any party authorized by the Purchasing Jurisdiction for systems integration purposes at any time initially or in the future, regardless of what parties are involved in the systems integration effort.

Figure 5 - Guide Document Model Wording for Documentation

This model wording should be augmented with additional requirements to provide

- Object groupings associated with functionality; and
- Object procedures associated with functionality.

These two requirements are especially important for vendor-supplied objects associated with functionality not required in a procurement specification. However, this information is also necessary for functionality required in a procurement specification for which the agency anticipates an independently developed management station (e.g., a central computer system).

Allowing vendors to identify object groupings and procedures associated with functionality will lead to "customized" management station software tailored to vendor devices. This kind of implementation will still allow deployment of interoperable systems that permit multiple devices to share the same communications lines. However, interoperability will be constrained by the need to maintain databases for each model and brand of equipment. Hence, it is important to acquire complete procedural and object grouping definitions during the procurement process.

An alternative procurement strategy is to identify both object procedures and object groupings as part of the specification. However this still does not address the issue of management station software for vendor-supplied functionality not identified in the procurement documents. For supplemental (manufacturer-specific) vendor-supplied functionality, complete documentation regarding object procedures and groupings is still required.

Section 3.3 illustrates wording that might be used in a traffic signal procurement specification to identify NTCIP requirements.

3.3. Example Specification Wording

3.3.1. Actuated Traffic Signal Controller Example Wording

The example wording in this section is applicable for procurement of an NTCIP full-actuated, solid state traffic signal controller unit (TS-2) that is NTCIP compatible on the date of installation.

3.3.1.1. Identify Which NTCIP Standards Apply

- The controller software shall comply with the referenced National Transportation Communications for ITS Protocol (NTCIP) Standards when installed. The software shall comply with the versions of the relevant NTCIP standards that are current at the date of this document, or a later version.

- The software shall comply with NEMA Standard Publication TS 3.2-1996 (TS 3.2), the Simple Transportation Management Framework, and shall meet the requirements for Conformance Level 2. The software shall comply with NEMA Standard Publication TS 3.3-1996 (TS 3.3), the Class B Profile, and shall include both an EIA/TIA 232-E and an FSK modem interface for NTCIP based communications.

3.3.1.2. Identify Which Objects Apply

- The software shall implement all mandatory objects of all mandatory conformance groups as defined in Global Object Definitions, NEMA Standard Publication TS 3.4-1996 (TS 3.4).

- Configuration Conformance Group

and Actuated Signal Controller Object Definitions, NEMA Standard Publication TS 3.5-1996 (TS 3.5)

- Phase Conformance Group
- Detector Conformance Group

- The software shall implement all *mandatory objects* of all *optional conformance groups* as defined in

  + Global Object Definitions, TS 3.4:
    - Database Management Conformance Group
    - Time Management Conformance Group
    - Time Base Event Schedule Conformance Group
    - Report Conformance Group
    - STMF Conformance Group
    - PMPP Conformance Group
  + and Actuated Signal Controller Object Definitions, TS 3.5.
    - Volume Occupancy Report Conformance Group
    - Unit Conformance Group
    - Special Function Conformance Group
    - Coordination Conformance Group
    - Time Base Conformance Group
    - Preempt Conformance Group
    - Ring Conformance Group
    - Channel Conformance Group
    - Overlap Conformance Group
    - TS 2 Port 1 Conformance Group

- The software shall also implement the following *optional objects* as defined in the Global Object Definitions, TS 3.4:
  - globalSetIDParameter
  - dbMakeID
  - eventLogOID
  - eventConfigAction
  - eventClassDescription

- The software shall also implement the following *optional objects* as defined in the Actuated Signal Controller Object Definitions, TS 3.5:
  - unitRedRevert
  - phaseDynamicMaxLimit
  - phaseDynamicMaxStep
  - phaseControlGroupTable
  - ringControlGroupForceOff
  - vehicleDetectorQueueLimit
  - vehicleDetectorFailTime

- vehicleDetectorReportedAlarms
- alarmGroupTable
- specialFunctionOutputTable
- preemptMinimumGreen
- preemptMinimumWalk
- preemptEnterPedClear
- preemptState
- preemptControlTable
- ringControlGroupMax2
- ringControlGroupMaxInhibit

3.3.1.3. Identify Applicable Ranges for the Objects

- All objects required by these procurement specifications shall support all values within its standardized range, unless otherwise approved by the PROJECT ENGINEER. The standardized range is defined by a size, range, or enumerated listing indicated in the object's SYNTAX field and/or through descriptive text in the object's DESCRIPTION field of the relevant standard. The following provides the current listing of known variances for this project:

Table 2.1 – Object Range Values for Actuated Signal Controllers

Object	Minimum Project Requirements
TS 3.4-1996	
Moduletype	Value 3
Dbcreatetransaction	All Values
Dberrortype	All Values
Globaldaylightsaving	Values 2 & 3
maxtimebasescheduleentries	255
maxdayplans	15
maxdayplanevents	10
maxeventlogconfigs	255
eventconfigmode	Values 2 thru 5
eventconfigaction	Values 2 & 3
maxeventlogsize	255
maxeventclasses	7
maxgroupaddress	2
TS 3.5-1996	
maxphases	16
phasestartup	Values 2 thru 6
phaseoptions	All Values
maxphasegroups	2
maxvehicledetectors	32
vehicledetectoroptions	All Values

Object	Minimum Project Requirements
maxpedestriandetectors	8
unitautopedestrianclear	All Values
unitcontrolstatus	All Values
unitflashstatus	All Values
unitcontrol	All Values
maxalarmgroups	1
maxspecialfunctionoutputs	8
coordcorrectionmode	Values 2 thru 4
coordmaximummode	Values 2 thru 4
coordforcemode	Values 2 & 3
maxpatterns	48
patterntabletype	Either 2 or 3
maxsplits	16
splitmode	Values 2 thru 7
localfreestatus	Values 2 thru 11
maxtimebaseascactions	255
maxpreempts	6
preemptcontrol	All Values
preemptstate	Values 2 thru 9
maxrings	2
maxsequences	16
maxchannels	16
channelcontroltype	Values 2 thru 4
channelflash	All Values
channeldim	All Values
maxchannelstatusgroups	16
maxoverlaps	8
overlaptype	Values 2 & 3
maxoverlapstatusgroups	8
maxport1addresses	255
port1status	Values 2 & 3

3.3.1.4. Identify Impact of Manufacturer-Specific Objects

- The controller shall be able to implement all NTCIP functionality called for in the specification without any additional vendor specific proprietary objects.

- The vendors controller may provide additional functionality not specifically identified in this procurement specification. If it does provide this additional functionality, the vendor will provide manufacturer-specific objects that allow

remote control of the functionality. These manufacturer-specific, NTCIP compatible objects will be provided with documentation as described below.

3.3.1.5. Identify Documentation Requirements

- The software shall be supplied with full documentation, including a 3.5 in. floppy disk(s) and/or CD-ROM containing ASCII versions of the following MIB files in ASN.1 format:
  - The relevant version of each official NEMA Standard MIB Module referenced by the device functionality; and
  - If the device does not support the full range of any given object within a NEMA Standard MIB Module, a manufacturer-specific version of the official NEMA Standard MIB Module with the supported range indicated in ASN.1 format in the SYNTAX field of the OBJECT-TYPE macro. The filename of this file shall be the same as the standard MIB filename with the extension ".man".

- The software shall be supplied with full documentation, including 3.5 in. floppy disk(s) and/or CD-ROM containing ASCII versions of any and all manufacturer-specific objects supported by the device in ASN.1 format in a manufacturer-specific MIB with accurate and meaningful DESCRIPTION fields and supported ranges indicated in the SYNTAX field of the OBJECT-TYPE macros.

- The manufacturer shall not place any restrictions as to the passage of any and all of this documentation within the procuring agency.

- The manufacturer shall allow the use of any and all of this documentation by any party authorized by the purchasing authority of the procuring agency for the purposes of systems integration at any time (initially or in the future), regardless of what parties are involved in the systems integration effort.

- The manufacturer shall provide a copy of the following table that has been completed to describe the operation of their controller including the objects that are used and the procedures that are done with these objects to implement the functions using NTCIP. If specific sets of objects are to be downloaded to the device before activating functionality, this requirement should also be included in the table.

  Any additional functionality not specifically identified in this procurement specification shall also be defined in this table along with their associated objects and procedures.

Table 3 – Object and Procedure Relationships

Function	Objects	Implementation Procedures
Example: Function X	Object T Object Y	Get object T, then set object Y if T > 0.
Example: Implement function A	Object T Object D Object F Object N	Use the Global Object Definitions of Section 2.3 of NEMA TS 3.4 to update Objects T, D, F, & N after Objects T, D, F, & N are buffered.

4. NTCIP RESOURCES

4.1. Introduction

The following documents and resources are pertinent to NTCIP. They include standards publications, Internet web sites, and other resources. Each item in this section includes a brief description and a reference for locating the resource.

