STANDARDS ITS TRAINING

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U.S. Department of Transportation

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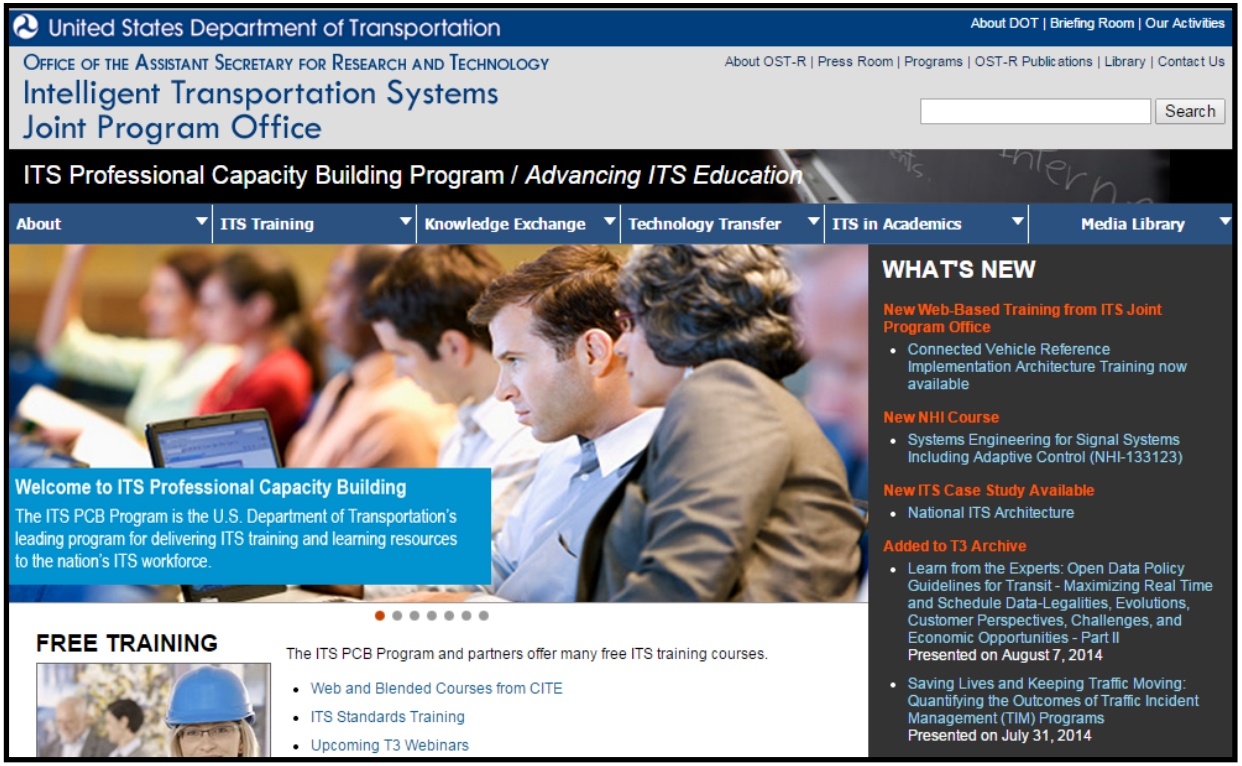

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ACTIVITY

STANDARDS ITS TRAINING

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

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

Instructor

Manny Insignares

Vice President, Technology

Consensus Systems Technologies

New York, NY, USA

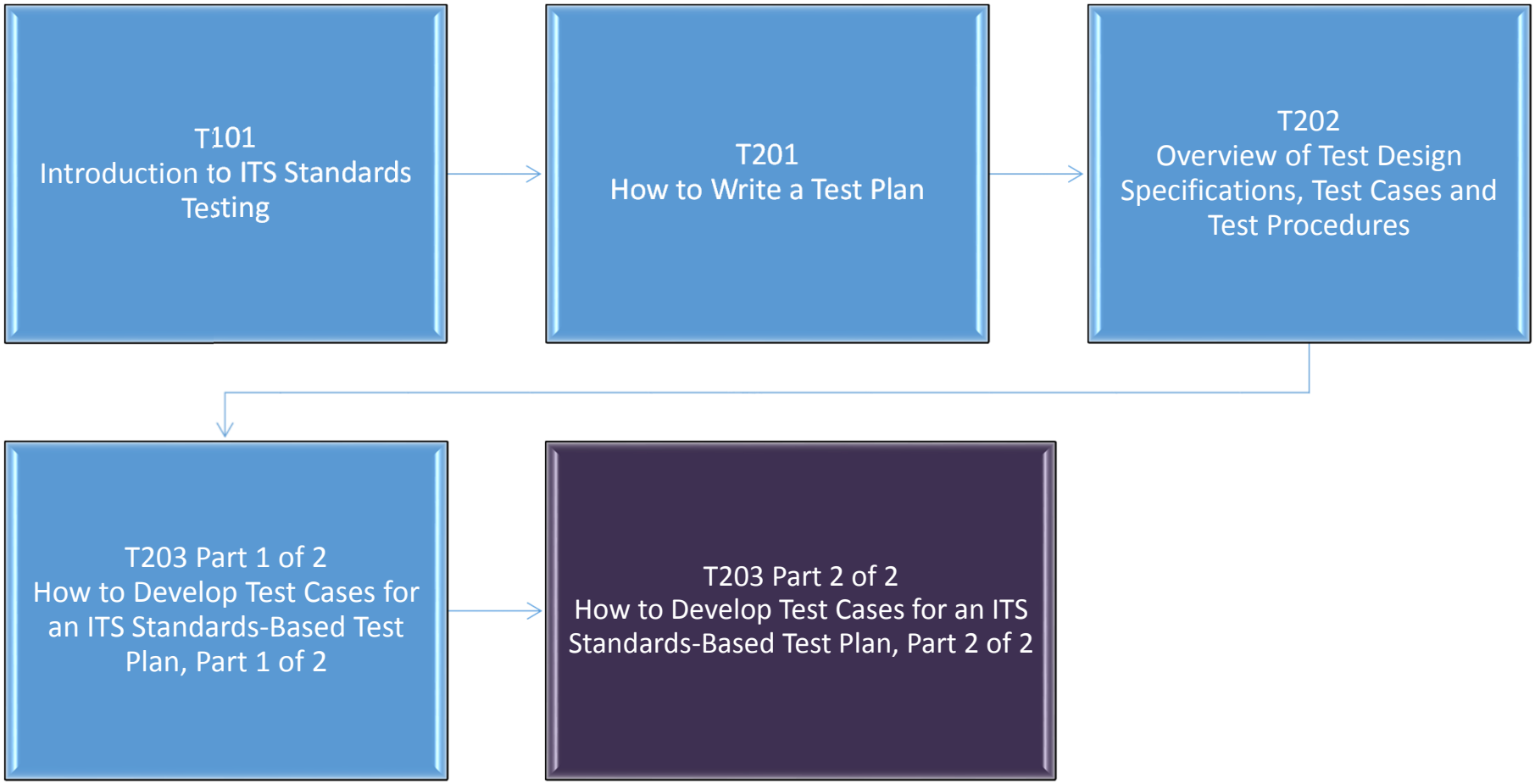
Target Audience

- Traffic management and engineering staff
- Maintenance staff
- System developers
- Test 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
- T203 Part 1 of 2: How to Develop Test Cases for an ITS Standards-Based Test Plan, Part 1 of 2

Curriculum Path



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. Learn to find information needed to develop a test case.
4. Understand 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 the test log and test anomaly report.

