Welcome

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ACTIVITY
Module A315b Part 2 of 2:

Understanding Requirements for Actuated Traffic Signal Controllers (ASC) Based on NTCIP 1202 Standard

Part 2 of 2
Instructor

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Target Audience

- Traffic management and engineering staff
- Traffic Management Center / operations staff
- Traffic signal maintenance staff
- System developers
- Software developers
- Private and public sector users including manufacturers
- Procurement personnel
Recommended Prerequisite(s)

- 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: Introduction to the Communications Protocols and Their Uses in ITS Applications
Recommended Prerequisite(s), continued

- A315a: Understanding User Needs for Actuated Traffic Signal Controllers (ASC) Based on NTCIP 1202 Standard
- A315b: Specifying Requirements for Actuated Traffic Signal Controllers (ASC) Based on NTCIP 1202 Standard Part 1 of 2
Learning Objectives

Part 1 of 2 covered:
1. Learn how to develop requirements using the NTCIP 1202 v02 Standard
2. Achieve interoperability and interchangeability
3. Understand traceability
4. Developing the specification

Part 2 of 2 will cover:
5. Manage special issues specific to ASC
6. Incorporate requirements not supported by standardized objects
Part 1 Covered: Requirements, Dialogs, and Traceability (RTM for Conformance)

1. Requirements can be identified from ___________, ___________ and the three (3) perspectives.

2. _______ define rules on how to exchange information while _______ define the meaning of the information; both must be defined to achieve ______________.

3. __________ table allows a user to quickly determine why a design feature is included.

4. An interface specification should _______ standards whenever possible rather than copying their content.
Part 1 Provided: Checklist for Interface Specification

See Student Supplement for Part 1*

- Example Text Included:
  - Boilerplate
  - User needs
  - Requirements (Who generates requirements)
  - Dialogs
  - Any custom objects
  - User needs to requirements traceability table (Who verifies conformance)
  - Requirements traceability matrix (RTM)
  - Communication stack specifications

*Presentation material for Part 1 Module (#32) is available at USDOT PCB website: [http://www.pcb.its.dot.gov/stds_training.aspx](http://www.pcb.its.dot.gov/stds_training.aspx)
Part 2 Learning Objectives 6 and 7 Answer Two Questions

**Question 1**
What are the specific ASC requirements related issues and how to manage them in a project specification?

**Question 2**
What if certain project requirements are **NOT supported** by the NTCIP 1202 v02 Standard?

How to properly use Manufacturer-Specific Objects (MSO) and recognize their improper use to avoid conflicts.
Learning Objective #5: Manage Special Issues Specific to ASC

1. Managing requirements: What does it mean?
2. ASC Types vs. Performance Requirements
3. Understand control, parameter, and status objects
4. Understand database transaction sets (i.e. dbcreate, etc.)
5. Understand NTCIP consistency checks and rules
6. Understand block objects
7. Simple Network Management Protocol (SNMP)
8. Simple Transportation Management Protocol (STMP)
Managing requirements means:

- Associating each requirement to the correct conformance group
- Correct implementation of objects within the conformance group
- Correct dialog to meet requirements

Requirements gatekeeper:

- Manages requirements on behalf of authorized stakeholders
- Enforces the quality of the requirements management process
1. Managing Requirements: What Does It Mean? (cont.)

Requirements Must be Testable to Conformance Groups

- Requirements gatekeeper is assigned and is responsible for:
  - Rejecting requirements that are not testable
  - Identifying requirements that cannot be fulfilled by CGs

- Requirements that cannot be fulfilled by CGs:
  - Manufacturer-Specific Object (later slide)
  - Becomes part of project special terms, conditions, and deliverables
2. ASC Types and Performance Requirements

Legacy: ASC Types in Service for Ten Years

- Communications: Private line, 1,200 bits per second
- Performance: Less than 1 million instructions per second (MIPS)
- Examples: Type 170, NEMA and Electromechanical

Performance is not specified and No Ethernet IP communications
2. ASC Types and Performance Requirements

Modern: Performance of Most ASCs in Service Today

- Communications: Ethernet Internet Protocol (IP), 10 M bps
- Performance: Greater than 4 MIPS
- **Examples**: ATC 5202 Standard (Model 2070L, 2070E), NEMA TS2
  - Performance typically > 4 MIPS and Single 10 Mbps Ethernet port

ATC: Performance of ATC5201 Standard Controllers

- Communications: (4) Ethernet Internet Protocol (IP), 10 M bps
- Performance: 60 MIPS minimum, typically > 400 MIPS
- **Examples**: ATC5201 (Model 2070LX and Shelf Mount ATC)
  - Performance: 60 MIPS minimum, > 400 MIPS typical
  - Separate internal 10/100 Mbps hubs for Central and Roadside
How Types Affect Performance Requirements (cont.)

