Welcome

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A315a: Understanding User Needs for Actuated Traffic Signal Controllers Based on NTCIP 1202 Standard
Instructor

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Target Audience

- Traffic management and engineering staff
- TMC/operations staff
- Traffic signal maintenance staff
- System developers
- Private and public sector users including manufacturers
Recommended Prerequisites

- I101: Using ITS Standards: An Overview
- A101: Introduction to Acquiring Standards-based ITS Systems
- A102: Introduction to User Needs Identification
- A201: Details On Acquiring Standards-based ITS Systems
- A202: Identifying and Writing User Needs When ITS Standards Do Not Have SEP Content
- A103: Introduction to ITS Standards Requirements Development
- A203: Writing Requirements When ITS Standards Do Not Have SEP Content
Recommended Prerequisites Cont.

- C101: Introduction to the Communications Protocols and Their Uses in ITS Applications

- Basic Understanding of Advanced Transportation Controller (ATC) Standards Family, if ATCs are to be used

- Knowledge of American-style traffic signal operations

- Basic Understanding of NEMA Technical Standard (TS) 2
Curriculum Path (Non-SEP)

I101 Using ITS Standards: An Overview

A101 Introduction to Acquiring Standards-based ITS Systems

A102 Introduction to User Needs Identification

A201 Details on Acquiring Standards-based ITS Systems

A202 Identifying and Writing User Needs When ITS Standards Do Not Have SEP Content

A103 Introduction to ITS Standards Requirements Development

A203 Writing Requirements When ITS Standards Do Not Have SEP Content

C101 Intro. to Comm. Protocols and Their Uses in ITS Applications

A315a Understanding User Needs for ASC Based on NTCIP 1202 Standard

A315b Specifying Requirements for ASC Based on NTCIP 1202 Standard
Learning Objectives

1. Review the structure of the NTCIP 1202 ASC v02 Standard
2. Evaluate ASC-specific operational needs
3. Identify and write user needs for ASC
4. Appreciate trade-offs between stakeholder desires versus realistic requirements
5. Briefly explain how to evaluate conformance to the ASC standard
6. Introduce the relationship of needs to requirements and conformance
Learning Objective #1—Review the Structure of NTCIP 1202 v02

- Be able to identify the ASC standard in the NTCIP Framework
- Understand content of the standard
- Understand the relationship between NEMA TS2 and NTCIP 1202
NTCIP Family

ASC Standard (NTCIP 1202) & Global Objects (NTCIP 1201)

Source: NTCIP 9001: NTCIP Guide
History of NTCIP 1202

- Version 1: Approved in 1996 (Originally called TS3.5)
- Amendment 1
  - Drafted in 1999 but content rolled into version 2
- Version 2: Approved in 2005
  - Added block objects to make more bandwidth efficient
What is NTCIP 1202?

What does it contain?

- Defines aspects of a communications interface standard
  - Between an Actuated Traffic Signal Controller (ASC) and its monitoring system (e.g., central or SSM)

- Defines data elements (i.e., the vocabulary) used to monitor and control an ASC
  - References NTCIP 1201 for generic data elements

- Supports functional requirements of NEMA TS2
  - NEMA TS2 standardizes the traditional functions of American traffic signal controllers
What is NTCIP 1202?

What is not included?

- Explicit support for adaptive signal control logic
- User needs
- Functional requirements
- Message dialogs
- Test procedures
What is NTCIP 1202?

Complements ASC hardware and functional specifications and standards
Understand the Structure of NTCIP 1202

- Section 1: General

- Section 2: Object Definitions
  - Data elements for field devices are called “objects”
  - Design elements for ASC functionality

- Annex A: Information Profile
  - Groups objects according to logical functions
  - Defines conformance groups
Understand the Structure of NTCIP 1202

- Annex B: Consistency Checks
  - Defines precise rules that must be followed when validating controller configuration

- Annex C: Concept of Operations
  - Explains a set of design patterns used to exchange information

- Annex D: Deprecated Objects
  - Old designs from previous versions of the standard
Advantages of NTCIP 1202

