



W E L C O M E



U.S. Department of Transportation
Office of the Assistant Secretary for
Research and Technology

Welcome



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A screenshot of the United States Department of Transportation's Intelligent Transportation Systems Joint Program Office website. The header includes the DOT logo, navigation links for About DOT, Briefing Room, Our Activities, and OST-R publications, and a search bar. The main content area features a banner for the ITS Professional Capacity Building Program, showing a group of people in a training session. A blue callout box on the left says "Welcome to ITS Professional Capacity Building" and describes the program as the U.S. Department of Transportation's leading program for delivering ITS training and learning resources to the nation's ITS workforce. On the right, there are sections for "WHAT'S NEW" (including a new web-based training course), "New NHI Course" (Systems Engineering for Signal Systems Including Adaptive Control), "New ITS Case Study Available" (National ITS Architecture), and "Added to T3 Archive" (two entries: Open Data Policy Guidelines and Saving Lives and Keeping Traffic Moving).

United States Department of Transportation

OFFICE OF THE ASSISTANT SECRETARY FOR RESEARCH AND TECHNOLOGY

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WHAT'S NEW

New Web-Based Training from ITS Joint Program Office

- Connected Vehicle Reference Implementation Architecture Training now available

New NHI Course

- Systems Engineering for Signal Systems Including Adaptive Control (NHI-133123)

New ITS Case Study Available

- National ITS Architecture

Added to T3 Archive

- Learn from the Experts: Open Data Policy Guidelines for Transit - Maximizing Real Time and Schedule Data-Legalities, Evolutions, Customer Perspectives, Challenges, and Economic Opportunities - Part II
Presented on August 7, 2014
- Saving Lives and Keeping Traffic Moving: Quantifying the Outcomes of Traffic Incident Management (TIM) Programs
Presented on July 31, 2014

Welcome to ITS Professional Capacity Building

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A C T I V I T Y



T203 Part 1 of 2: How to Develop Test Cases for an ITS Standards-based Test Plan, Part 1 of 2



Instructor



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Target Audience

- Traffic management and engineering staff
- Maintenance staff
- System developers
- Testing personnel
- Private and public sector users including manufacturers

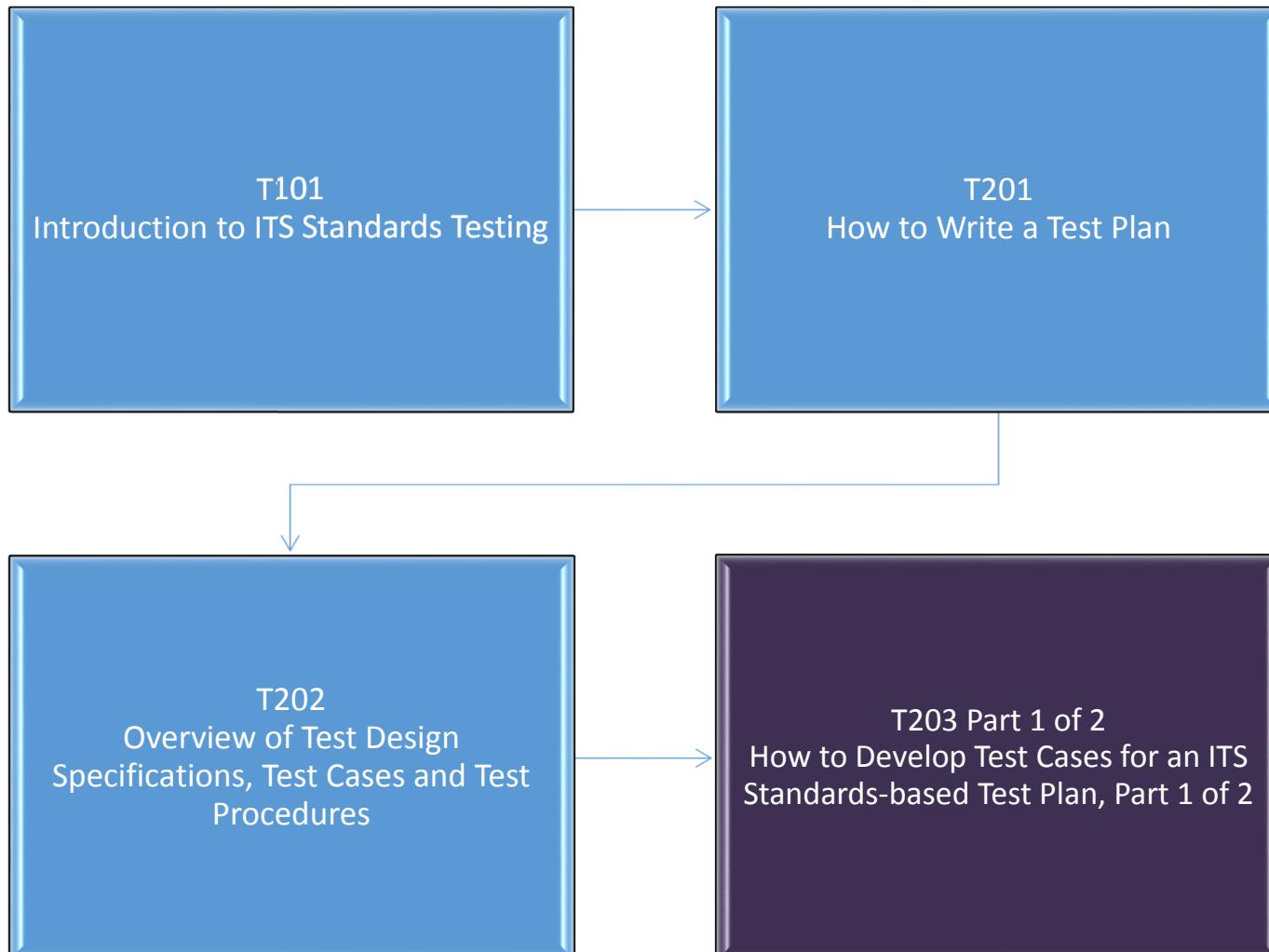


Recommended Prerequisite(s)

- T101: Introduction to ITS Standards Testing
- T201: How to Write a Test Plan
- T202: Overview of Test Design Specifications, Test Case Specifications, and Test Procedures



Curriculum Path (Testing)



List of Acronyms Used in this Module

| | |
|-------|---|
| ASN.1 | Abstract Syntax Notation 1 |
| C2C | Center-to-Center (Information Exchange) |
| C2F | Center-to-Field (NTCIP Devices) |
| CCTV | Closed Circuit Television |
| DMS | Dynamic Message Sign |
| ESS | Environmental Sensor Station |
| MIB | Management Information Base |
| NRTM | Needs to Requirements Traceability Matrix |
| NTCIP | National Transportation Communications for ITS Protocol |
| PRL | Protocol Requirements List |
| PDU | Protocol Data Unit |
| RTM | Requirements Traceability Matrix |
| RTCTM | Requirements to Test Case Traceability Matrix |



List of Acronyms Used in this Module (cont.)

| | |
|------|------------------------------------|
| TMDD | Traffic Management Data Dictionary |
| TDS | Test Design Specification |
| TCS | Test Case Specification |
| SE | System Engineering |
| SEP | System Engineering Process |
| XML | Extensible Markup Language |



Learning Objectives

Part 1 of 2:

1. Review the role of test cases within the overall testing process.
2. Discuss ITS data structures used in NTCIP and Center-to-Center standards (TMDD) and provide examples.
3. Find information needed to develop a test case.
4. Explain test case development.

Part 2 of 2:

5. Handle standards that are with and without test documentation.
6. Develop a Requirements to Test Case Traceability Matrix (RTCTM).
7. Identify types of testing.
8. Recognize the purpose of test logs and test anomaly report.