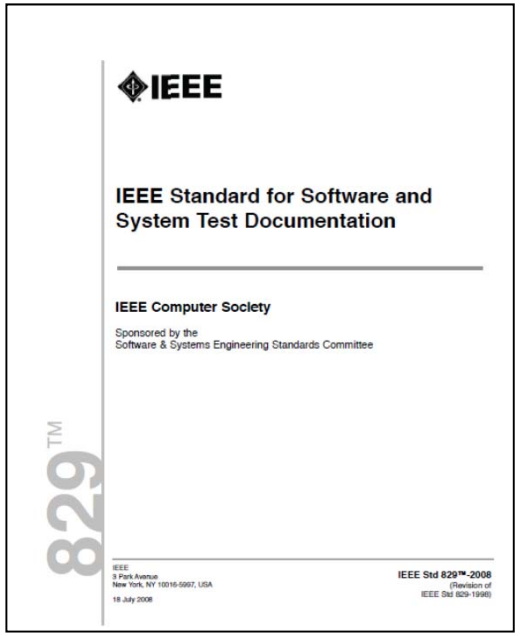
Brief Review of Part 1 Discussion

1. We have discussed the role of test cases within the overall testing process and test plan.
2. We have discussed ITS data structures used in NTCIP and center-to-center standards (TMDD).
3. We have learned about the test case development process.
4. We have learned where to find information needed for test case preparation.

Let's re-cap IEEE 829 and the relationship between test cases and test procedures, then continue with the remaining four learning objectives 5-8.

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 Log
    - Test Anomaly Report
    - Test Report



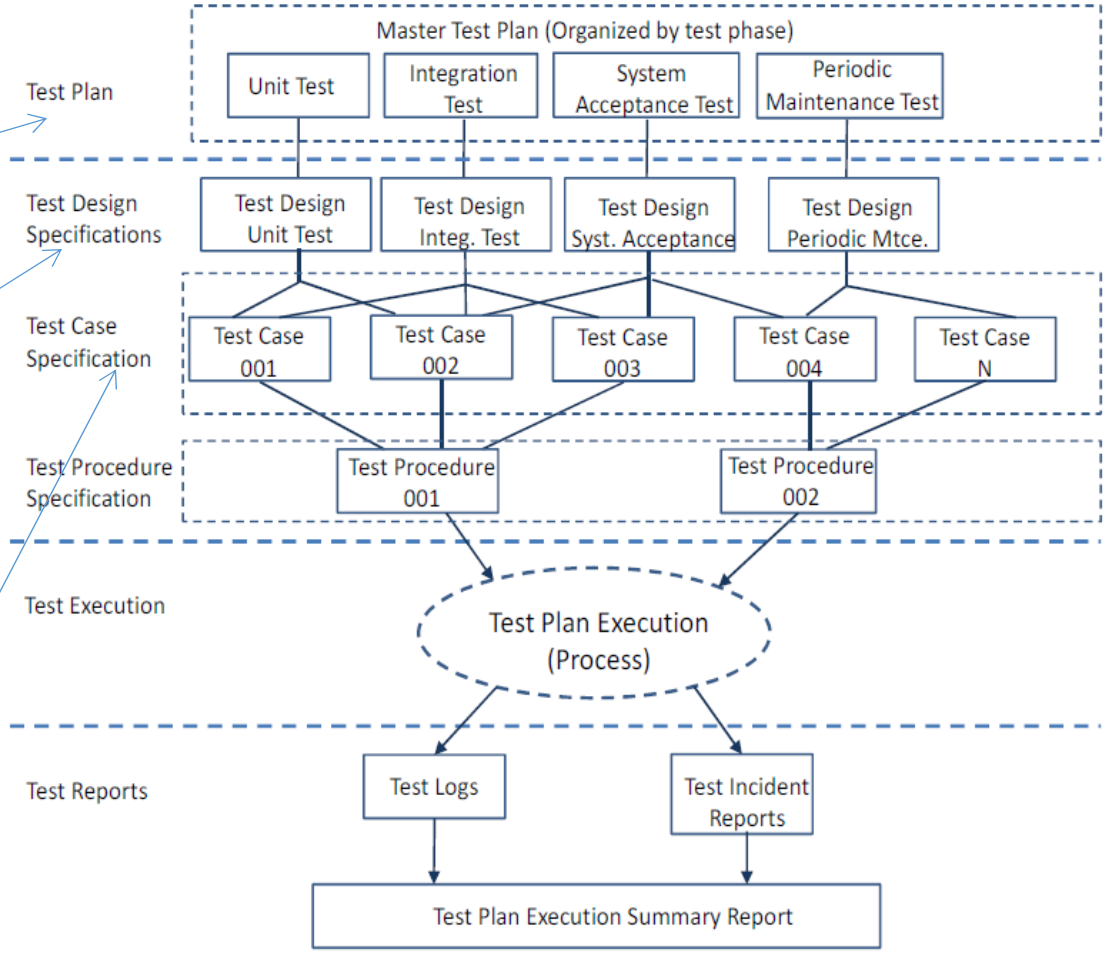
- Testing professionals across ITS are familiar with these definitions' formats

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

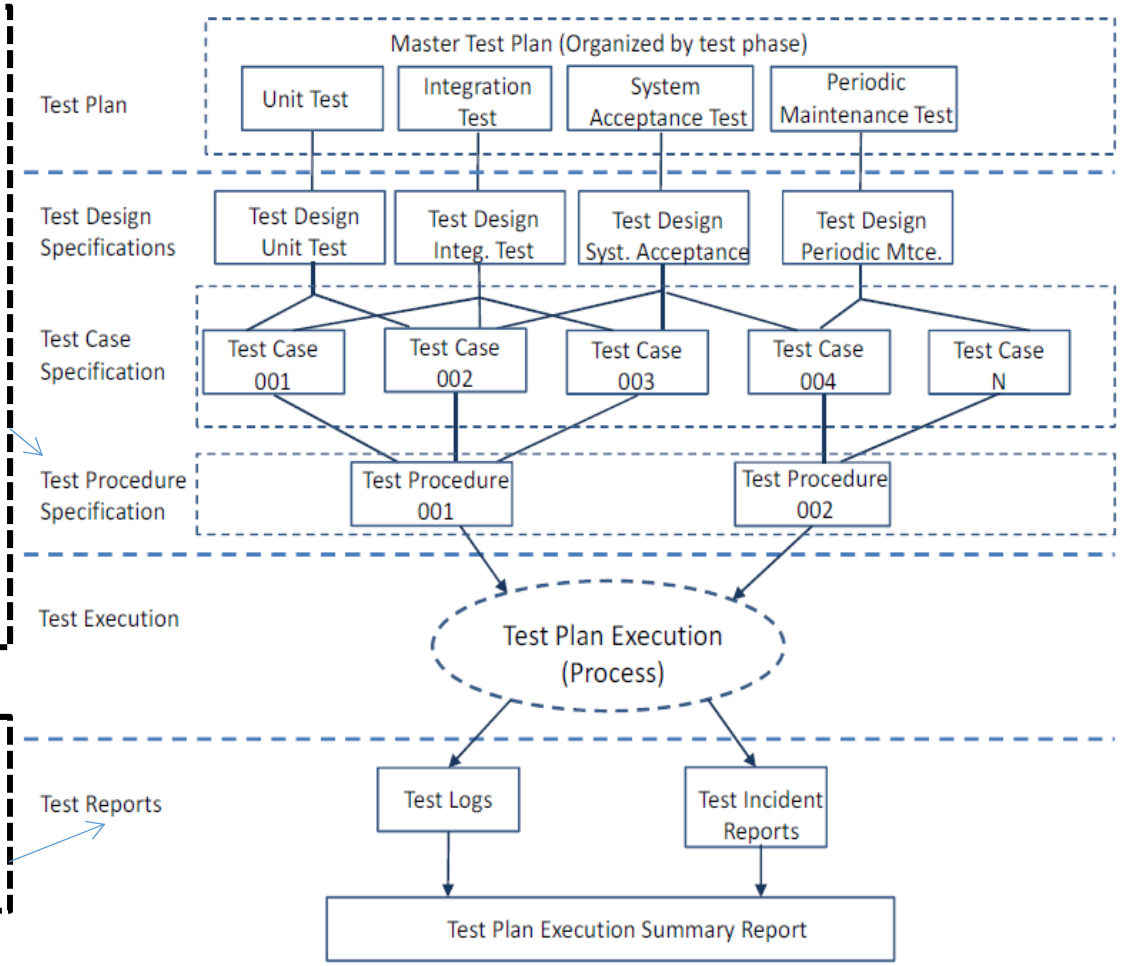
Test Case Specification identifies objectives, inputs, outcomes, and conditions for execution of a test