- Provides common design elements and definitions
- Defines common baseline of conformance
- Defines specific set of consistency checks that must be performed
- A step towards interoperability and interchangeability
  - NTCIP does not yet provide a complete solution
  - NTCIP does address some of the issues that must be overcome to integrate disparate systems
Relationship: NTCIP 1202 and NEMA TS2

Most NTCIP 1202 data elements reference NEMA TS2
- NEMA TS2 standardized signal functionality in the U.S.
- NTCIP supplements TS2 by defining data elements
  - Data elements are the individual pieces of data that are exchanged between the signal controller and the monitoring system
- For example, NTCIP 1202 Clause 2.2.2.8 defines the “phaseYellowChange” data element and includes the following line:

REFERENCE "NEMA TS2 Clause 3.5.3.1 and 3.5.3.2.5.a"
**Data Element Definitions**

- An instance of a “Data Element” can be called a “parameter.”
- NEMA TS2 Clause 3.5.3.2.5.a
  - “Following the Green interval of each phase the Controller Unit (CU) shall provide a Yellow Change interval which is timed according to the Yellow Change timing control for that phase.”
- NTCIP 1202 Clause 2.2.2.8
  - “Following the Green interval of each phase the CU shall provide a Yellow Change interval which is timed according to the Yellow Change parameter for that phase.”
Range Definitions

- NEMA TS2 Clause 3.5.3.1: Minimum Requirements
  - Function: Yellow Change
  - Minimum Range: 3-25.5 seconds
  - Maximum Increment: 0.1 second

- NTCIP 1202 Clause 2.2.2.8
  - Parameter: phaseYellowChange
  - SYNTAX: INTEGER (0..255)
  - UNIT: tenth second
NTCIP 1202 Based on Accepted Standard

- Does not contain user needs
- Based on established standard (NEMA TS2) that defines core functionality
Which item is not a part of NTCIP 1202?

**Answer Choices**

a) Consistency checks  
b) Information profile  
c) User needs  
d) Object (data) definitions
Review of answers

a) Consistency checks
   Incorrect; consistency checks are included in Annex B.

b) Information profile
   Incorrect; an information profile is included in Annex A.

c) User needs
   Correct; NTCIP 1202 does not contain any Systems Engineering content.

d) Object (data) definitions
   Incorrect; object definitions are provided in Section 2.
Summary of Learning Objective #1

Review the Structure of NTCIP 1202 v02

- Defines the data elements for information exchange between signal controller and monitoring system
- Based heavily on NEMA TS2
- Complements all American signal controller hardware standards
- Does not include Systems Engineering Process (SEP) content, such as user needs
Learning Objective #2—Evaluate ASC-specific Operational Needs

- Be able to evaluate your operational needs
- Understand how ASC standard meets your operational and maintenance needs
- Recognize how TS2 and 1202 are intertwined
- Understand constraints which will impact cost-benefits
- Be aware of issues that one can confront when preparing a procurement
Developing User Needs

- Course A202: Identifying and Writing User Needs When ITS Standards Do Not Have SEP Content
  - Provides generic background on how to extract needs from non-SEP standards
  - We will apply this process to NTCIP 1202
Understand ASC Specific Operational Needs

- Concept of Operations reveals the “big picture”
  - What is the current situation and problem?
  - Who are the users? Who is affected?
  - What are the operational scenarios?
  - What are the operational needs?
  - Are there any regional aspects?
- NTCIP 1202 implicitly makes assumptions about these questions
- Projects should explicitly address these issues in their own ConOps
Current Situation, Problem Statement

- Agencies are responsible for managing the operation of the transportation network
- Conflicting movements at intersections must be managed to prevent collisions
- Some intersections need more than simple yield/stop sign control due to safety and/or efficiency reasons
- Industry solution is to use a traffic signal controller sequentially grant right of way to specific movements
Current Situation, Problem Statement

- Signals located near one another can impact each other’s operations and should be coordinated.

- Agencies wish to manage signals remotely to reduce maintenance and operations costs.

- Prior to NTCIP, there was no industry standard for remote communications, only proprietary solutions.
Reference Physical Architecture

.learning Objective #2

Control Center

NTCIP

Signal Controller Hardware

NEMA TS2, ATC, 170, 179, etc.