Learning Objective 1: Review the Role of Test Cases Within the Overall Testing Process

- Review test documentation as defined in IEEE Std 829
- Show test cases in relationship to test plans, test designs, and test procedures
- Review ITS standards testing approaches and advantages of IEEE Std 829-based testing



Brief Review of Module T202

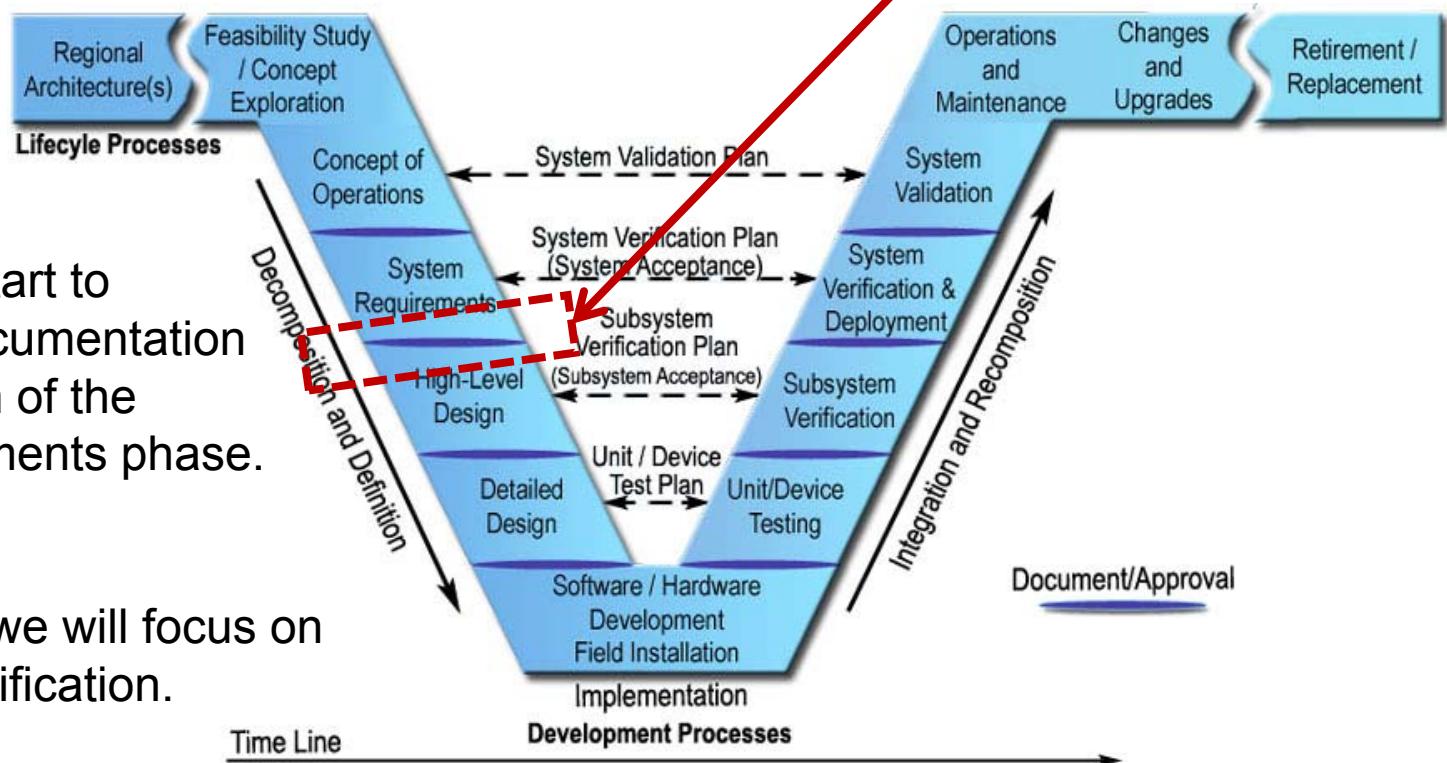
- **Module T202** provided the context of the testing life cycle; what to test and when to test during System Engineering life cycle:
 - Provided overview of testing documentation, including Test Design Specifications, Test Cases, and Test Procedures
 - Introduced IEEE Std 829-2008, a Standard for Software and System Test Documentation that guides on formats
 - This module teaches how to use IEEE approach (users can customize testing documentation for their specification)



Beginning of a Project Level Test Process

Agencies can start to prepare test documentation after completion of the system requirements phase.

In this module, we will focus on Test Case Specification.



SE Life Cycle

What is a Testing Process?

- The purpose of software and software-based systems testing is:
 - To help build quality into the software and system during the life cycle processes and to validate that the quality was achieved
 - To determine whether the products of a given life cycle activity conform to the requirements of that activity, and whether the product satisfies its intended use and user needs
 - Includes inspection, demonstration, analysis, and testing of software and software-based system products
 - To perform test activities in parallel with development efforts, not just at the conclusion of the development effort



What is a Test Case?

- A test case specifies the inputs, outcomes, and conditions for execution of a test
- A test case is identified and included in a Test Case Specification (TCS) as part of an ITS project overall Test Plan
- This module teaches how to prepare a test case documentation by the agencies



Approaches to Preparing Project Testing Documentation

1. ITS Standards Approach
2. IEEE Std 829 Approach



A Joint Information Management Policy of AASHTO, ITE, and NEMA

NTCIP 8007 version v01

National Transportation Communications for ITS Protocol

Testing and Conformity Assessment Documentation within NTCIP Standards Publications

published in May 2008

A Joint Standard of AASHTO, ITE, and NEMA

NTCIP 1204 version v03

National Transportation Communications for ITS Protocol

Environmental Sensor Station (ESS) Interface Protocol

published in October 2009

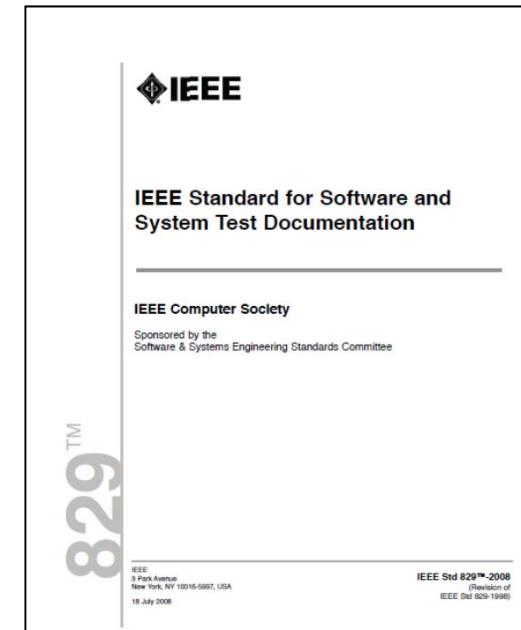
IEEE Std 829 Testing Approach

- IEEE approach is applicable to all devices
 - Separates test cases and test procedures allows re-use of procedures
 - Includes a test plan and a method to split testing into test designs
 - Includes test reports
- IEEE approach can be more broadly applied (common format) across ITS, including center-to-center and center-to-field standards



What does IEEE Std 829 Provide?

- Guidance and formats for preparing testing documentation:
 - Test Plan
 - Test Design Specification
 - Test Case Specification
 - Test Procedure Specification
 - Test Reports
 - Test Logs
 - Test Anomaly Report
 - Test Report
- Testing professionals across ITS are familiar with these definitions-formats