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 Log, Test Anomaly Reports, Test Report**



Learning Objective #5: Handle Standards That Are With and Without Test Documentation

- Learn how to develop test cases where test documentation is **not included** in the standard: **Case Study-1: NTCIP 1205 CCTV**
- Learn how to develop test cases where test documentation **is included** in the standard: **Case Study-2: NTCIP 1204 ESS**
- Learn how to develop test cases where test documentation is **not included** in the standard: **Case Study-3: TMDD (C2C)**

About ITS Standards

- ITS standards developed using Systems Engineering Process (SEP):
  - SE content includes ConOps, user needs, requirements and PRL, RTM and NRTM, and design elements
  - Example: DMS and ESS

- Non-SEP standards only provided standardized design elements:
  - Example: CCTV

Status of C2F and C2C Standards Content

Standard	**SE Content** (ConOps, User Needs, Requirements, Design)	**Testing Content** (Testing Plan, Test Cases)
NTCIP 1202 ASC	No (being added)	No
NTCIP 1203 DMS	Yes	Yes
NTCIP 1204 ESS	Yes	Yes
NTCIP 1205 CCTV	No	No
NTCIP 1206 DCM	No	No
NTCIP 1207 RM	No	No
NTCIP 1209 TSS	Yes	No
NTCIP 1210 FMS	Yes	No
NTCIP 1211 SCP	Yes	No
NTCIP 1213 ELMS	Yes	No
TMDD v03 (C2C)	Yes	No

Preparation for a Test Case

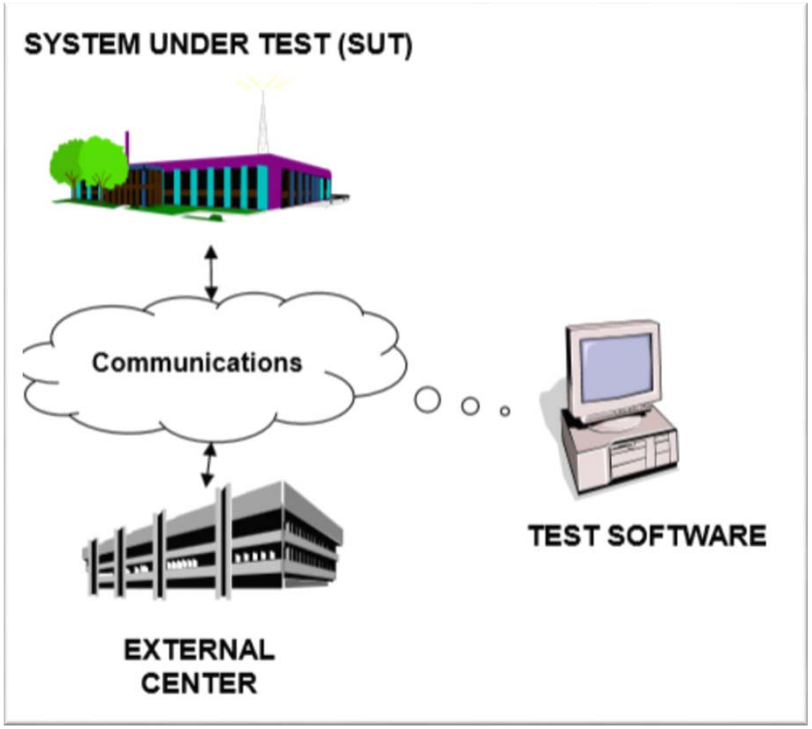
- Leverage SEP content where available in the standards; if it is not available, you **will need to develop** it for your project
- Realize that the available testing documentation in the standards is **limited** as it relates to test case development
- **Use** the test case development process introduced in Part 1:
  - Identify user needs
  - Identify requirements
  - Develop test case objective
  - Identify design content: dialogs, inputs, and outputs
  - Document value constraints in an input or output specification
  - Complete the test case

Step-by-Step Process to Follow Through Case Studies

1. Identify user needs
2. Identify requirements
3. Develop test case objective
4. Identify design content: dialogs, inputs, and outputs
5. Document value constraints of inputs and outputs
6. Complete test case

Overview of Case Studies

1. **NTCIP 1205 CCTV (C2F)**
   - No SE content
   - No testing content
2. **NTCIP 1204 ESS (C2F)**
   - Yes has SE content
   - Yes has testing content
3. **TMDD (C2C)**
   - Yes has SE Content
   - No testing content



CASE STUDY 1

STANDARDS ITS TRAINING

U.S. Department of Transportation
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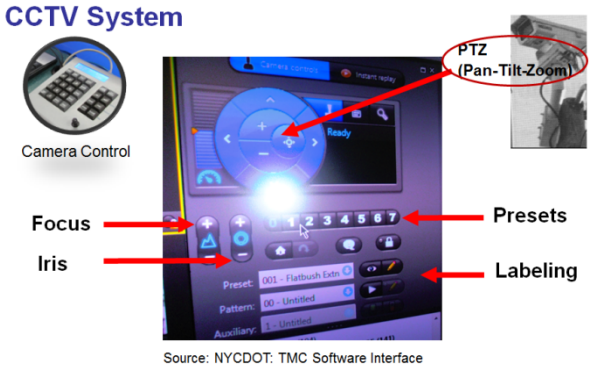
Research and Technology

Case Study 1: NTCIP 1205 CCTV

Background

1. Characteristics of the standard: NTCIP 1205 CCTV
   - NTCIP 1205 CCTV is a Center-to-Field (C2F) Communications Device Standard
   - NTCIP 1205 does not have SE content
   - NTCIP 1205 does not contain test documentation (i.e., there is no ANNEX C: Test Procedures)
2. Information sources for this test case
   - A317a: Understanding User Needs for CCTV Systems Based on NTCIP 1205 Standard (Ref.4)
   - A317b: Understanding Requirements for CCTV Systems Based on NTCIP 1205 Standard (Ref.5)
   - NTCIP 1205 v01 – Object Definitions for CCTV Standard

Case Study CCTV User Needs



User Needs and Requirements are the basis for a system interface design; test cases verify each requirement.