Operational Logic

NEMA TS2
Steps to Writing a User Need

A. Operational Needs

B. ITS Standard

C. Extraction Process

D. Writing Criteria
How to Identify Operational Needs

- Regional architecture
  - Are any specific functions assigned to the local controller?
- Project description
  - Are there specific features being requested for signal control?
- Operational scenarios
  - Work with stakeholders to discover how they want to operate and interact with the system under different scenarios
How to Identify Operational Needs

- NEMA TS2 defines functionality for traffic signal controllers
  - Functional aspects of standard provides the logical model used by virtually all American controller deployments
- NTCIP 1201 and NTCIP 1202
  - 1201 defines generic data and 1202 defines ASC-specific data
- Case studies/industry experience
  - Work with other agencies that have deployed signal systems
How to Identify Operational Needs
Pitfalls in Identifying Operational Needs

Failure to consider any source can lead to problems

- Failure to consider project description can result in missing capabilities or specifying unnecessary features
- Failure to consider architecture may impose functionality on device that will be performed elsewhere
- Failure to consider scenarios may inadvertently ignore performance needs

This is largely true of SEP standards as well
Steps to Writing a User Need

A  Operational Needs

1. Desire to **configure** traffic signals from a remote management center using third-party software
2. Desire to **control** traffic signals from a remote management center using third-party software
3. Desire to **monitor** traffic signals from a remote management center using third-party software
Categories of Operational Needs

- **Configure**
  - Maintenance desires a single ASC model that can be configured for any intersection
  - Management desires safety features to prevent remote reconfiguration of safety-critical information

- **Control**
  - Operators desire to control the selection of timing patterns

- **Monitor**
  - Operators desire to monitor real-time signal operations
  - Maintenance desires to monitor signal diagnostics to detect equipment failures
Benefit/Cost Considerations

Need to live within budget constraints

- How many phases do you really need to support?
- Are desired custom features justified by added cost to project?

NEMA TS2 provides a baseline of what industry typically supports

- Number of phases, detectors, etc.
- Which standardized features are mandatory

Interoperability requires significant agency specifications
Which of the following can be used to discover operational needs?

**Answer Choices**

a) Regional architecture  
b) Operational scenarios and stakeholder input  
c) ITS standards  
d) All of the above
Review of answers

a) Regional architecture
   *Incorrect; the architecture can identify high-level needs, but the other options are also useful.*

b) Operational scenarios and stakeholder input
   *Incorrect; scenarios can identify mid-level needs, but the other options are also useful.*

c) ITS standards
   *Incorrect; ITS standards can identify low-level needs, but the other options are also useful.*

d) All of the above
   *Correct! All of these tools can be used to identify user needs.*
Summary of Learning Objective #2

Evaluate ASC-specific Operational Needs

- Identifying operational needs is an important part of the ConOps process
- Operational needs should be derived from a number of sources
- Definition of operational needs will impact project costs
- A baseline of widely supported features is defined in NEMA TS2
Learning Objective #3—Identify and Write User Needs for ASC

- Understand that standardized user needs do not exist for traffic signals
- Understand how to extract and write needs for ASC procurement
- Appreciate trade-offs between fulfilling desires of stakeholders versus setting realistic requirements
Learning to Identify and Write User Needs

- User needs are not in NTCIP 1202
- Agencies must develop them for the acquisition
  - Identify major desired capabilities from various sources
  - Compare to extracted capabilities from standard
  - Write user needs
Steps to Writing a User Need

A  Operational Needs
1. Desire to configure traffic signals from a remote management center using third-party software
2. Desire to control traffic signals from a remote management center using third-party software
3. Desire to monitor traffic signals from a remote management center using third-party software

B  ITS Standard
NTCIP 1202 ASC
NEMA TS2 and NTCIP 1202

- NEMA TS2 is America’s main standard for signal control logic

- NTCIP 1202 based largely on NEMA TS2 logical concepts

- NTCIP 1202 implements a few features not defined in NEMA TS2
  - Typically features used by non-NEMA controllers
Steps to Writing a User Need

B  ITS Standard
   NTCIP 1202 ASC

C  Extraction Process
Simple Extraction

Some generic needs can be derived from NTCIP standards that contain SEP content, such as NTCIP 1203 for DMS