4.1 Standards Documents

Although the NTCIP standards developed during the fiscal year ending 1997 have not been adopted by all three NTCIP standards development organizations, NEMA has adopted and published five NTCIP standards. The following description of the published standards was taken from NEMA's web site http://www.nema.org/nema/standards/ntcip/avail.html. The standards may be ordered from NEMA Customer Service at (703) 841-3200.

- "TS 3.1-1996 National Transportation Communications for ITS Protocol — Overview"
  This publication provides an overview of the concepts and protocols that are planned for the NTCIP series of standards, which can be used to implement a working NTCIP-based transportation control system. This standard encompasses roadside device control, data collection, data routing, and file transfer services using various communication system topologies.
  Price: $34.00 Cat. No. 30503

- "TS 3.2-1996 National Transportation Communications for ITS Protocol—Simple Transportation Management Framework"
  The STMF describes the simple transportation management framework used for managing and communicating information between management stations and transportation devices. It covers integrated management of transportation networks, networking devices, and transportation-specific equipment attached to NTCIP-based networks.
  Price: $46.00 Cat. No. 30504

- "TS 3.3-1996 National Transportation Communications for ITS Protocol — Class B Profile"
  This communications protocol standard can be used for interconnecting transportation and traffic control equipment over low bandwidth channels. It establishes a common method of interconnecting ITS field equipment such as traffic controllers and dynamic message signs (DMS), defines the protocol and procedures for establishing communications between those components, and references common data sets to be used by all such equipment.
  Price: $51.00 Cat. No. 30505

- "TS 3.4-1996 National Transportation Communications for ITS Protocol — Global Object Definitions"
  The messaging between Transportation Management and field devices is accomplished by using the NTCIP Application Layer services to convey requests to access or modify values stored in a given device; these values are referred to as objects. The purpose of this publication is to identify and define these objects, definitions that may be supported by multiple device types (e.g., actuated signal controllers and variable message signs). The grouping of objects for a given device type is performed in the device-type-specific object definition standard.
  Price: $33.00 Cat. No. 30507

- TS 3.5-1996 National Transportation Communications for ITS Protocol-Actuated Traffic Signal Controller Units
  This publication defines objects that are specific to actuated signal controllers. It also defines standardized object groups that can be used for conformance statements.
  Price: $69.00 Cat. No. 30506

4.2 Internet Web Sites

- http://www.ntcip.org/
  This site is hosted by FHWA and populated with content by the Joint AASHTO/ITE/NEMA Committee for NTCIP. It includes subordinate hot links for the following topics.
  - NTCIP Background
  - Calendar of Events
  - NTCIP News
  - Committee Work Areas
  - NTCIP Library
  - NTCIP Forums
  - Areas of Interest
  - NTCIP Specifications

- http://www.nema.org/nema/standards/ntcip/
  This site, hosted by NEMA, provides an overview of NTCIP activities. Other NEMA sites linked to this URL include one that describes what NTCIP standards are available for purchase from NEMA and another that describes pending standards.

- http://www.tcip.org/
  This site is hosted by ITE and provides detail on the transit component of NTCIP, termed TCIP (Transit Communications Interface Protocols). It includes TCIP white papers, notice of meetings, and transit object definitions.

- http://www.ite.org/tmdd/strcom/

  The standards effort termed TMDD (Traffic Management Data Dictionary) affects NTCIP since the data elements defined in its data dictionary are directly correlated to the NTCIP object definitions. This site contains white papers and data dictionary definitions associated with the TMDD activity.

4.3 Other Resources

- "National Transportation Communications for ITS Protocol (NTCIP) Guide"
  The "Guide" document provides an overview and explanation of the NTCIP and guidance to those using the NTCIP. It is a supplementary document that provides a broad general overview of NTCIP. This document is available for download from the NTCIP web site http://www.ntcip.org/library/index.html.

5. REFERENCES

1 Beronio, George, "Brief: Formal Adoption of ITS Standards by U.S. Department of Transportation," August 12, 1997.

2 "National Transportation Communications for ITS Protocol (NTCIP) Guide" http://www.ntcip.org, Revision 2-March 3, 1997 Draft, page 12.

3 "National Transportation Communications for ITS Protocol (NTCIP) Guide" http://www.ntcip.org, Revision 2-March 3, 1997 Draft, page 13.

4 "National Transportation Communications for ITS Protocol (NTCIP) Guide" http://www.ntcip.org, Revision 2-March 3, 1997 Draft, page 14.

5 "National Transportation Communications for ITS Protocol (NTCIP) Guide" http://www.ntcip.org, Revision 2-March 3, 1997 Draft, page 16.

6 "National Transportation Communications for ITS Protocol (NTCIP) Guide" http://www.ntcip.org, Revision 2-March 3, 1997 Draft, page 16.