UN ID	User Need	RQ. ID	Requirement	Additional Specs.
3.0	Remote Monitoring	3.3.3	Status condition within the device	
		3.3.3.2	Temperature	
		3.3.3.2	Pressure	
		3.3.3.2	Washer fluid	
		3.3.3.3	ID Generator	

User Needs

Requirements

Step 1: Identify User Needs

Case Study CCTV Requirements

Rq. ID	Requirement	Dialog	Object Reference and Title NTCIP 1205 Section 3
3.3.3	Status condition within the device	D.1 Generic SNMP GET Interface	
3.3.3.2	Temperature		3.7.5 alarmTemperatureCurrentValue
3.3.3.2	Pressure		3.7.6 alarmPressureHighLowThreshold 3.2.7 alramPressureCurrentValue
3.3.3.2	Washer fluid		3.7.8 alarmWasherFluidHighLowThreshold 3.2.9 alarmWasherCurrentValue
3.3.3.3	ID Generator		3.11 cctv label Objects

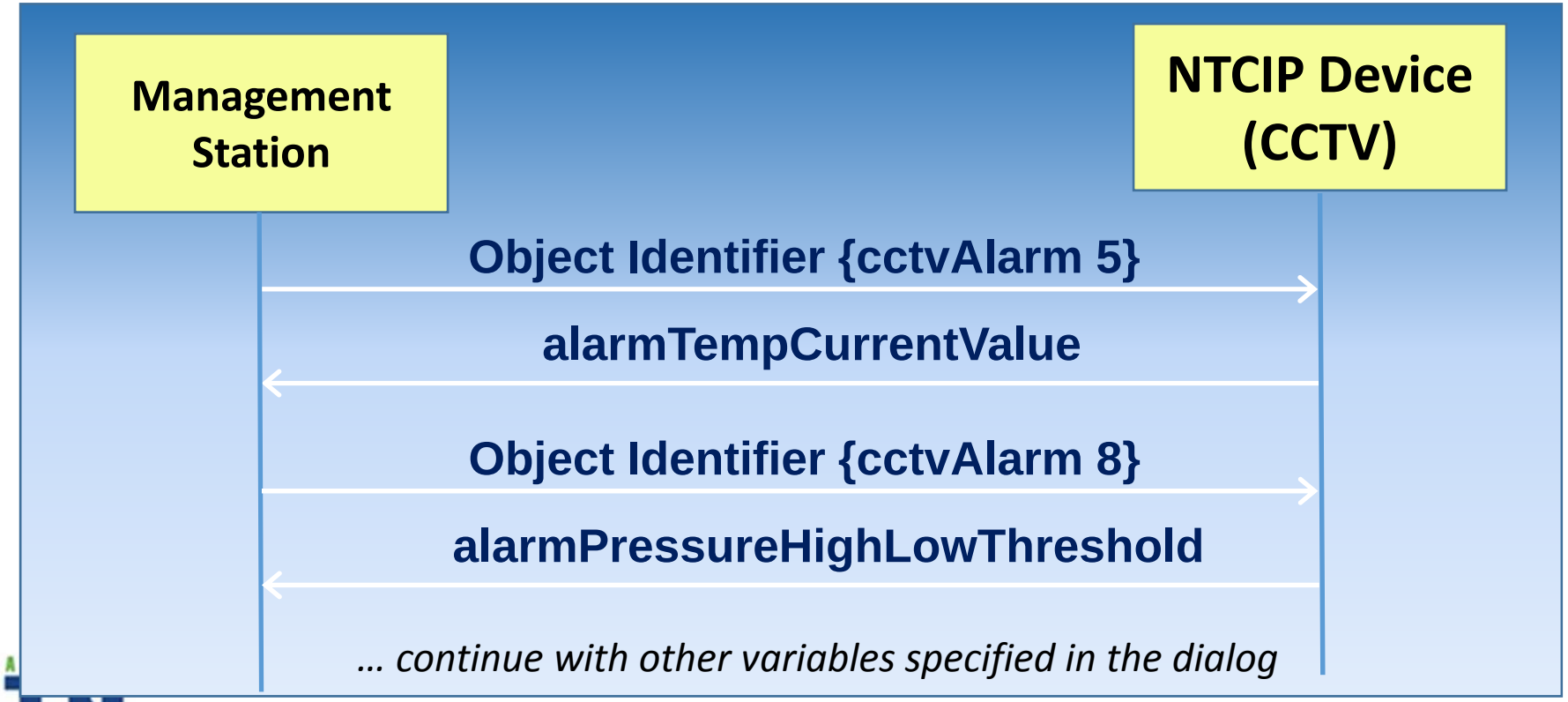
Requirements

Design Content

We need to look up value constraints for these objects.

Dialog Example for 3.3 Status Condition within the Device

- The Object Identifier (OID) is used to make requests for data from a device
- Object data is returned in response to a SNMP GET



CCTV Test Case Objective and Purpose

Test Case	
ID: TC001	Title: Request Status Condition within the Device Dialog Verification (Positive Test Case)
Objective:	To verify system interface implements (positive test case) requirements for a sequence of OBJECT requests for: • 3.7.5 alarmTemperatureCurrentValue • 3.7.6 alarmPressureHighLowThreshold • 3.7.7 alarmPressureCurrentValue • 3.7.8 alarmWasherFluidHighLowThreshold • 3.7.9 alarmWasherCurrentValue • 3.11 cctv label Objects The test case verifies that the data value of the OBJECTs requested are within specified ranges. The object identifier (OID) of each object requested is the only input required. An output specification is provided to show valid value constraints per the NTCIP 1205 v01 object definitions.
Inputs:	
Outcome(s):	
Environmental Needs:	
Tester/Reviewer	
Special Procedure Requirements:	
Intercase Dependencies:	

Step 3: Develop Test Case Objective

CCTV Test Case Output Specification: Data Concept ID, Data Concept Name, and Data Concept Type Filled in

Test Case Output Specification			
ID: TCOS001		Title: Status Condition within the Device	
Data Concept ID	Data Concept Name (Variable)	Data Concept Type	Value Constraints
3.7.5	**alarmTemperatureCurrentValue**	Data Element	
3.7.6	**alarmPressureHighLowThreshold**	Data Element	
3.7.7	alarmPressureCurrentValue	Data Element	
3.7.8	**alarmWasherFluidHighLowThreshold**	Data Element	
3.7.9	alarmWasherCurrentValue	Data Element	
3.11	cctv label Objects	Data Element	

No dialogs are documented in NTCIP 1205 v01. These are simple GET/SET operations, consisting of an object request followed by the result that we will document in an output specification.