- **UN 1.1**: Live Data Exchange (NTCIP 1203 Clause 2.4.2.1)
- **UN 1.2**: Logged Data Exchange (NTCIP 1203 Clause 2.4.2.2)
- **UN 1.3**: Support Legacy Communication Networks (NTCIP 1210 Clause 2.4.4)

When applicable, these are valuable since they are generally fully defined
Extract Capabilities from Conformance Groups

Conformance Groups

Categories of Functions

Major Desired Capability

Learning Objective #3
Conformance Group (CG)

- A CG is a logical grouping of related objects
- CGs help in determining required information to support a function
- Example: Volume Occupancy Report CG
  - volumeOccupancySequence
  - volumeOccupancyPeriod
  - activeVolumeOccupancyDetectors
  - volumeOccupancyTable
    - detectorVolume
    - detectorOccupancy
Extract Capabilities: Read

From NTCIP 1202 Information Profile

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</table>

Source: NTCIP 1202 v02 p. 135
Example: Extract Capabilities from Standard

- **Read:** Phase Conformance Group
  - Includes `phaseWalk`, `phaseMinimumGreen`, `phaseYellowChange`, etc.

- **Recognize:** Phase timing parameters
  - Maps to identified operational needs of configuring for any intersection and safety issues

- **Infer:** Consider three major operational categories
  - Configure
  - Control
  - Monitor
Infer Major Desired Capability

- Configure intersection timing parameters
  - May want to restrict some parameters for safety issues
- Control intersection timing parameters
  - Not applicable
- Monitor intersection timing parameters
  - Allows agency to determine current configuration
Example: Extract Capabilities from Standard

- Read: Phase Conformance Group
  - maxPhases has a range of 2 to 255
- Recognize: Two phases will not meet our needs; requiring 255 phases may increase costs
- Infer: Need to determine and document how many phases we need
Example: Extract Capabilities from Standard

- Read: Phase Conformance Group
  - phaseStatusGroupReds, phaseStatusGroupGreens, etc.

- Recognize: Monitor current signal timing
  - Maps to identified operational need of monitoring real-time signal timing

- Infer: Consider three major categories
  - Configure
  - Control
  - Monitor
Example: Extract Capabilities from Standard

- Read: Phase Conformance Group
  - phaseControlGroupPhaseOmit,
  - phaseControlGroupHold, etc.

- Recognize: Remotely control detailed signal operations
  - Does not map to any identified operational need
  - Should verify with stakeholders that feature is not needed
Example: Extract Capabilities from Standard

- Read: Coordination Conformance Group
  - coordOperationalMode, coordPatternStatus

- Recognize: Ability to manually select timing pattern
  - Maps to desire to control selection of a timing pattern

- Infer: Consider three major categories
  - Configure
  - Control
  - Monitor
Example: Extract Capabilities from Standard

- Read: Detector Conformance Group
  - vehicleDetectorTable, maxVehicleDetectors, etc.

- Recognize: Ability to configure detectors for the intersection
  - Maps to configuring for any intersection

- Infer: Consider three major categories
  - Configure
  - Control
  - Monitor
Example: Extract Capabilities from Standard

- **Read:** Detector Conformance Group
  - vehicleDetectorErraticCounts, vehicleDetectorAlarms, vehicleDetectorStatusGroupAlarms, etc.

- **Recognize:** Ability to identify detector diagnostics
  - Maps to desire to monitor signal diagnostics

- **Infer:** Consider three major categories
  - Configure
  - Control
  - Monitor
Example: Extract Capabilities from Standard

- Safely Configure Signal for Intersection Layout
- Monitor Signal Configuration
- Monitor Signal Timing
- Control Selection of Timing Pattern
- Monitor Timing Pattern Selection
- Monitor Signal Diagnostics

Groups:
- Phase Conformance Group
- Detector Conformance Group
- Coordination Conformance Group
Write User Need

Review rules for a well-written user need

- Uniquely identifiable
- Identifies one major desired capability
  - Explains the need, not a “shall” type of statement
- Solution free
- Capture rationale
Configure Signal for Intersection Layout

Uniquely Identifiable

UN 2.1:
Configure Signal for Intersection Layout

Identifies One Major Desired Capability

**UN 2.1:** The agency needs a signal controller that can be safely configured to control any intersection within its jurisdiction, including those with atypical layouts.
Configure Signal for Intersection Layout

Solution Free

UN 2.1: The agency needs a signal controller that can be safely configured to control any intersection within its jurisdiction, including those with atypical layouts.
Configure Signal for Intersection Layout

Capture Rationale

UN 2.1: The agency needs a signal controller that can be safely configured to control any intersection within its jurisdiction, including those with atypical layouts.