**Legacy ASC Requirements Constrained by Network Performance:**
- Data traffic is constrained within the available bandwidth
- Requires additional manufacturer information for testing

**Modern ASC Requirements Constrained by Processor Performance:**
- Use of standardized objects eliminates special testing
- Ethernet IP communications can overwhelm the processor

**ATC 5201 Requirements Have the Fewest Constraints:**
- Standardized objects without special testing or documentation
- Superior computational performance for communications
How Types Affect Performance Requirements (cont.)

Communications Volume Affects Requirements

**Requirement to GET** status of a ASC continually:
- Legacy ASCs may be constrained by communications
- Modern ASCs may be constrained by computational speed

**Requirement for a Dialog:**
- Legacy ASCs require **small** dialogs of compact, complex objects that must be documented and tested for each ASC
- Modern ASCs can use **long** dialogs of standardized objects but may be constrained to computational speed
- ATC5201 ASCs can use **long** dialogs of standardized objects without being constrained by computational speed
Examples: Large Data Download to ASC

- A single NTCIP central (channel) may be connected to a mixture of:
  - **Legacy** ASCs communicating via private lines at 1200 bps
  - **Modern** ASCs communicating via Ethernet IP at 10 Mbps
  - **ATC 5201** ASCs communicating via Ethernet IP at 100 Mbps

- Identical ASC functions may require different NTCIP objects
  - **Legacy** ASC: SET many objects may overwhelm communications
  - **Modern** ASC: SET many objects may overwhelm processor
  - **ATC 5201**: SET many objects are handled within time constraints
Bandwidth Analysis: Center-to-Field

NTCIP 9001 v04.06 Guide, Annex E

- Typical SNMP Message Size
  - 26 header bytes of header
  - 23 bytes per data element
- Typical STMP Message Size
  - 1 byte of header
  - 1 byte per data element
- STMP is defined within devices
  - Maintain each unique device
  - Test each unique message

SNMP requires more bandwidth, but is identical among manufacturers.
3. Understand Control, Parameter, & Status Objects

- Control objects (C) are sent to an ASC to alter an operation
  - Central monitoring system is required to alter the ASC
  - For example, to SET the ASC time of day on the ASC

- Parameter objects (P) indicate a range
  - Central system is required to know the ASC capabilities
  - For example, the number of phases serviced by the ASC

- Status objects (S) are received from an ASC, indicating operation
  - Central monitoring system is required to display ASC data
  - For example, to GET the time of day from an ASC
4. Understand Database Transaction Sets

Transaction Set Effects and Advantages

- Database transaction sets:
  - Changes the ASC operation, just as a Control Object SET
  - Forces the buffering of multiple objects
  - All of the objects are modified within the ASC at one time
  - Used when required to alter multiple ASC parameters that could have a detrimental effect if not all done at the same time
4. Understand Database Transaction Sets (cont.)

Example: dbcreate

- Example of Transaction Set:
  - Requirement to change multiple phases at a time of day.
  - If communications is interrupted, none of the phases are altered.

- Example of dbcreate:
  - Normal mode: SETs are stored in ASC immediately
  - Transaction mode: SETs are buffered until verified with consistency check
  - Used when required to initialize ASCs for safe operation
  - The entire database is configured, sent to ASC, and verified for consistency before the ASC can operate
5. Understand NTCIP Consistency Checks and Rules

- **Consistency Checks:**
  - Checks on data received by the ASC
  - Compares the data against expected values
  - Operation is not completed if consistency check fails
  - For example, an error message would occur if one or more defined concurrent phases have the same ring assignment as the new phase or when defining a phase in a ring with that phase number already defined
5. Understand the NTCIP Consistency Checks and Rules (cont.)

- NTCIP Rules Insure ASC Interoperability:
  - The NTCIP Protocol defines the structure
  - Rules define what is required for interoperability
  - Interoperability requires that both sides of the interface have the same interpretation of the data
  - Interoperability requires that both sides of the interfaces have the same interpretation of the order of the data received
6. Understand the Block Objects

Block Objects are Pre-Defined Sets of Objects

- Block objects:
  - Provide an efficient method of uploading and downloading
  - Entire ASC database can be uploaded with one block object
  - More efficient than multiple GET objects
6. Understand the Block Objects (cont.)