Object Definition for: 3.7.5 alarmTemperatureCurrentValue

3.7.5 Temperature Alarm Current Value Parameter
alarmTemparatureCurrentValue OBJECT-TYPE
SYNTAX OCTET STRING (SIZE(1))
ACCESS read-write
STATUS mandatory
DESCRIPTION "Identifies the current value for the temperature within the camera enclosure measured in degrees C."
::= {cctvAlarm 5}

Value Constraints:

Type: OCTET STRING (1 OCTET)

Value Constraints:

Value Range: 0 to 255

(Though not specified, the value range of an OCTET is 0 to 255)

Object Identifier (OID)

Identify Value Constraints for Inputs, Outputs

Source: NTCIP 1205 v01

Object Definition for: 3.7.8 alarmWasherFluidHighLowThreshold

3.7.8 Washer Fluid Alarm High-Low Threshold Parameter
alarmWasherFluidHighLowThreshold OBJECT-TYPE
SYNTAX OCTET STRING (SIZE(2))
ACCESS read-write
STATUS mandatory
DESCRIPTION "Identifies the high and low thresholds for the washer fluid alarm, as shown below;
Byte1 Low Threshold denotes the percentage of minimum filled capacity between zero (0) and 100 percent,
Byte2 HighThreshold denotes the percentage of maximum filled capacity between zero (0) and 100 percent."
::= {cctvAlarm 8}

Value Constraints:

Type: OCTET STRING (2 OCTETS)

Value Constraints:

Value Range: 0 to 100

Object Identifier (OID)

Identify Value Constraints for Inputs, Outputs

Source: NTCIP 1205 v01

CCTV Test Case Output Specification

Test Case Output Specification			
ID: TCOS001		Title: Status Condition within the Device	
Data Concept ID	Data Concept Name (Variable)	Data Concept Type	Value Domain
3.7.5	**alarmTemperatureCurrentValue**	Data Element	OCTET STRING (SIZE(1)) - Range: 0 to 255.
3.7.6	**alarmPressureHighLowThreshold**	Data Element	OCTET STRING (SIZE(2)) - Range: 0 to 255 each byte Note: B yte1 Low Threshold denotes the value of minimum pressure within the camera enclosure measured in psig, Byte2 High Threshold denotes the value of maximum pressure within the camera enclosure measured in psig
3.7.7	alarmPressureCurrentValue	Data Element	OCTET STRING (SIZE(1)) - Range: 0 to 255
3.7.8	**alarmWasherFluidHighLowThreshold**	Data Element	OCTET STRING (SIZE(2)) - Range: 0 to 100 each byte. Note: Byte1 Low Threshold denotes the percentage of minimum filled capacity between zero (0) and 100 percent, Byte2 HighThreshold denotes the percentage of maximum filled capacity between zero (0) and 100 percent.
3.7.9	alarmWasherCurrentValue	Data Element	OCTET STRING (SIZE(1)) – Range: 0 to 100
3.11	cctv label Objects	Data Element	*etc. 3.11 contains numerous object definition entries.*

CCTV Test Case

Test Case	
ID: TC001	Title: Request Status Condition within the Device Dialog Verification (Positive Test Case)
Objective:	To verify system interface implements (positive test case) requirements for a sequence of OBJECT requests for: • 3.7.5 alarmTemperatureCurrentValue • 3.7.6 alarmPressureHighLowThreshold • 3.7.7 alarmPressureCurrentValue • 3.7.8 alarmWasherFluidHighLowThreshold • 3.7.9 alarmWasherCurrentValue • 3.11 cctv label Objects The test case verifies that the data value of the OBJECTs requested are within specified ranges. The object identifier (OID) of each object requested is the only input required. An output specification is provided to show valid value constraints per the NTCIP 1205 v01 object definitions.
Inputs:	The object identifier of each object requested is needed.
Outcome(s):	All data are returned and verified as correct per the OBJECT constraints of NTCIP 1205 v01. See Test Case Output Specification TCOS001 – Status Condition within the Device (Positive Test Case)
Environmental Needs:	When testing for alarm temperature current value, set up is needed to measure temperature.
Tester/Reviewer	M.I.
Special Procedure Requirements:	None
Intercase Dependencies:	None

Summary of CCTV Case Study

- Identified **user needs** from the PRL developed in **Module A317a** (Understanding User Needs for CCTV Systems Based on NTCIP 1205 Standard)
- Identified relevant **requirements** from the RTM developed in Module A317b (Understanding Requirements for CCTV Systems Based on NTCIP 1205 Standard)
- Identified **dialogs**, **inputs and outputs**, created a list of **objects** from the requirements and partially filled in a test output specification
- Identified and documented **value constraints**, for relevant objects from above step to completed test output specification
- **Developed the test case** for a non-SEP standard-CCTV

What have we learned from this case study?

We have learned that the NTCIP 1205 CCTV Standard does **NOT** have **user needs (PRL)** and **requirements (RTM)** and we must derive content from the PCB Module **A317b CCTV** and then proceed with test case development.

Using CCTV design objects, we have learned to identify and document **value constraints** in a test case .

MODULE 34: A317b: UNDERSTANDING REQUIREMENTS FOR CCTV SYSTEMS BASED ON NTCIP 1205 STANDARD
(Source: http://www.pcb.its.dot.gov/StandardsTraining)

CASE STUDY 2

STANDARDS ITS TRAINING

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

Case Study 2: NTCIP 1204 v03 ESS

Background

- Characteristics of the Standard: NTCIP 1204 v03 ESS
  - NTCIP 1204 is a Center-to-Field Communications Standard
  - NTCIP 1204 contains Systems Engineering content (i.e., the standard has a PRL and an RTM)
  - NTCIP 1204 contains test documentation (i.e., there is an ANNEX C: Test Procedures)
- Information Source:
  - NTCIP 1204 v03 Object Definitions for ESS

Case Study ESS User Needs

Source: NTCIP 1204 v03 Protocol Requirement List (PRL).

User Need ID	User Need	FR ID	Functional Requirement	Conformance	Project Requirement	Additional Project Requirements
2.5.2.1.2 (Wind)	Monitor Winds			O.3 (1..*)	Yes / No / NA	
		3.5.2.3.2.2	Retrieve Wind Data	M	Yes / NA	
		3.6.2	Required Number of Wind Sensors	M	Yes / NA	The ESS shall support at least ____ wind sensors.

User Needs

Requirements

Case Study ESS Requirements

Req ID	Dialog	Requirement	Object ID	Add'l Requirements/Object
3.5.2.3.2.2	F.4.6	Retrieve Wind Data		
			5.6.8	windSensorTableNumSensors
			5.6.10.1	windSensorIndex
			5.6.10.4	windSensorAvgSpeed
			5.6.10.5	windSensorAvgDirection
			5.6.10.6	windSensorSpotSpeed
			5.6.10.7	windSensorSpotDirection
			5.6.10.8	windSensorGustSpeed
			5.6.10.9	windSensorGustDirection
			5.6.10.10	windSensorSituation

Source: NTCIP 1204 v03 Requirements Traceability Matrix (RTM).

Requirements

Design Content

We need to look up value constraints for these objects.

Discussion: Case Study ESS RTCTM

Requirement		Test Case	
ID	Title	ID	Title
3.5.2.3.2	Monitor Weather Condition		
3.5.2.3.2.1	Retrieve Atmospheric Pressure		
		C.2.3.3.2	Retrieve Atmospheric Pressure
3.5.2.3.2.2	Retrieve Wind Data		
		C.2.3.3.3	Retrieve Wind Data
3.5.2.3.2.3	Retrieve Temperature		
		C.2.3.3.4	Retrieve Temperature
3.5.2.3.2.4	Retrieve Daily Minimum and Maximum Temperature		
		C.2.3.3.5	Retrieve Daily Minimum and Maximum Temperature
3.5.2.3.2.5	Retrieve Humidity		
		C.2.3.3.6	Retrieve Humidity

Requirements

Test Content

Source: NTCIP 1204 v03 Requirements To Test Case Traceability Matrix (RTCTM).