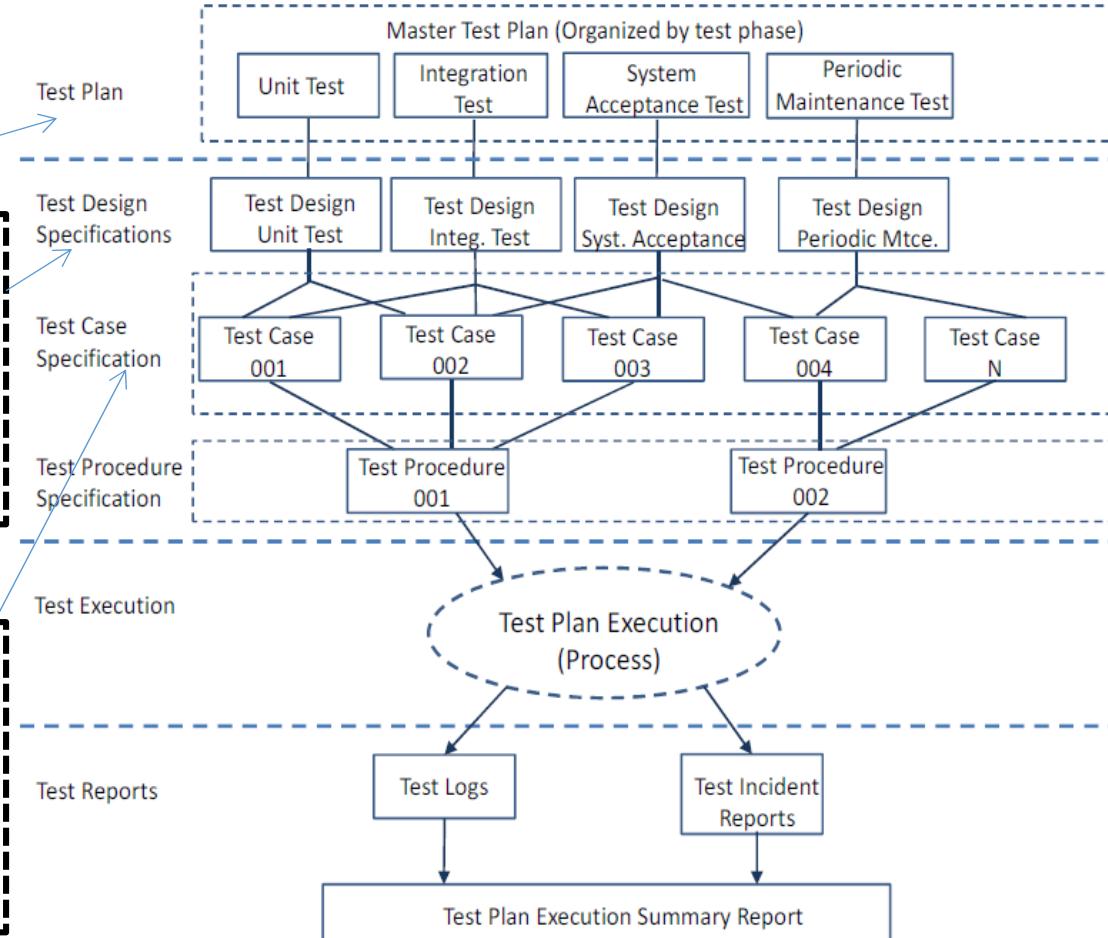


Testing Documentation Structure (IEEE Std 829)

Test Plan describes the overall approach to testing

Test Design Specification describes which requirements are to be tested and associated test cases

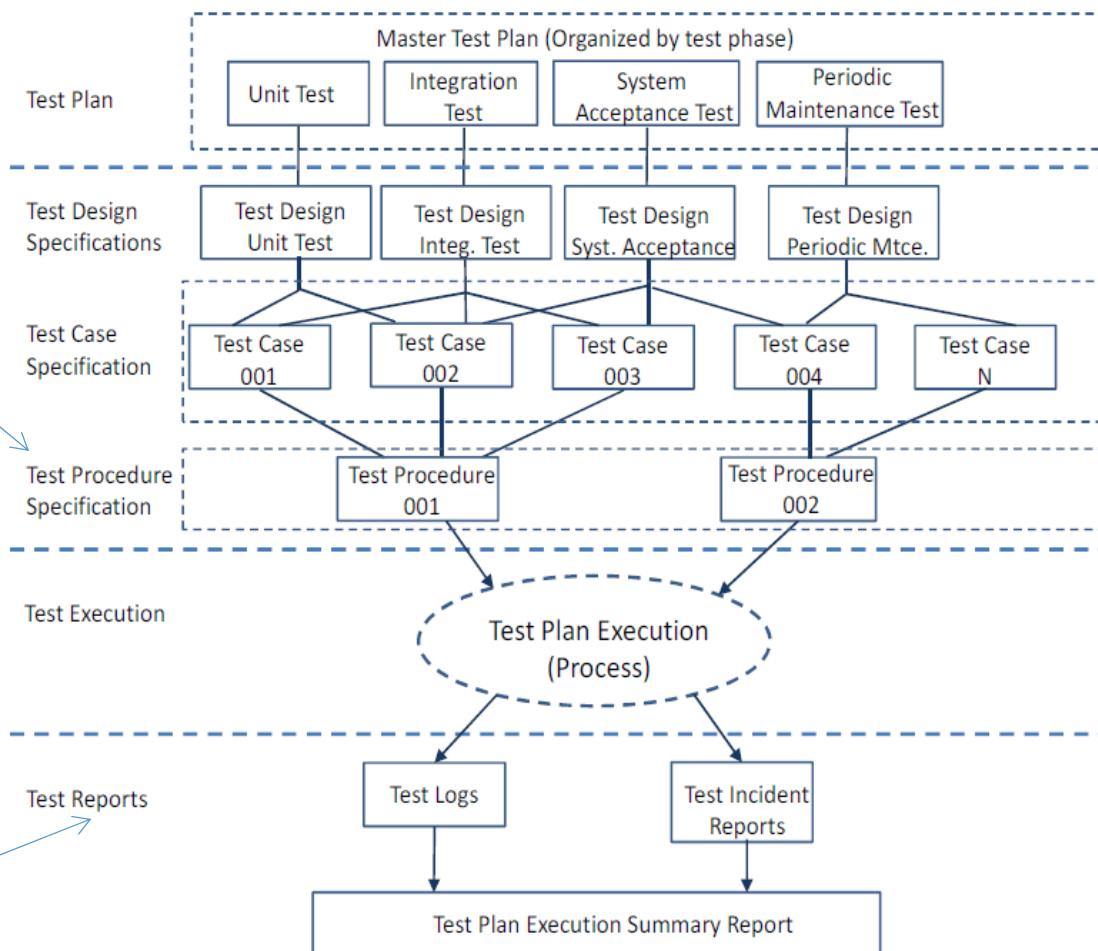
Test Case Specification identifies objectives and inputs, outcomes, and conditions for execution of a test



Testing Documentation Structure (cont.)

- **Test Procedure Specification** defines the steps to execute a test
- Multiple Test Cases may reference a single Test Procedure
- Test Procedures may be more costly to develop than Test Cases

- **Test Reports: Test Logs, Test Anomaly Reports, Test Report**



Key Differences Between the Two Approaches

- IEEE standard approach is applicable to all ITS standards including C2C and C2F
- IEEE standard approach separates test cases from test procedures while previous efforts combined both such as per NTCIP 8007 information report
- IEEE standard approach allows re-use of test procedures, where agencies typically place more efforts
- IEEE standard approach includes a test plan and method to split testing into test designs, and includes test reports



A C T I V I T Y



Which of the following IEEE Std 829-based component describes data inputs and outputs to be tested?

Answer Choices

- a) Test Plan
- b) Test Case Specification
- c) Test Design Specification
- d) Test Procedure Specification



Review of Answers



- a) Test Plan

Incorrect. Test plan describes overall approach.



- b) Test Case Specification

Correct! Test Case Specification focuses on data input and output requirements to be tested.



- c) Test Design Specification

Incorrect. Test Design Specification specifies the requirements to be tested and which test cases are associated with which requirements.



- d) Test Procedure Specification

Incorrect. Test procedures outlines steps.

Summary of Learning Objective #1

Review the Role of Test Cases Within the Overall Testing Process

- Reviewed test documentation structure as defined in IEEE Std 829
- Discussed test cases in relationship to test plans, test designs, and test procedures
- Review ITS standards testing approaches and IEEE Std 829-based testing approach and key difference