- When block object may be needed to meet requirements
  - Block objects fulfill a requirement to GET a snapshot of multiple objects at the same point in time, while multiple GETs result in the status of blocks at different times
  - Block objects are often used to remain within the bandwidth requirements of the communications channel
6. Understand the Block Objects (cont.)

Example: High Resolution Performance Measures

**Requirements: The Central shall:**
- Log all ASC vehicle actuations
- Correlate all logged vehicle actuation to a phase
- Further correlate to signal color
- Report correlated data each second

**Realization:**
- Phase blocks to GET all phases and colors with timestamp
- Detector blocks to GET the status of all detectors with timestamp
- Multiple GETs would not meet 1 second latency requirement
7. Simple Network Management Protocol (SNMP)

SNMP is a Widely Used Communication Protocol Used by Computer Networks

- Typical SNMP Message Size
  - 26 header bytes of header
  - 23 bytes per data element

SNMP requires more bandwidth, but is identical among manufacturers.
8. Simple Transportation Management Protocol (STMP)

STMP is an Extension of SNMP Developed Specifically for the Transportation Industry

- Typical STMP message size
  - 1 byte of header
  - 1 byte per data element
- Messages can be unique
  - Dynamic messages
  - Established when connected
  - Sets of ASC data elements
  - Each end must know how to establish and interpret data

STMP requires little bandwidth, but varies among manufacturers.
STMP Pros: Reduced Bandwidth

Advantages

- Significantly reduces the number of bytes on the communications channel
- Data traffic reductions of 25:1 are typical
- Allows operation via low-speed modems
- Allows operation on existing twisted pair private phone lines
- Allows continued use of legacy controllers via a software update that replaces proprietary protocols
STMP Cons: Complexity, Maintenance, Testing

Disadvantages

- Object identifiers are removed
- Increases software complexity, STMP objects are unique
- Increases testing complexity, requires unique test plan per STMP object
- Data content is not defined by the NTCIP standards, need to know the manufacturer’s data structure
- Because objects are dynamically composed, typically at power-up, each ASC must know how to compose and interpret the composite objects
STMP Related to Requirements

- **What to consider when developing requirements:**
  - As Legacy ASCs are replaced, STMP advantages are negated
  - Suggest that STMP only be used to meet requirements to operate ASCs on a low-speed communications channel
  - Absent of bandwidth restrictions, consider the project cost and milestone requirements, as well as the total cost of ownership using SNMP vs. STMP
  - System expansion via competitive bids would need each manufacturer to develop similar dynamic objects
  - Configuration management costs to archive and maintain the configuration of each ASC, vs. identical SNMP objects
  - Regression testing costs of each dynamic object
Additional Information Provided in the Student Supplement

- Background on ASC Types in Service
- Managing ASC Specific Requirements
  - Communications loading
  - Clock coordination
ACTIVITY
Which of the following is NOT part of managing requirements correctly?

**Answer Choices**

a) Associating each requirement to the correct conformance group  
b) Correct implementation of objects within conformance group  
c) Correct dialog to meet requirements  
d) Adding a new requirement received via email
Review of Answers

a) Associating each requirement to the correct conformance group
Incorrect. Each requirement is fulfilled by a conformance group.

b) Correct implementation of objects within conformance group
Incorrect. Content of each object must be correct.

c) Correct dialog to meet requirements
Incorrect. Objects must transact in the correct sequence.

d) Adding a new requirement received via email
Correct! Gatekeeper insures that the requirement came from an authorized source is well-stated and includes an incremental estimate of cost and schedule impact before review and approval by stakeholders.
How do ASC types affect requirements?

**Answer Choices**

a) Different objects and dialogs needed to meet identical requirements

b) Legacy ASCs require the use of compact, complex objects

c) ATC 5201 ASCs handle long dialogs of standardized objects

d) Legacy ASCs are being replaced within existing budgets and have standardized objects

e) All of the above
Review of Answers

a) Different objects and dialogs needed to meet identical requirements

Correct. Legacy ASCs are constrained to short dialogs.

b) Legacy ASCs require the use of compact, complex objects

Correct. Legacy ASCs are constrained to low speeds.

c) ATC 5201 ASCs handle long dialogs of standardized objects

Correct. Each object can be standardized with ID.

d) Legacy ASCs are being replaced within existing budgets and have standardized objects

Correct. Suppliers build only Modern, ATC 5201, ATC 5202.

e) All of the above

Correct! All of the above are true.
Summary of Learning Objective #5

Manage Requirements Specific to ASC

We discussed each of the following issues:

1. Managing requirements: What does it mean?
2. ASC Types vs. Performance Requirements
3. Understand control, parameter and status objects
4. Understand database transaction sets (i.e. dbcreate, etc.)
5. Understand NTCIP consistency checks and rules
6. Understand block objects
7. Simple Network Management Protocol (SNMP)
8. Simple Transportation Management Protocol (STMP)
Learning Objective #6: Incorporate Requirements Not Supported by Standardized Objects

1. Proper use of manufacturer-specific objects to support advanced functions beyond TS-2
2. Improper use of manufacturer-specific objects that creates conflicts with standards
3. Example of manufacturer-specific object for advance function
4. Example of contract wording to avoid improper use of manufacturer-specific objects
5. Adaptive control and architectures
6. Exception-based reporting
7. Verify NTCIP conformance
1. Proper use of Manufacturer-Specific Objects

What are MSOs?

Manufacturer-specific objects (MSO) are:

- Objects defined by ASC manufacturers and developers
- Allowed by the NTCIP Standards
- Implemented to support advanced functions beyond TS-2 Standard
1. Proper Use of Manufacturer-Specific Objects

MSOs Versus Optional Objects

- Optional objects are defined by the NTCIP Standard
- MSOs are defined by ASC manufacturers
- Optional objects are interoperable
- MSOs are not interoperable
1. Proper Use of Manufacturer-Specific Objects (cont.)

To Support Advanced Functions Beyond TS-2

- Proper use of MSOs:
  - Allows innovation and new features beyond TS-2 functionality
  - Provides a migration path to optional if widely used
  - Example of MSO migration:
    - Purdue University Indiana Performance Measures began as a private NTCIP node for interoperability
    - Adopted by three manufacturers to date
    - Appearing in contract specifications beyond Indiana
2. Improper Use of Manufacturer-Specific Objects

Creates Conflicts with Standards

- Manufacturer-specific objects (MSOs) are:
  - Never a substitute for standardized NTCIP objects that perform similar functions
  - Not to be used as a disguise for proprietary protocols
2. Improper Use of Manufacturer-Specific Objects (cont.)

Examples of Improper Uses

- Replace mandatory object
- Replace optional object
- Wrapper for proprietary protocols
Proper MSO Use for Adaptive Control:

- **User Need:** ASC signal timing needs to automatically adjust based on vehicles departing nearby ASCs

- **Requirements:**
  - ASC shall detect vehicles departing intersection
  - ASC shall transmit detection of departing vehicles to central
  - Transmission of departures shall occur once per second
  - Central shall adjust signal timing on all ASCs once every three seconds

- **Analysis:**
  - No standard mandatory object meets the requirement
  - No standard optional object meets the requirements
Proper MSO Use for Adaptive Control (continued):

- Create the following MSOs to meet requirements:
  - PhasesToStage MSO to configure each combination of non-conflicting Phases as Stage ID
  - StageNext MSO to force ASC to a stage of non-conflicting phases that best handles arrivals from all directions

- Deliverables:
  - Documentation for two MSOs for interoperability
  - List of mandatory objects provided
  - List optional object required for ASC interoperability
4. Example of Contract Wording

Learn to Avoid Improper Use of MSOs

- Example contract wording:
  - All mandatory objects shall be provided
  - All optional objects required for ASC functions shall be listed
  - No MSOs are allowed except as listed in the procurement contract for advanced functions not contained in NTCIP Standards
5. Exception-Based Reporting

What is Exception Reporting?

- NTCIP 1103 v03 contains common transportation management protocols and is referenced by NTCIP 1202 v02
- Defined events are reported by ASC when they occur
-Eliminates the need to poll each ASC to avoid missing an event
- Significantly reduces communications loading to many ASCs
- Use of exception-based reporting to meet requirements
  - Required number of bits to GET required status from all ASCs
  - Required additional communications bits, SETs, etc.
  - Required update rate
  - If the required data exceeds the available bandwidth, exception-based reporting may be used to meet requirements
5. Exception-Based Reporting (cont.)

Example

- User needs to:
  - Maintain the status of 12,000 ASCs
  - Use existing communications infrastructure

- Requirements:
  - Central data shall update within 1 second
  - Central shall monitor 12,000 ASCs

- Design:
  - Existing communications infrastructure bandwidth constrains polling of each ASC to 76 ASCs per second
  - Central sets each database for initialization
  - ASCs push exceptions to central that identify data changes
6. Verify NTCIP Conformance

Conformance to Requirements

- Include NTCIP conformance in contract terms and conditions
- Require lists of mandatory and optional objects for each ASC as a deliverable
- For interoperability, dialogs for each function must be included
- Conformance for 1202 v3 will be different than 1202 v2
- MSOs should be contractually forbidden except for features not defined by NTCIP
- Acceptance terms should be included in the contract
- Develop RTM to insure conformance and reinforce conformance
6. Verify NTCIP Conformance (cont.)