Discussion: Case Study ESS Test Procedure

C.2.3.3.3 Retrieve Wind Data

Test Case: 3.3	***Title:***	*Retrieve Wind Data*	
	Description:	*This test case verifies that the ESS allows a management station to determine current wind information.*	
	Variables:	*Required_Wind_Sensors*	*PRL 3.6.2*
	Pass/Fail Criteria:	*The device under test (DUT) shall pass every verification step included within the Test Case in order to pass the Test Case.*	

Step	***Test Procedure***	***Device***
1	CONFIGURE: Determine the number of wind sensors required by the specification (PRL 3.6.2). RECORD this information as: »Required_Wind_Sensors	
2	GET the following object(s): »windSensorTableNumSensors.0	Pass / Fail (Clause 3.5.2.3.2.2)
3	VERIFY that the RESPONSE VALUE for windSensorTableNumSensors.0 is greater than or equal to Required_Wind_Sensors.	Pass / Fail (Clause 3.6.2)
4	Determine the RESPONSE VALUE for windSensorTableNumSensors.0. RECORD this information as: »Supported_Wind_Sensors	
5	FOR EACH value, N, from 1 to Supported_Wind_Sensors, perform Steps 5.1 through 5.22.	
5.1	GET the following object(s): »windSensorAvgSpeed.N »windSensorAvgDirection.N »windSensorSpotSpeed.N »windSensorSpotDirection.N »windSensorGustSpeed.N »windSensorGustDirection.N »windSensorSituation.N	Pass / Fail (Clause 3.5.2.3.2.2)
5.2	VERIFY that the RESPONSE VALUE for windSensorAvgSpeed.N is greater than or equal to 0.	Pass / Fail (Clause 5.6.10.4)

Discussion: ESS Standard's SE and Test Content Makes the Implementers' Job Easier

- Test case material is integrated into the test procedures in the ESS Standard.
- Once requirements are selected, then the design and test procedures are selected.
- What is missing from ESS and DMS, and what needs to be added, are input values and outcomes.
- For a simple device like an ESS and DMS, the NTCIP 8007 test documentation is adequate. However, this approach does not work for more complex standards such as NTCIP 1202 or TMDD. IEEE 829 is a better fit for handling more complex standards.
- Lastly, there is no direct translation between NTCIP 8007 and IEEE 829, so we continue with the steps as we've outlined for development of test cases.

ESS Test Case Objective and Purpose

Test Case	
ID: TC0012	Title: Retrieve Wind Data (Positive Test Case)
Objective:	To verify system interface implements (positive test case) requirements for a sequence of OBJECT requests for: • 5.6.8 windSensorTableNumSensors • 5.6.10.1 windSensorIndex • 5.6.10.4 windSensorAvgSpeed • 5.6.10.5 windSensorAvgDirection • 5.6.10.6 windSensorSpotSpeed • 5.6.10.7 windSensorSpotDirection • 5.6.10.8 windSensorGustSpeed • 5.6.10.9 windSensorGustDirection • 5.6.10.10 windSensorSituation The test case verifies that the data value of the OBJECTs requested are within specified ranges. The object identifier (OID) of each object requested is the only input required. An output specification is provided to show the valid value constraints per the NTCIP 1204 v03 object definitions.
Inputs:	
Outcome(s):	
Environmental Needs:	
Tester/Reviewer	
Special Procedure Requirements:	
Intercase Dependencies:	

ESS Test Case Output Specification: With Data Concept ID, Data Concept Name, and Data Concept Type Filled in

Test Case Output Specification			
ID: TCOS022		Title: Wind Data	
Data Concept ID	Data Concept Name (Variable)	Data Concept Type	Value Domain
5.6.8	windSensorTableNumSensors	Data Element	
5.6.10.1	windSensorIndex	Data Element	
5.6.10.4	windSensorAvgSpeed	Data Element	
5.6.10.5	windSensorAvgDirection	Data Element	
5.6.10.6	windSensorSpotSpeed	Data Element	
5.6.10.7	windSensorSpotDirection	Data Element	
5.6.10.8	windSensorGustSpeed	Data Element	
5.6.10.9	windSensorGustDirection	Data Element	
5.6.10.10	windSensorSituation	Data Element	

Object Definition for: 5.6.10.4 windSensorAvgSpeed

Source: NTCIP 1204 v03

Value Constraints:

Type: INTEGER

5.6.10.4 Wind Sensor Average Speed
windSensorAvgSpeed OBJECT-TYPE
SYNTAX INTEGER (0..65535)
ACCESS read-only
STATUS mandatory
DESCRIPTION "<Definition>A two minute average of the wind speed in tenths of meters per second as measured by the wind sensor.
<SetConstraint>read-only
<DescriptiveName>WindSensor.avgSpeed:quantity
<Valid Value Rule>
The value of 65535 shall indicate an error condition or missing value.
<Data Concept Type>Data Element
<Unit>tenths of meters per second"
REFERENCE "WMO Binary Code Form FM 94 BUFR Table B item 0 11 002."
::= { windSensorEntry 4 }

Value Constraints:

Value Range: 0 to 65535

Value Constraints:

Enumerated List of Values

Object Identifier

Step 4: Identify Dialogs, Inputs, Outputs

Object Definition for: 5.6.10.10 windSensorSituation

Source: NTCIP 1204 v03

Value Constraints:

Type: INTEGER

Value Constraints:

Enumerated List

Object Identifier

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), *etc. – list has been abbreviated* }
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 }

Step 4: Identify Dialogs, Inputs, Outputs

ESS Test Case Output Specification (1 of 3)

Test Case Output Specification			
ID: TCOS022		Title: Wind Data	
Data Concept ID	Data Concept Name (Variable)	Data Concept Type	Value Constraints
5.6.8	windSensorTableNumSensors	Data Element	INTEGER (0..255)
5.6.10.1	windSensorIndex	Data Element	INTEGER (1..255)
5.6.10.4	windSensorAvgSpeed	Data Element	INTEGER (0..65535) tenths of meters per second WMO Binary Code Form FM 94 BUFR Table B item 0 11 002
5.6.10.5	windSensorAvgDirection	Data Element	INTEGER (0..361) The value of zero (0) shall indicate 'calm', when the associated speed is zero (0), or 'light and variable,' when the associated speed is greater than zero (0). Normal observations, as defined by the WMO, shall report a wind direction in the range of 1 to 360 with 90 meaning from the east and 360 meaning from the north. The value of 361 shall indicate an error condition and shall always be reported if the associated speed indicates error.
5.6.10.6	windSensorSpotSpeed	Data Element	INTEGER (0..65535) tenths of meters per second The value of 65535 shall indicate an error condition or missing value.

ESS Test Case Output Specification (2 of 3)

Test Case Output Specification			
ID: TCOS022		Title: Wind Data	
Data Concept ID	Data Concept Name (Variable)	Data Concept Type	Value Constraints
5.6.10.7	windSensorSpotDirection	Data Element	INTEGER (0..361) The value of zero (0) shall indicate 'calm', when the associated speed is zero (0), or 'light and variable,' when the associated speed is greater than zero (0). Normal observations, as defined by the WMO, shall report a wind direction in the range of 1 to 360 with 90 meaning from the east and 360 meaning from the north. The value of 361 shall indicate an error condition and shall always be reported if the associated speed indicates error.
5.6.10.8	windSensorGustSpeed	Data Element	INTEGER (0..65535) tenths of meters per second WMO Code Form FM 94 BUFR Table B item 0 11 041. The value of 65535 shall indicate an error condition or missing value.
5.6.10.9	windSensorGustDirection	Data Element	INTEGER (0..361) (See 5.6.10.7)

ESS Test Case Output Specification (3 of 3)

Test Case Output Specification			
ID: TCOS022		Title: Wind Data	
Data Concept ID	Data Concept Name (Variable)	Data Concept Type	Value Domain
5.6.10.10	windSensorSituation	Data Element	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) (See object definition for additional detail.)