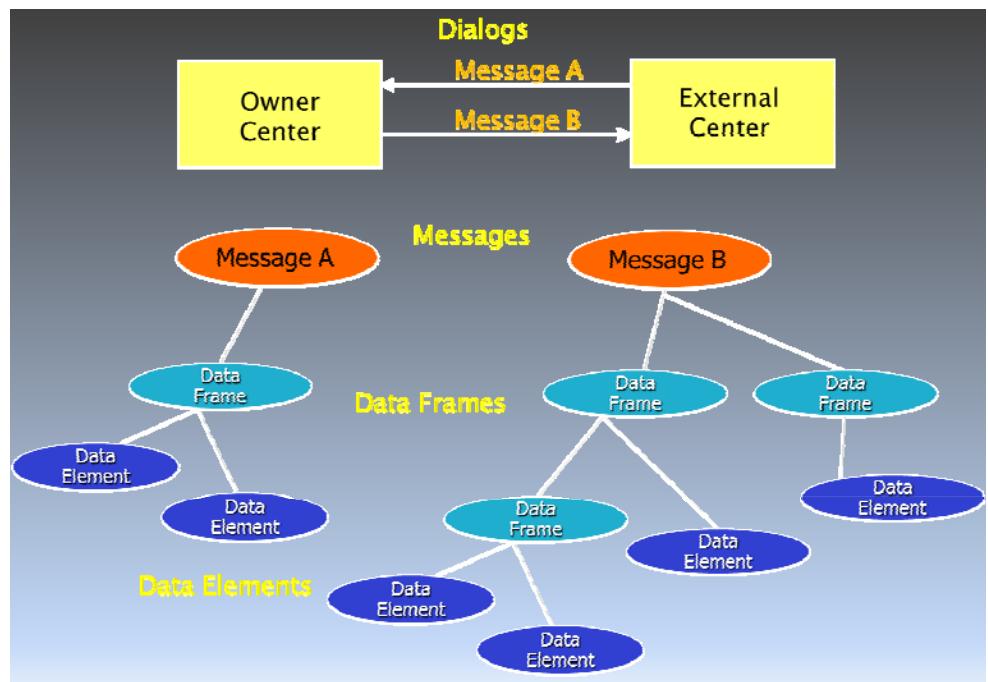
Learning Objective #2: Discuss ITS Data Structures Used in NTCIP and Center-to-Center Standards (TMDD) and Provide Examples

- Review data structure of ITS information and provide examples
- Discuss how a test case verifies the **correct structure of the data** as specified in the standards
- Discuss how a test case verifies the **correct value of the data** (range-syntax) and **data types** to conform the standards



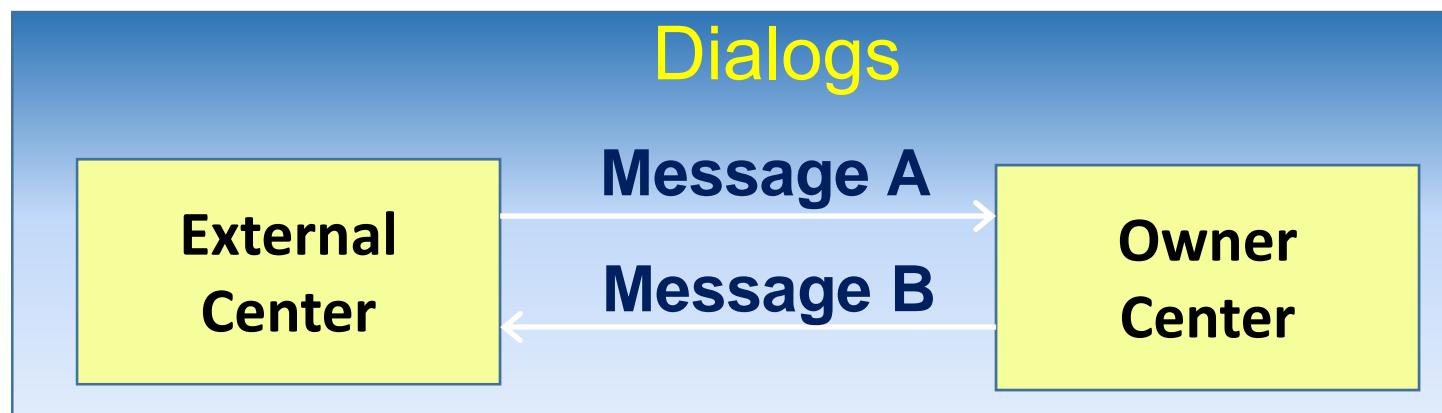
Example: Information Exchange Between ITS Centers

- Centers exchange information using **Dialogs**
- Dialogs contain **Messages**
- Messages are formed with **Data Frames** and **Data Elements**



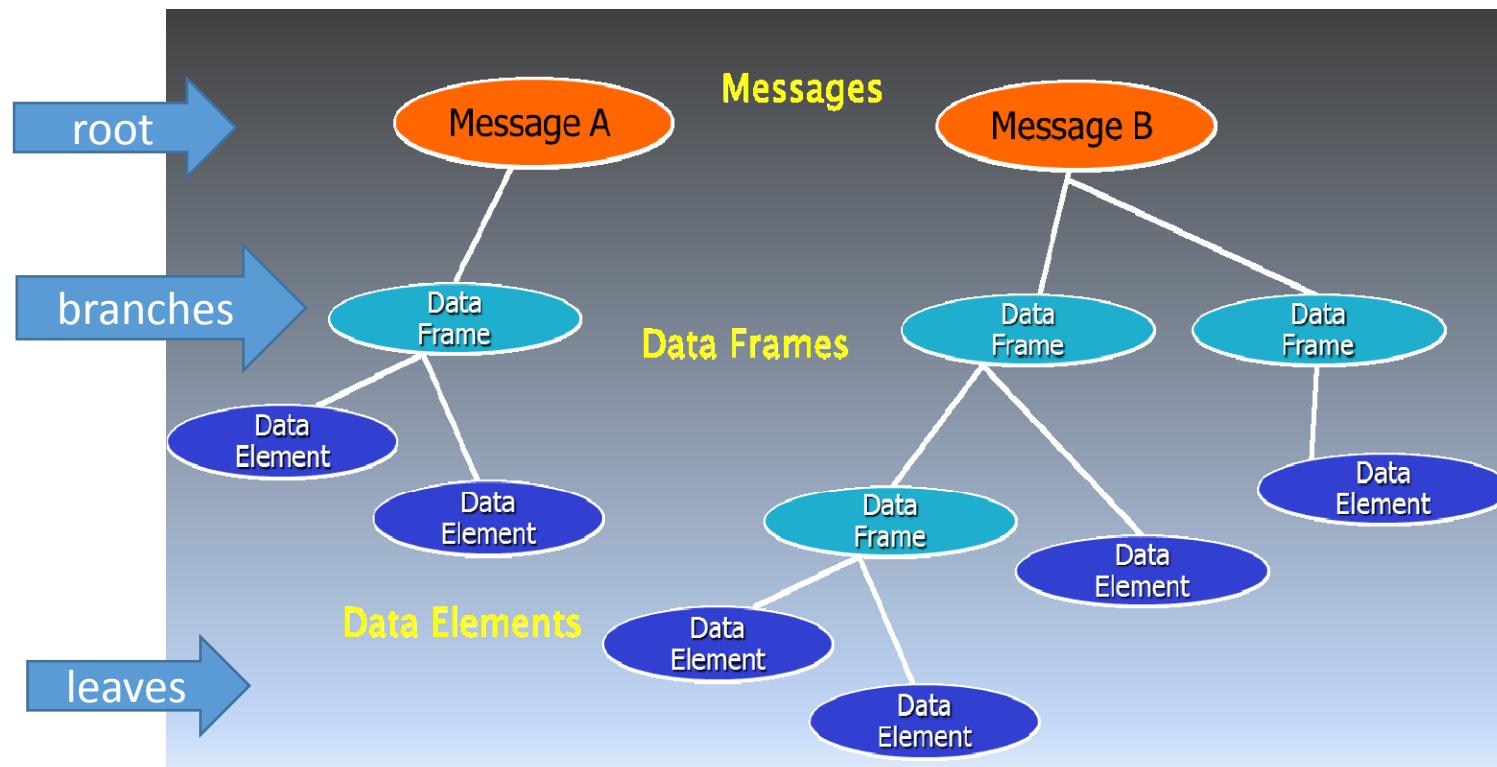
What does Testing Verify? (Information Exchange Standards)

- Testing verifies the correct sequence of information being exchanged:
 - Standardized **Dialogs** specify the correct sequence of information exchanges



Verifying the Correct Structure of Information

- ITS standards specify the tree-like exact structure of information



Data Structure Is Tree-Like (Hierarchical)

- **Messages** (Root level)
 - Root element in the hierarchy of data exchanged between centers
 - A message is made up of data frames and data elements
- **Data Frames** (Branch level)
 - Reusable bundles of data elements and other data frames
- **Data Elements** (Leaf level)
 - Leaves in the hierarchy of data structure
 - Provide value constraints for data content



How?