Use of Test Scripts

- Test scripts should be required to test interfaces before equipment is installed using off-the-shelf testers
- Test scripts are a record of dialogs that are installed on an off-the-shelf tester that simulates the connected device
- Test scripts are provided by the systems engineer
- Test scripts define the interfaces of the high-level design
6. Verify NTCIP Conformance (cont.)

**Verify, Not Enforce**

- Use the Requirements Traceability Matrix (RTM)
- Verify each requirement ID using the test scripts
- Ideally, the test scripts are available to the manufacturers

<table>
<thead>
<tr>
<th>RID</th>
<th>Requirement</th>
<th>Dialog (Design)</th>
<th>Object ID</th>
<th>Object</th>
<th>Dialog (Test)</th>
</tr>
</thead>
</table>

Verify that the Design Dialog matches each ASC manufacturer’s Test Dialog
Additional Information Provided in the Student Supplement

- Adaptive Systems
  - List of available Adaptive Systems
  - Requirements for Adaptive Systems
  - MOS example for Adaptive Control
ACTIVITY
Why should dialogs be defined in a procurement specification?

Answer Choices

a) Devices are more likely to conform to the standards
b) Devices are more likely to interoperate and interchange
c) Increases the total cost of ownership
d) Device costs are likely to be less expensive
Review of Answers

a) Devices are more likely to conform to the standard

Incorrect. *Dialogs are not part of the standards. Dialogs are part of the design used to meet project requirements.*

b) Devices are more likely to interoperate and interchange

Correct! *Dialogs promote a common expectation on how objects are to be exchanged among devices.*

c) Increases the total cost of ownership

Incorrect. *Interoperability results in lower integration and testing costs. Interchangeability allows competitive bids of standard equipment throughout the service life of the system.*

d) Device costs are likely to be less expensive

Incorrect. *Specifying longer dialogs of standardized objects might require upgrading or relocating legacy ASCs.*
Summary of Learning Objective #6

Incorporate Requirements Not Supported by Standardized Objects

- MSOs are used only for ASC functions not defined by NEMA TS-2
- Using MSOs to replace standardized objects:
  - Creates conflicts with the NTCIP Standards
  - Breaks interoperability with other manufacturers
- Adaptive control is an example of an MSO properly used to automatically adjust signal timing, which is not defined by TS-2
- Procurement contracts should contain wording that prohibits the use of MSOs to replace standardized functions defined by NEMA TS-2
Summary of Learning Objective #6

Incorporate Requirements Not Supported by Standardized Objects (cont.)

- Adaptive control algorithms are used to automatically adapt signal timing to approaching vehicles
  - “Per-second” automatic adjustments before vehicle arrivals
  - Not based on traditional timing plans or actuations of vehicles that have already arrived
  - Immediate response to incidences and events

- Exception-based reporting can be used to meet requirements for large ASC deployments lacking bandwidth to poll each ASC

- Verification should be a contract term, not an afterthought, including the expected results of test scripts using off-the-shelf test equipment
What We Have Learned

1) The same functionality may lead to different requirements for ASC performance types.

2) Depending upon requirements, parameter, control and status can be realized as individual objects, block objects, or transaction sets.

3) STNP should be avoided to use standardized objects when communicating on modern networks.

4) ASC clock coordination is constrained by service power, communications, and coordination type.
What We Have Learned

5) Manufacturer-specific objects are properly used for functions not defined by __optional___ and __mandatory___ objects.

6) Except for their proper use, manufacturer specific objects should be banned by __contract terms and conditions___.

7) Adaptive control is an example of a __manufacture-specific object__ used to meet requirements not possible by using standard objects.

8) __Exception-based reporting___ can be used to receive status changes without repeatedly polling all ASCs on the communications network.

9) Contract terms should include __requirements traceability matrix___ and __test scripts___ for standard 3rd party test equipment.
Resources

- Institute of Transportation Engineers, ATC 5201 Advanced Transportation Controller (ATC) Standard Version 06. ATC Joint Committee, 30 July 2012.
- Institute of Transportation Engineers, ATC 5202 Model 2070 Controller Standard Version 03. ATC Joint Committee, 28 December 2012.
- NTCIP 12xx, Device Data Dictionaries and NTCIP Guide (available at ntcip.org)
Fill in information here
Deborah Rouse, 4/9/2015
QUESTIONS?