ESS Test Case

Test Case	
ID: TC0012	Title: Retrieve Wind Data (Positive Test Case)
Objective:	To verify system interface implements (positive test case) requirements for a sequence of OBJECT requests for: • 5.6.8 windSensorTableNumSensors • 5.6.10.1 windSensorIndex • 5.6.10.4 windSensorAvgSpeed • 5.6.10.5 windSensorAvgDirection • 5.6.10.6 windSensorSpotSpeed • 5.6.10.7 windSensorSpotDirection • 5.6.10.8 windSensorGustSpeed • 5.6.10.9 windSensorGustDirection • 5.6.10.10 windSensorSituation The test case verifies that the data value of the OBJECTs requested are within specified ranges. The object identifier (OID) of each object requested is the only input required. An output specification is provided to show the valid value constraints per the NTCIP 1204 v03 object definitions.
Inputs:	The object identifier of each object requested.
Outcome(s):	All data are returned and verified as correct per the OBJECT constraints of NTCIP 1204 v03. See Test Case Output Specification TCOS022 – Wind Data.
Environmental Needs:	When testing for average wind speed, an artificial wind device is needed to provide the wind for the sensor to measure.
Tester/Reviewer	M.I.
Special Procedure Requirements:	Wind simulator set-up. (See test procedures.)
Intercase Dependencies:	None

Step 6: Complete Test Case

Summary of the ESS Case Study

- Identified **user needs** from the SEP-based NTCIP 1204 v03 PRL
- Identified relevant **requirements**, used the **PRL** to trace from user needs to requirements, and used the **RTM** to trace requirements to relevant design content (dialogs, and objects)
- Identified dialogs, inputs, and outputs; created a list of **objects** from the requirements and partially filled in a test output specification.
- Identified and documented **value constraints** from object definitions and completed test output specification
- **Developed the Test Case** for a SEP based ESS standard

What Have We Learned from This Case Study?

We have learned that the NTCIP 1204 ESS standard has SEP content : **user needs (PRL)** and **requirements (RTM)** and **testing documentation** which we can review for the test cases development.

Using ESS design objects, we have learned to identify and document **value constraints** and develop a test case.

MODULE 18: T313: Applying your test plan to NTCIP 1204 v03 ESS standard
(Source: http://www.pcb.its.dot.gov/StandardsTraining)

ACTIVITY

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Which of the following standards provides testing content?

Answer Choices

a) TMDD v03 C2C Standard

b) NTCIP 1204 v03 ESS Standard

c) NTCIP 1205 v01 CCTV Standard

d) All of the above

Review of Answers

a) TMDD v03 C2C Standard

Incorrect. This standard only provides NRTM, and no test documentation.

b) NTCIP 1204 v03 ESS Standard

Correct! The NTCIP ESS standard has SE and testing content.

c) NTCIP 1205 v01 CCTV Standard

Incorrect. This standard only provides design elements (objects) and no SE content and no test documentation. Our case study 1 explained this.

d) All of the above

Incorrect. Only certain ITS standards were developed using SE content and only two have test documentation-DMS and ESS.

CASE STUDY 3

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Case Study 3: TMDD (C2C)

Background

1. Characteristics of the TMDD v3.03c Standard
   - TMDD is a Center-to-Center (C2C) Communications Standard
   - TMDD contains SE content (i.e., the standard has a NRTM and an RTM)
   - TMDD does not contain test documentation
2. Information Sources
   - TMDD v3.03c Volume I: ConOps and Requirements
   - TMDD v3.03c Volume II: Design
3. User Needs and Requirements are contained in the NRTM in Volume I
4. Relevant Dialogs, Input and Output Definitions (Data Concepts) and RTM are contained in Volume II

Background: Context Diagram

- Positive test case for a specified sequence of messages
  - linkStatusRequestMsg is used to make the request
  - linkStatusMsg contains the response

Case Study TMDD Needs

UN ID	User Need		Requirement ID	Requirement	Conformance	Support	Other Requirements
2.3.4.2.2	Need to Share Link State				Optional	Yes / No	
		Dialogs					
			3.3.4.3.2.1	Send Link Status Information Upon Request	M	Yes	The owner center shall respond within ___ (100 ms – 1 hour; Default = 1 minute) after receiving the request. See Section 3.4.2.
			Publication and Subscription Dialog not shown.				
		Request Message					
			3.3.4.1.1	Contents of the Traffic Network Information Request	M	Yes	
			3.3.4.1.1.1	Required Traffic Network Information Request Content	M	Yes	
			3.3.4.1.1.2.1	Authentication – Network (AuthNetwork)	O	Yes / No	
			3.3.4.1.1.2.1.1	Operator Identifier – Network	AuthNetwork:O	Yes / No / NA	
			3.3.4.3.2.4	Contents of the Link Status Request	M	Yes	
		Response Message					
			3.3.4.3.2.5	Contents of the Link Status Information	M	Yes	
			3.3.4.3.2.5.1	Required Link Status Information Content	M	Yes	
			3.3.4.3.2.5.2.1	Restrictions – Link Status	O	Yes / No	
			3.3.4.3.2.5.2.2	Link Name - Link Status	O	Yes / No	
			3.3.4.3.2.5.2.3	Link Direction - Link Status	O	Yes / No	
			3.3.4.3.2.5.2.4	Lanes Open	O	Yes / No	
			3.3.4.3.2.5.2.19	Roadway Event Source	O	Yes / No	
			3.3.4.3.2.5.2.37	Event Description Time - Link Status	O	Yes / No	
			3.3.4.3.2.5.2.38	Link Status Date and Time Change Information	O	Yes / No	
		Error Report Message (*detail not shown*)					

User Needs

Requirements

Step 1: Identify User Needs

Case Study TMDD Requirements

A portion of the RTM is shown, see student supplement for a full view.

Req ID (Vol. I)	Requirement	Dialog	DC Type	Definition Class Name	DC ID (Vol. II)	Data Concept Instance Name
3.3.4.3.2.1	Send Link Status Information Upon Request	2.4.1	dialog	dlLinkStatusRequest	3.1.13.2	dlLinkStatusRequest
~~3.3.4.3.2.2~~	~~Publish Link Status Information~~	~~2.4.3~~	~~dialog~~	~~dlLinkStatusUpdate~~	~~3.1.34.2~~	~~dlLinkStatusUpdate~~
~~3.3.4.3.2.3~~	~~Subscribe to Link Status Information~~	~~2.4.2~~	~~dialog~~	~~dlTrafficNetworkInformationSubscription~~	~~3.1.19.1~~	~~dlTrafficNetworkInformationSubscription~~
3.3.4.3.2.4	Contents of the Link Status Request		message	trafficNetworkInformationRequestMsg	3.2.19.1	trafficNetworkInformationRequestMsg
3.3.4.3.2.5	Contents of the Link Status Information		message	linkStatusMsg	3.2.13.2	linkStatusMsg
3.3.4.3.2.5.1	Required Link Status Information Content		data-frame	organizationInformation	3.3.16.3	organization-information
3.3.4.3.2.5.1	Required Link Status Information Content		data-element	transportation-network-identifier	3.4.20.1	network-id
3.3.4.3.2.5.1	Required Link Status Information Content		data-element	transportation-network-identifier	3.4.20.1	link-id
3.3.4.3.2.5.1	Required Link Status Information Content		data-element	link-status	3.4.14.34	link-status
3.3.4.3.2.5.2.1	Restrictions - Link Status		data-frame	restrictions	3.3.16.5	restrictions
3.3.4.3.2.5.2.2	Link Name - Link Status		data-element	transportation-network-name	3.4.21.1	link-name
3.3.4.3.2.5.2.3	Link Direction - Link Status		data-element	link-direction	3.4.14.9	link-direction
3.3.4.3.2.5.2.4	Lanes Open		data-element	link-lanes-count	3.4.14.12	lanes-number-open
3.3.4.3.2.5.2.5	Link Priority		data-element	link-priority-type	3.4.14.21	priority-type
3.3.4.3.2.5.2.6	Link Restrictions - Axles		data-element	link-restriction-axle-count	3.4.14.22	restriction-axle-count
3.3.4.3.2.5.2.7	Link Restrictions - Height		data-element	link-restriction-height	3.4.14.23	restriction-height
3.3.4.3.2.5.2.8	Link Restrictions - Length		data-element	link-restriction-length	3.4.14.24	restriction-length