- **Test Case Specification (TCS) Identifies:**
 - Inputs (Message A)
 - Outcomes-Predicted results (Message B)
 - Execution conditions (sequence): Owner Center responds with Message B upon receipt of Message A from External Center



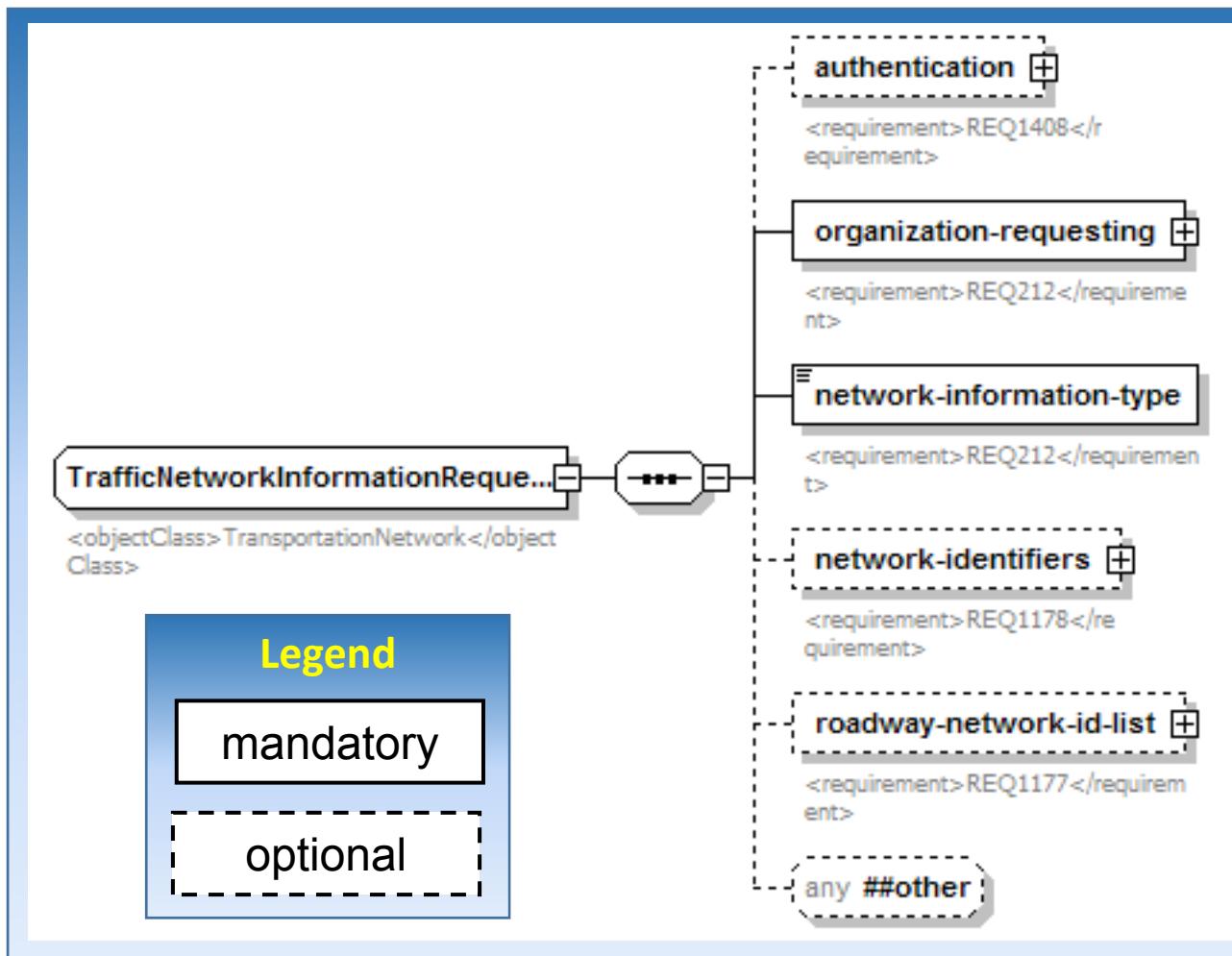
Example: Center-to-Center Dialog

- Only specified sequence of messages and combinations are valid
 - linkStatusRequestMsg is used to make the request
 - linkStatusMsg contains the response



Example: Center-to-Center Data Structure of linkStatusRequestMsg

- linkStatusRequestMsg is of type TrafficNetworkInformationRequest



Constraints on Content of Data Values

- Device Standards: Testing verifies the **correct value** of object instance and protocol data units (PDUs)
- ITS standards use XML format for C2C information exchange data and ASN.1 for C2F NTCIP device data
- Typical data value constraints are:
 - Data type such as text or number
 - Enumerations such as a list of valid values
 - Text length
 - Numerical value ranges such as 0-255 in NTCIP Objects

(Note: some devices use 0 as value to turn OFF a Device, 1 to turn ON, Ramp Meter Control standard uses 1-255 range)



Example: Center-to-Field Device (ESS)

- Only number values are valid: Values 1 through 12.

Constraint:
Number Value

SYNTAX INTEGER

Constraint:
Value Range

1 to 12

5.6.10.10 Wind Sensor Situation

windSensorSituation OBJECT-TYPE

SYNTAX INTEGER {

other (1), **unknown** (2), **calm** (3), **lightBreeze** (4), **moderateBreeze** (5), **strongBreeze** (6), **gale** (7), **moderateGale** (8), **strongGale** (9),
stormWinds (10), **hurricaneForceWinds** (11), **gustyWinds** (12)}

ACCESS read-only

STATUS mandatory

DESCRIPTION "<Definition>Describes the weather and travel situation in terms of wind from staffed stations only. Specific ranges for these values are defined in the Glossary of Meteorology.

<DescriptiveName>WindSensor.situation:code

gustyWinds defined by a peak and a lull of greater than 46.3 tenths of meters per second within a 2 minute period.

<Data Concept Type>Data Element"

::= { windSensorEntry 10 }

Source: NTCIP 1204 v03

Examples of Constraints on Data Structure

- **C2F NTCIP Devices:**
 - Management Information Base (MIB)
 - ASN.1 Object Value specification
- **C2C TMDD (Volume II - Design):**
 - XML Value specification
 - ASN.1 Value specification
- **Data Structure:**
 - Message
 - Data Frames
 - Data Elements



What is the Purpose of a Test Case?

- To verify the requirements related to information exchanged between two systems by:
 - Verifying the sequence of information exchanged is correct:
 - Standards use dialogs to define information exchange sequence
 - Verifying the structure of information exchanged is correct
 - Standards define the order of Messages-Data Frames-Data Elements
 - Verifying the content of information exchanged is correct
 - Standards define the valid value rules (e.g., value ranges) for data exchanged



Relationship of Test Case to Requirements

- Purpose: To test monitoring capability stated by a requirement
- A Requirement to Test Case Traceability Matrix (RTCTM) relates the test case to requirement(s) being tested.

NTCIP 1204 v03.08
Page 154

| Requirement | | Test Case | |
|-------------|---|-----------|---|
| ID | Title | ID | Title |
| 3.5.1.1.2 | <i>Retrieve Compressed Station Metadata</i> | | |
| | | C.2.3.1.2 | <i>Retrieve Compressed Station Metadata</i> |
| 3.5.1.1.3 | <i>Configure ESS Manager</i> | | |
| | | C.2.3.1.1 | <i>ESS Characteristics</i> |
| 3.5.1.2 | <i>ESS Status Monitoring Requirements</i> | | |
| 3.5.1.2.1 | <i>Retrieve ESS Door Status</i> | | |
| | | C.2.3.1.3 | <i>Retrieve ESS Door Status</i> |
| 3.5.1.2.2 | <i>Retrieve Battery Status</i> | | |
| | | C.2.3.1.4 | <i>Retrieve Battery Status</i> |



A C T I V I T Y



Which of the following defines the structure and data content of inputs and outputs?

Answer Choices

- a) Data Dictionary Standard (e.g., NTCIP 1204 ESS, TMDD)
- b) Protocol Requirements List (PRL)
- c) Requirements to Test Case Traceability Matrix (RTCTM)
- d) All of the above

Review of Answers



- a) Data Dictionary (e.g., NTCIP 1204 ESS, TMDD)

Correct! A data dictionary specifies the structure of data and constraints of valid values for data content.



- b) Protocol Requirements List (PRL)

Incorrect. The PRL traces requirements to needs, and allows you to specify optional requirements for a specific project.



- c) Requirements to Test Case Traceability Matrix (RTCTM)

Incorrect. The RTCTM traces test cases to the requirements the test case verifies.