This will result in lower overall maintenance costs for the Maintenance Division. However, the operators must still be able to control every intersection, including 6-legged intersections. In addition, due to the safety critical nature of this information coupled with the static nature of the information, this process should require the presence of a field technician to verify any change.
Monitor Signal Timing

**UN 4.1:** The agency needs a signal controller that will allow the management system to monitor the status of each signal indication with a one second resolution.

The agency needs a way to remotely verify that the traffic signal is operating as expected.
Which of the following components is not part of a well-defined user need?

**Answer Choices**

a) Unique Identifier  
b) Major capability  
c) “Shall” statement  
d) Rationale
Review of answers

a) Unique identifier
   *Incorrect; each need should have an identifier so that it can be uniquely referenced.*

b) Major capability
   *Incorrect; the major capability is the central idea in a user need.*

c) “Shall” statement
   *Correct! “Shall” statements should only appear in requirements, not user needs.*

d) Rationale
   *Incorrect, the rationale should be included so that the reader can understand why the feature is being requested.*
Summary of Learning Objective #3

Identify and Write User Needs for ASC

- User needs are not defined in NTCIP 1202
  - Agencies must develop based on stakeholder input and literature
  - Major capabilities can be extracted from the standard and mapped to stakeholder input
  - User need should fully document justification along with major capability
  - Users should consider cost implications before extending the standard
Learning Objective #4—Stakeholder Desires vs. Realistic Requirements

- NTCIP 1202 provides an excellent starting point for all standardized functionality
- Some features were deemed to be too early to standardize
  - Adaptive control
- Less common features were not defined in NTCIP 1202
  - Flashing yellow arrow
  - Leading pedestrian interval
- Stakeholders may identify other capabilities that are not addressed by the standard
Examples of Extended Features

- Consider whether any non-standard capabilities are really needed
  - Will likely be a custom/proprietary solution
  - Determine if there are alternatives that stakeholders will consider
- If still needed, fully document the user need in the Concept of Operations
- Consider cost implications of extended features
  - Specification
  - Testing
  - Maintenance of proprietary solution
Summary of Learning Objective #4

Stakeholder Desires vs. Realistic Requirements

- NTCIP 1202 standardizes the most common ASC features
- Stakeholders may want some additional features
- Non-standard features will increase life-cycle costs
Learning Objective #5—Explain How to Evaluate Conformance

- Understand the minimum conformance requirements
- Appreciate how backwards compatibility is handled
Evaluating Conformance to NTCIP 1202

- NTCIP 1202 does not define SEP “requirements,” but does define conformance
  - Mandatory features of mandatory conformance groups must be supported
  - Many of the conformance groups reference objects defined in NTCIP 1201

- If user needs do not trace to these items, it may suggest an incomplete analysis
  - NTCIP mandatory features are generally very basic requirements
Backwards Compatibility

When considering major capabilities, one must also consider if different versions of equipment will need to interoperate

- If any differences exist in the specifications or design, the new equipment may have to be designed to work with both the older and newer versions
- From a user need perspective, this just needs to be recorded so that the requirements and design properly accommodate this need
Backwards Compatibility

The major backwards compatibility issues related to NTCIP 1202 include:

- Database transaction feature (NTCIP 1201 v01 to v02)
- Daylight savings time (NTCIP 1201 v02 to v03)
- Logic in setting local time (NTCIP 1201 v1 to v2)
- Special function output state (NTCIP 1202 v01 to v02)

Each change has resulted from identifying ambiguities or problems in the initial version of the standard; your specification needs to clarify how existing equipment has interpreted these ambiguous features.
Which is the best way to complete this user need?

UN 5.1: Operators need the central system to _____.