- d) All of the above

Incorrect. Only a) above is correct.

Summary of Learning Objective #2

Discuss ITS Data Structures used in NTCIP and Center-to-Center Standards (TMDD) and Provide Examples

- Reviewed data structure of ITS information with examples
- Discuss how a test case verifies the correct structure of the data as specified in the standards
- Discussed how a test case verifies the correct value of the data (range-syntax) and data types to conform the standards



Learning Objective #3: Find Information Needed for a Test Case

- What information is needed:
 - Relevant User Needs for Project
 - Relevant Requirements
 - Relevant Design (dialogs, data elements, and valid values)
- Where to find content for a Test Case for C2C standards (TMDD)
- Where to find content for a Test Case for C2F standards (NTCIP)



Where to Find C2C Standards Content

- Requirements and dialogs are identified by project level **Needs to Requirements Traceability Matrix (NRTM)**
- Dialogs identifies **inputs and outputs** needed to develop the test case specification

TMDD v03 NRTM

Each project tailors
this matrix

| UN ID | User Need | Reqmt Type | Req ID | Requirement | Conformance | Support |
|---|----------------------------|------------------|--------|--|----------------|-----------|
| 2.5.2.2 | Travel Time Data for Roads | | | | Optional | Yes/No |
| Dialogs for Link Based Information | | | | | | |
| | | 3.5.3.3.2.1 | | Send Link Status Information Upon Request | M | Yes/No/NA |
| | | 3.5.3.3.2.2 | | Publish Link Status Information | Subscription:O | Yes/No/NA |
| | | 3.5.3.3.2.3 | | Subscribe to Link Status Information | Subscription:O | Yes/No/NA |
| Request Message | | | | | | |
| | | 3.5.3.3.2.4 | | Contents of the Link Status Request | M | Yes |
| | | 3.5.3.1.1 | | Contents of the Traffic Network Information Request | M | Yes |
| | | 3.5.3.1.1.1 | | Required Traffic Network Information Request Content | M | Yes |
| | | 3.5.3.1.1.2.1 | | Authentication | O | Yes/No |
| | | 3.5.3.1.1.2.1.1 | | Operator Identifier | O | Yes/No |
| | | 3.5.3.1.1.2.2 | | Roadway Network Identifier | O | Yes/No |
| | | 3.5.3.1.1.2.3 | | Traffic Network Identifier | O | Yes/No |
| Response Message | | | | | | |
| | | 3.5.3.3.2.5 | | Contents of the Link Status Information | M | Yes |
| | | 3.5.3.3.2.5.1 | | Required Link Status Information Content | M | Yes |
| | | 3.5.3.3.2.5.2.1 | | Restrictions | O | Yes/No |
| | | 3.5.3.3.2.5.2.2 | | Link Name | O | Yes/No |
| | | 3.5.3.3.2.5.2.3 | | Link Direction | O | Yes/No |
| | | 3.5.3.3.2.5.2.4 | | Link Travel Time | M* | Yes/No |
| | | 3.5.3.3.2.5.2.11 | | Status Date and Time Change Information | O | Yes/No |
| Error Report Message | | | | | | |
| | | 3.4.4.1 | | Contents of the Error Report | M | Yes |
| | | 3.4.4.1.1 | | Required Error Report Contents | M | Yes |
| | | 3.4.4.1.2.1 | | Restrictions | O | Yes / No |



Example of a Project Level NRTM

| UN ID | User Need | Reqmt Type | Req ID | Requirement | Conformance | Support |
|---------|----------------------------|------------------------------------|------------------|--|----------------|-----------|
| 2.5.2.2 | Travel Time Data for Roads | | | | Optional | Yes/No |
| | | Dialogs for Link Based Information | | | | |
| | | | 3.5.3.3.2.1 | Send Link Status Information Upon Request | M | Yes/No/NA |
| | | | 3.5.3.3.2.2 | Publish Link Status Information | Subscription:O | Yes/No/NA |
| | | | 3.5.3.3.2.3 | Subscribe to Link Status Information | Subscription:O | Yes/No/NA |
| | | Request Message | | | | |
| | | | 3.5.3.3.2.4 | Contents of the Link Status Request | M | Yes |
| | | | 3.5.3.1.1 | Contents of the Traffic Network Information Request | M | Yes |
| | | | 3.5.3.1.1.1 | Required Traffic Network Information Request Content | M | Yes |
| | | | 3.5.3.1.1.2.1 | Authentication | O | Yes/No |
| | | | 3.5.3.1.1.2.1.1 | Operator Identifier | O | Yes/No |
| | | | 3.5.3.1.1.2.2 | Roadway Network Identifier | O | Yes/No |
| | | | 3.5.3.1.1.2.3 | Traffic Network Identifier | O | Yes/No |
| | | Response Message | | | | |
| | | | 3.5.3.3.2.5 | Contents of the Link Status Information | M | Yes |
| | | | 3.5.3.3.2.5.1 | Required Link Status Information Content | M | Yes |
| | | | 3.5.3.3.2.5.2.1 | Restrictions | O | Yes/No |
| | | | 3.5.3.3.2.5.2.2 | Link Name | O | Yes/No |
| | | | 3.5.3.3.2.5.2.3 | Link Direction | O | Yes/No |
| | | | 3.5.3.3.2.5.2.4 | Link Travel Time | M* | Yes/No |
| | | | 3.5.3.3.2.5.2.11 | Status Date and Time Change Information | O | Yes/No |
| | | Error Report Message | | | | |
| | | | 3.4.4.1 | Contents of the Error Report | M | Yes |

A Section of NRTM Tailored For Project-Specific Needs

| UN ID | User Need | Reqmt Type | Req ID | Requirement | Conformance | Support |
|---------|----------------------------|------------------------------------|-------------|---|----------------|---|
| 2.5.2.2 | Travel Time Data for Roads | | | | Optional | Yes/No |
| | | Dialogs for Link Based Information | | | | |
| | | | 3.5.3.3.2.1 | Send Link Status Information Upon Request | M | Yes/ <input checked="" type="checkbox"/> /No/N A |
| | | | 3.5.3.3.2.2 | Publish Link Status Information | | Yes/ <input type="checkbox"/> /No/N A |
| | | | 3.5.3.3.2.3 | Subscribe to Link Status Information | Subscription:O | Yes/ <input type="checkbox"/> /No/N A |

Section of the tailored RTM that corresponds with the requirements identified from the NRTM above. Section covering User Needs 2.5.2.2 is shown below.

| | RTSMIP-DXFS Requirement ID | Requirement | DC Type | TMDD Vol II DC Instance Name | TMDD Vol II DC ID | TMDD Vol II DC Class Name |
|--|----------------------------|---|---------|---|-------------------|---|
| | 3.5.3.3.2.1 | Send Link Status Information Upon Request | dialog | dIIlinkStatusRequest | 3.1.13.2 | dIIlinkStatusRequest |
| | 3.5.3.3.2.2 | Publish Link Status Information | dialog | dIIlinkStatusUpdate | 3.1.34.2 | dIIlinkStatusUpdate |
| | 3.5.3.3.2.3 | Subscribe to Link Status Information | dialog | dITrafficNetworkInformationSubscription | 3.1.19.1 | dITrafficNetworkInformationSubscription |

Where to Find C2F Standards Content

- Requirements are identified by project level **Protocol Requirements List (PRL)**
- NTCIP SEP standards such as DMS provides a PRL
- Non-SEP standards such as CCTV must develop a project PRL

| USER NEED SECTION NUMBER | USER NEED | FR SECTION NUMBER | FUNCTIONAL REQUIREMENT | CONFORMANCE | SUPPORT / PROJECT REQUIREMENT | ADDITIONAL PROJECT REQUIREMENTS |
|--------------------------|--------------------------------|-------------------|--|-------------|-------------------------------|---------------------------------|
| 2.5.2.3 | Control the Sign Face | | | M | Yes | |
| 2.5.2.3.1 | Activate and Display a Message | | | M | Yes | |
| | | 3.5.2.3.1 | Activate a Message | M | Yes | |
| | | 3.5.2.3.3.5 | Retrieve Message | M | Yes | |
| | | 3.5.2.3.6 | Activate a Message with Status | Drum:M | Yes / NA | |
| | | 3.6.5 † | Supplemental Requirements for Message Activation Request | M | Yes | |
| | | 3.6.7 † | Supplemental Requirements for Locally Stored Messages | M | Yes | |

Where to Find C2F Standards Content (cont.)