Answer Choices

a) Work with Manufacturer X Model 1 controllers that are currently deployed as these are too costly to update.

b) Support dbErrorType, dbErrorID, dbTransactionID, and dbMakeID.

c) Support backwards compatibility for older controllers.

d) Support NTCIP v01 and NTCIP v02 so that it can work with older controllers that are too costly to update.
Review of answers

a) Work with Manufacturer X Model 1 controllers that are currently deployed as these are too costly to update.

Correct, this statement identifies a desired capability sufficiently to allow the designer to create a solution without additional information. It is also solution-free, and indicates the rationale.

b) Support dbErrorType, dbErrorID, dbTransactionID, and dbMakeID.

Incorrect, a user need should not define a specific solution; it should describe the capability so that a user can understand it and provide a justification.
Review of answers

c) Support backwards compatibility.
   Incorrect, this statement does not define the type of backwards compatibility or provide a justification.

d) Support NTCIP v01 and NTCIP v02 so that it can work with older controllers that are too costly to update.
   Incorrect, this statement does not identify a valid standard number nor does it address how to resolve the ambiguities that led to the revision of the standard.
Summary of Learning Objective #5

Explain How to Evaluate Conformance

- NTCIP 1202 defines a minimum set of items that must be supported to claim conformance

- Features within NTCIP 1202 depend on NTCIP 1201

- There have been multiple versions of the standard and users should consider whether this will be an issue within their system
Learning Objective #6—Relationship of Needs to Requirements

- Introduce the concept of a traceability table
- Awareness of follow-on module
Needs to Requirements

User needs should be traced to their requirements

- Can be done in a table format

- Similar to Protocol Requirements List (PRL) in SEP-based NTCIP standards
  - Does not need a conformance column since it only includes items that are needed for your project
  - Assist deployments by providing a checklist
Needs to Requirements

- Unique User Need ID and title reference the precise user need
- Requirements uniquely reference the requirements traced to the need

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Learning Objective #6
# Needs to Requirements

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Needs to Requirements

- User needs describe what features the device needs to support and why
- Functional requirements support and satisfy the user needs into detailed, measurable specifications
- The traceability table visually maps the relationships between user needs and functional requirements
Functional Requirements

Functional requirements will be covered in the next module(s)

- A315b: Specifying Requirements for Actuated Traffic Signal Controllers (ASC) Based on NTCIP 1202 Standard
The benefit of the needs to requirements table is that it:

**Answer Choices**

a) Maps needs to requirements  
b) Provides a high-level summary of the features  
c) Provides a convenient checklist during deployment  
d) All of the above
Review of answers

a) Maps needs to requirements
   \textit{Incorrect, one of the main purposes is to show this mapping}

b) Provides a high-level summary of the features
   \textit{Incorrect, the table provides a quick reference to each major feature with a lookup reference}

c) Provides a convenient checklist during deployment
   \textit{Incorrect, this becomes valuable during the testing of the equipment once delivered}

d) All of the above
   \textit{Correct, the best answer is that they are all true}
Summary of Learning Objective #6

Relationship of Needs to Requirements

- User needs should be summarized in a table
- Table will be used to map needs to requirements in next phase for traceability
- Requirements will provide measurable statements for subsequent testing
What We Have Learned

1) NTCIP 1202 does not include _SEP_ content.
2) A description of ASC functionality and a practical baseline conformance statement for NTCIP 1202 can be found in _NEMA TS2_.
3) Major capabilities can be extracted from _NTCIP 1202_.
4) Requiring non-standard features will increase life-cycle _costs_.
5) Conformance to the standard only requires minimal support of the _mandatory_ objects contained in the _mandatory_ conformance groups.
6) User needs should be mapped to _requirements_ in a table.
Resources

- NTCIP 1201: Global Object Definitions
- NTCIP 1202: Object Definitions for ASC
- NEMA TS2: Traffic Controller Assemblies with NTCIP Requirements
- NTCIP 9001: NTCIP Guide
- IEEE 1362: Concept of Operations Document
QUESTIONS?
Next Course Module

A315b: Specifying Requirements for Actuated Traffic Signal Controllers (ASC) Based on NTCIP 1202 Standard

- Explains how to write ASC requirements
- Derives sample requirements to satisfy needs
- Explains how to show the relationship between requirements and the design from the standard