- Requirements Traceability Matrix (RTM) references relevant design content needed to define the **inputs and outputs** for the test case specification
- NTCIP SEP standards such as DMS provides a RTM
- Non-SEP standards such as CCTV must develop a project RTM

| Requirements Traceability Matrix (RTM) | | | | | |
|--|------------------------|-----------|------------|-------------------------------|---------------------------|
| FR ID | Functional Requirement | Dialog ID | Object ID | Object Name | Additional Specifications |
| 3.5.2.3 | Control the Sign Face | | | | |
| 3.5.2.3.1 | Activate a Message | 4.2.3.1 | 5.7.3 | dmsActivateMessage | |
| | | | 5.11.2.1.1 | shortErrorStatus | |
| | | | 5.7.17 | dmsActivateMsgError | |
| | | | 5.7.24 | dmsActivateErrorMsgCode | |
| | | | 5.7.18 | dmsMultiSyntaxError | |
| | | | 5.7.19 | dmsMultiSyntaxErrorPosition | |
| | | | 5.7.20 | dmsMultiOtherErrorDescription | |



A C T I V I T Y



Which of the following will provide information on project needs for a C2C project?

Sources of Information:

- a) Needs to Requirements Traceability Matrix (NRTM)
- b) Requirements to Test Case Traceability Matrix (RTCTM)
- c) Requirements Traceability Matrix (RTM)
- d) Design (dialogs, data elements, valid values)

Review of Answers



- a) Needs to Requirements Traceability Matrix (NRTM)

Correct! NRTM identifies project needs for a C2C project.



- b) Requirements to Test Case Traceability Matrix (RTCTM)

Incorrect. The RTCTM traces test cases to the requirements the test case verifies.



- c) Requirements Traceability matrix (RTM)

Incorrect. The RTM traces requirements to design objects for C2F NTCIP standard based project.



- d) Design (dialogs, data elements, valid values)

Incorrect. Project design does not trace to project needs.

Summary of Learning Objective #3

Find Information Needed for a Test Case

- Reviewed content sources for a test case information for C2C standard such as TMDD
- Reviewed content sources for a test case information for C2F standards such as NTCIP-ESS



Learning Objective #4: Explain Test Case Development

- Outline of a test case:
 - Suggested template
 - Required content
- Where do we find information for test case template?
 - Center-to-Center Standards (C2C)
 - Center-to-Field Standards (C2F)
- Discuss Positive/Negative Testing
- Additional test case Requirements



Outline of a Test Case-Suggested Template (IEEE Std 829)

- Required Content of a test case:
 - Test case identifier
 - Objective
 - Inputs
 - Outcomes
 - Environmental needs
 - Special procedural requirements
 - Intercede dependencies

| Test Case | |
|---------------------------------------|--|
| ID: | |
| Objective: | |
| Inputs: | |
| Outcome(s): | |
| Environmental Needs: | |
| Tester/Reviewer: | |
| Special Procedure Requirements: | |
| Intercase Dependencies: | |



Test Case Identifier

- Each test case requires a unique identifier to distinguish it from all other test cases.

| Test Case | |
|--|---|
| ID: TC001 | Title: Link Status Request-Response Dialog Verification (Positive Test Case) |
| Objective: | <p>To verify system interface implements (positive test case) requirements for:</p> <ol style="list-style-type: none"> 1) Link Status Request-Response Dialog message exchange 2) Contents of the Link Status Request Message 3) Contents of the Link Status Information Message <p>The test case verifies that the dialog, request message content, and response message content are correct by sending a request message (verified to be correct) across the system interface, and verification that the response message is correct. Input and output specifications are provided to verify the request and response message are correct per the requirements for the request and response message.</p> |
| Inputs: | Use the input file linkStatusRequest.xml. See Test Case Input Specification TCIS001 - LinkStatusRequest (Positive Test Case). |
| Outcome(s): | All data are returned and verified as correct: correct sequence of message exchanges, structure of data, and valid value of data content. See Test Case Output Specification TCOS001 - LinkStatusInformation (Positive Test Case) |
| Environmental Needs: | No additional needs outside of those specified in the test plan. |
| Tester/Reviewer | M.I. |
| Special Procedure Requirements: | None |
| Intercase Dependencies: | None |

Test Case Objective

- **Purpose:** The objective identifies the purpose of the test case
- **Focus:** Describe the special focus of a particular test case and relation to other test cases
- **Priority:** Test case priority



Test Case Objective: Focus

- Whether TC is for testing a dialog (i.e., correct sequence of message exchanges)
- Whether TC is testing correct structure and content of data
- Intercase dependencies
 - An example of an intercase dependency is when a test case to verify a publication dialog must be preceded by a complete and correct subscription dialog



Test Case Objective: Priority

- Identifies the relative importance of accomplishing certain test cases in advance of others
- Priority is project specific
- Examples:
 - Specify the order of which devices to test (e.g., CCTV first, DMS next, etc.)
 - Specify that inventory and status dialogs shall be tested first, followed by the testing of device control dialogs
 - Specify that request-response dialogs shall be tested first, followed by subscription-publication dialogs
 - Specify that positive test cases shall be tested first, followed by negative test cases



Test Case Inputs

- Specify each input required to execute each test case:
 - Some inputs will be specified by value (with tolerances where appropriate)
 - Some others such as constant tables or transaction files will be specified by name
 - Specify each input and timing of input(s) required to execute the test case



Example Test Case Input Specification

| Test Case Input Specification | | |
|--|---|--|
| ID: TCIS001 | Title: LinkStatusRequest (Positive Test Case) | |
| Data Concept Name (Variable) | Data Concept Type | Value Domain |
| trafficNetworkInformationRequestMsg | Message | |
| - organization-requesting | Data Frame | |
| - organization-id | Data Element | IA5String (SIZE(1..32)) |
| - organization-name | Data Element | IA5String (SIZE(1..128)) |
| - network-information-type | Data Element | 1 = "node inventory" 2 = "node status" 3 = "link inventory" 4 = "link status" 5 = "route inventory" 6 = "route status" 7 = "network inventory" |



Test Case Outcome(s)

- Outcomes specify all outputs and the expected behavior (e.g., response time) required of the test items
- Provides representative value(s) (with tolerances where appropriate) for each required output and expected behavior



Example Test Case Output Specification

| Test Case Output Specification | | |
|--------------------------------|---|--|
| ID: TCOS001 | Title: LinkStatusInformation (Positive Test Case) | |
| Data Concept Name (Variable) | Data Concept Type | Value Domain |
| linkStatusMsg | Message | |
| - link-status-item | Data Frame | |
| - organization-information | Data Frame | |
| - organization-id | Data Element | IA5String (SIZE(1..32)) |
| - organization-name | Data Element | IA5String (SIZE(1..128)) |
| - link-status-list | Data Frame | |
| - link | Data Frame | |
| - network-id | Data Element | IA5String (SIZE(1..32)) |
| - link-id | Data Element | IA5String (SIZE(1..32)) |
| - link-name | Data Element | IA5String (SIZE(1..128)) |
| - link-status | Data Element | 1 = "no determination" 2 = "open" 3 = "restricted" 4 = "closed" |
| - travel-time | Data Element | INTEGER (0..65535), units=seconds |

Sample Filled-in Test Case Specification

| Test Case | |
|--|---|
| ID: TC001 | Title: Link Status Request-Response Dialog Verification (Positive Test Case) |
| Objective: | <p>To verify system interface implements (positive test case) requirements for:</p> <ul style="list-style-type: none"> 1) Link Status Request-Response Dialog message exchange 2) Contents of the Link Status Request Message 3) Contents of the Link Status Information Message <p>The test case verifies that the dialog, request message content, and response message content are correct by sending a request message (verified to be correct) across the system interface, and verification that the response message is correct. Input and output specifications are provided to verify the request and response message are correct per the requirements for the request and response message.</p> |
| Inputs: | Use the input file linkStatusRequest.xml. See Test Case Input Specification TCIS001 - LinkStatusRequest (Positive Test Case). |
| Outcome(s): | All data are returned and verified as correct: correct sequence of message exchanges, structure of data, and valid value of data content. See Test Case Output Specification TCOS001 - LinkStatusInformation (Positive Test Case) |
| Environmental Needs: | No additional needs outside of those specified in the test plan. |
| Tester/Reviewer | M.I. |
| Special Procedure Requirements: | None |
| Intercase Dependencies: | None |



Positive Test Case

- Positive Test Case Inputs and Outputs include:
 - Data values within the range of values (or text length or format) specified in the standards
 - Data that are correctly structured as specified in the standard
 - All mandatory data values, including those optional elements in the standard made mandatory for a project



Positive Test Case Data Example

```
<?xml version="1.0" encoding="UTF-8"?>
<trafficNetworkInformationRequestMsg>
    <authentication>
        <user-id>user</user-id>
        <password>pass</password>
    </authentication>
    <organization-requesting>
        <organization-id>ORG001</organization-id>
        <center-contact-list>
            <center-contact-details>
                <center-id>test</center-id>
            </center-contact-details>
        </center-contact-list>
    </organization-requesting>
    <network-information-type>link inventory</network-information-type>
<trafficNetworkInformationRequestMsg>
```



Negative Test Case

- Negative Test Case inputs and outputs:
 - Include data values that are not within the range of values (or text length or format) specified in the standards.
 - May have data not correctly structured as specified in the standard
 - May have missing mandatory data elements, including those optional elements in the standard made mandatory for a project



Negative Test Case Data Example

Errors:

1. Invalid User Name and Password
2. Missing mandatory element
`<organization-id>`, and
3. Extra element
`<depreciation-method>` not defined in TMDD or project specific NRTM.

```
<?xml version="1.0" encoding="UTF-8"?>
<trafficNetworkInformationRequestMsg>
<!-- Error: Invalid User Name and Password -->
<authentication>
    <user-id>user</user-id>
    <password>incorrectpass</password>
</authentication>
<organization-requesting>
    <!-- Error: Missing TMDD Mandatory Element:-->
    <!-- organization-id -->
    <center-contact-list>
        <center-contact-details>
            <center-id>test</center-id>
        </center-contact-details>
    </center-contact-list>
    <!-- Error: Extra element not defined -->
    <depreciation-method>sum of the years digits
    </depreciation-method>
</organization-requesting>
<network-information-type>link inventory</network-information-type>
<trafficNetworkInformationRequestMsg>
```



Missing Elements and Incorrect Data Structure

- A missing element or incorrect structure of a message may be specified in the TCS inputs, perhaps referencing a file with an example



Example Missing Elements

```
<?xml version="1.0" encoding="UTF-8"?>
<trafficNetworkInformationRequestMsg>
  <authentication>
    <user-id>user</user-id>
    <password>pass</password>
  </authentication>
  <organization-requesting>
    <organization-id>ORG001</organization-id>
    <center-contact-list>
      <center-contact-details>
        <center-id>test</center-id>
      </center-contact-details>
    </center-contact-list>
  </organization-requesting>
  <network-information-type>link
inventory</network-information-type>
<trafficNetworkInformationRequestMsg>
```

Correct Message

```
<?xml version="1.0" encoding="UTF-8"?>
<trafficNetworkInformationRequestMsg>
  <authentication>
    <user-id>user</user-id>
    <password>pass</password>
  </authentication>
  <organization-requesting>
    <!-- Missing Mandatory Element -->
    <center-contact-list>
      <center-contact-details>
        <center-id>test</center-id>
      </center-contact-details>
    </center-contact-list>
  </organization-requesting>
  <network-information-type>link
inventory</network-information-type>
<trafficNetworkInformationRequestMsg>
```

Incorrect Message: Missing
Mandatory Element organization-id

Example Incorrect Data Structure

```
<?xml version="1.0" encoding="UTF-8"?>
<trafficNetworkInformationRequestMsg>
  <authentication>
    <user-id>user</user-id>
    <password>pass</password>
  </authentication>
  <organization-requesting>
    <organization-id>ORG001</organization-id>
    <center-contact-list>
      <center-contact-details>
        <center-id>test</center-id>
      </center-contact-details>
    </center-contact-list>
  </organization-requesting>
  <network-information-type>link
inventory</network-information-type>
<trafficNetworkInformationRequestMsg>
```

Correct Message

```
<?xml version="1.0" encoding="UTF-8"?>
<trafficNetworkInformationRequestMsg>
  <authentication>
    <password>pass</password>
    <user-id>user</user-id>
  </authentication>
  <organization-requesting>
    <organization-id>ORG001</organization-id>
    <center-contact-list>
      <center-contact-details>
        <center-id>test</center-id>
      </center-contact-details>
    </center-contact-list>
  </organization-requesting>
  <network-information-type>link
inventory</network-information-type>
<trafficNetworkInformationRequestMsg>
```

Incorrect Message: Incorrect Sequence of Elements user-id and password



Test Case Environmental Needs

- Describe the test environment needed for test setup, execution, and results recording
- Ideally, the test plan identifies environmental needs for conducting testing
- This section of the test case may simply reference the section of the test plan that identifies environmental needs if there are no special test case-specific needs
- In some instances, a test case may specify additional environmental needs or exceptions to environmental needs identified in the test plan or referenced test procedure



Test Case Special Procedural Requirements

- Describes special constraints on test case execution
- Pre- and post-conditions for test case execution
- This section may reference the use of automated test tools not described in the test plan or referenced test procedure
- Exceptions to what is described in the test plan or referenced test procedure would be included in this section



Test Case Intercase Dependencies

- Lists the identifiers of test cases that must be executed prior to this test case
- Summarize the nature of the dependencies
- For example, when testing subscription-publication dialogs, a subscription must take place (or be tested) prior to testing for a publication update



A C T I V I T Y



Which of the following is part of the IEEE Std 829 Test Case Specification?

Answer Choices

- a) Description and valid values of inputs and outputs
- b) Project Sponsor
- c) Steps to Conduct a Test
- d) Test Pass-Fail



Review of Answers



- a) Description and valid values of inputs and outputs

Correct! The test case includes specification of inputs, including their value.



- b) Project Sponsor

Incorrect. The project sponsor is not a formal part of a TC.



- c) Steps to Conduct a Test

Incorrect. This feature is contained in a test procedure.



- d) Test Pass-Fail

Incorrect. This feature is contained in a test procedure.

Summary of Learning Objective #4

Understand Test Case Development

- Reviewed an outline of a test case and a suggested template with required content
- Discussed where do we find information for test case template for C2C and C2F standards
- Discussed positive/negative testing
- Reviewed additional test case requirements



What We Have Learned

- 1) The role of test cases in relation to other test documents: test plan,
test designs, test procedures, and test reports.
- 2) The purpose of a test case specification is to document the inputs,
expected outcomes, and execution conditions for a test.



What We Have Learned (cont.)

- 3) The outline for a test case specification is defined in
IEEE Std 829.
- a) Test case identifier
 - b) Objective
 - c) Inputs
 - d) Outcomes
 - e) Environmental needs
 - f) Special procedural requirements
 - g) Intercase dependencies



What We Have Learned (cont.)

- 4) ITS data dictionary standards constrain the structure of data and content of data of information exchanges between systems.
- 5) Walked through an example test case to learn how to develop one.



Resources

- IEEE Std 829-2008 IEEE Standard for Software and System Test Documentation (<http://www.ieee.org>)
- IEEE Std 610-1990 Standard Glossary of Software Engineering Terminology 9 (<http://www.ieee.org>)
- NTCIP 8007 Testing and Conformity Assessment Documentation within NTCIP Standards Publications, <http://www.ntcip.org/library/>
- NTCIP 1204 v03 Environmental Sensor Station Interface Standard
<http://www.ntcip.org/library/>
- Traffic Management Data Dictionary Version 3.03
<http://www.ite.org/standards/tmdd/>
- T202: Overview of Test Design Specifications, Test Case Specifications, and Test Procedures http://www.pcb.its.dot.gov/stds_training.aspx



Next Course Module

T203 Part 2 of 2: How to Develop Test Cases for ITS Standards-based Test Plan, Part 2 of 2

Part 2 of 2:

5. Handle standards that are with and without test documentation
6. Develop a Requirements to Test Case Traceability Matrix (RTCTM)
7. Identify types of testing
8. Recognize the purpose of test logs and test anomaly report



QUESTIONS?