Requirements

Design Content

We need to look up value constraints for these data concepts.

TMDD Test Case Objective and Purpose

Test Case	
ID: TC001	Title: Link Status Request-Response Dialog Verification (Positive Test Case)
Objective:	To verify system interface implements (positive test case) requirements for: 1) Link Status Request-Response Dialog message exchange 2) Contents of the Link Status Request Message 3) Contents of the Link Status Information Message 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.
Inputs:	
Outcome(s):	
Environmental Needs:	
Tester/Reviewer	
Special Procedure Requirements:	
Intercase Dependencies:	

Data Concept Definition for: 3.3.16.3 organizationInformation (1 of 2)

Data Structure:

Data Concept Type

Data Structure:

Referenced Data Frames

Data Structure:

Referenced Data Elements

3.3.16.3 organization-information
3.3.16.3 organizationInformation
3.3.16.3.1 ASN.1 REPRESENTATION
organizationInformation ITS-DATA-FRAME ::= {
DESCRIPTIVE-NAME "OrganizationInformation:frame"
ASN-NAME "OrganizationInformation"
ASN-OBJECT-IDENTIFIER { tmddDataFrames 158 }
DEFINITION "The information content describing an organization information for a single organization."
DESCRIPTIVE-NAME-CONTEXT {"Manage Traffic"}
DATA-CONCEPT-TYPE data-frame
STANDARD "TMDD"
REFERENCED-DATA-FRAMES {
{ tmddDataFrames 156 }, -- ContactDetails
{ tmddDataFrames 157 }, -- OrganizationCenterInformation
{ tmddDataFrames 114 } -- DateTimeZone
}
REFERENCED-DATA-ELEMENTS {
{ tmddDataElements 192 }, -- Organization-resource-identifier
{ tmddDataElements 193 }, -- Organization-resource-name
{ tmddDataElements 191 }, -- Organization-location-fips
{ tmddDataElements 188 } -- Organization-function }

Source: TMDD v03.03c Vol II

Step 4: Identify Dialogs, Inputs, Outputs

Data Concept Definition for: 3.3.16.3 organizationInformation (2 of 2)

Source: TMDD v03.03c Vol II

Data Structure:

Sequence of Data Concepts

```
DATA-TYPE "OrganizationInformation ::= SEQUENCE {
organization-id Organization-resource-identifier,
organization-name Organization-resource-name OPTIONAL,
organization-location Organization-location-fips OPTIONAL,
organization-function Organization-function OPTIONAL,
organization-contact-details ContactDetails OPTIONAL,
center-contact-list SEQUENCE (SIZE(1..1024)) OF
OrganizationCenterInformation OPTIONAL,
last-update-time DateTimeZone OPTIONAL,
... }"
}
```

Data Concept Definition for: 3.4.14.34 link-status

Source: TMDD v03.03cVol II

Data Concept Type:

Data Element

Value Constraints:

Enumerated List

3.4.14.34 link-status

3.4.14.34.1 ASN.1 REPRESENTATION

link-status ITS-DATA-ELEMENT ::= {
DESCRIPTIVE-NAME "Link.Link-status:cd"
ASN-NAME "Link-status"
ASN-OBJECT-IDENTIFIER { tmddDataElements 175 }
DEFINITION "The current status that provides an indication of standard or non-standard link or route operations."
DESCRIPTIVE-NAME-CONTEXT {"Manage Traffic"}
DATA-CONCEPT-TYPE data-element
STANDARD "TMDD"
DATA-TYPE "Link-status ::= ENUMERATED {
no-determination (1), open (2),
restricted (3), closed (4), other (5) }"
FORMAT "ASN.1 encoding"
UNIT-OF-MEASURE ""
VALID-VALUE-RULE "see the ASN.1 DATA-TYPE" }

TMDD Test Case Input Specification

Test Case Input Specification			
ID: TCIS001		Title: Input Specification for Link Status Information Request (Positive Test Case)	
Data Concept ID	Data Concept Name (Variable)	Data Concept Type	Value Constraints
3.2.19.1	trafficNetworkInformationRequestMsg	Message	
3.3.16.3	organization-requesting	Data Frame	
3.4.16.8	organization-id	Data Element	IA5String (SIZE(1..32))
3.4.16.9	organization-name	Data Element	IA5String (SIZE(1..128))
3.4.20.2	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"

TMDD Test Case Output Specification

Test Case Output Specification			
ID: TCOS001	Title: Output Specification for Link Status Information Request (Positive Test Case)		
Data Concept ID	Data Concept Name (Variable)	Data Concept Type	Value Constraints
3.2.13.2	linkStatusMsg	Message	
3.3.16.3	organization-information	Data Frame	
3.4.16.8	organization-id	Data Element	IA5String (SIZE(1..32))
3.4.16.9	organization-name	Data Element	IA5String (SIZE(1..128))
3.4.20.1	network-id	Data Element	IA5String (SIZE(1..32))
3.4.20.1	link-id	Data Element	IA5String (SIZE(1..32))
3.4.21.1	link-name	Data Element	IA5String (SIZE(1..128))
3.4.14.34	link-status	Data Element	1 = "no determination" 2 = "open" 3 = "restricted" 4 = "closed"
3.4.14.37	travel-time	Data Element	INTEGER (0..65535), units=seconds

TMDD Test Case

Test Case	
ID: TC001	Title: Link Status Request-Response Dialog Verification (Positive Test Case)
Objective:	To verify system interface implements (positive test case) requirements for: 1) Link Status Request-Response Dialog message exchange 2) Contents of the Link Status Request Message 3) Contents of the Link Status Information Message 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.
Inputs:	Use the input file linkStatusRequest_pos.xml. See Test Case Input Specification TCIS001 - LinkStatusRequest (Positive Test Case). Set network-information-type to 4 or the text "link status".
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

Summary of the TMDD Case Study

- Identified **user needs** from the TMDD NRTM Standard
- Identified relevant **requirements** from the TMDD NRTM (Volume I) to trace user needs to requirements and RTM (Vol II) to trace requirements to relevant design content (dialogs, and data concepts)
- Identified dialogs, inputs, and outputs and created a list of **data concepts** (Volume II) from the requirements and partially filled in test input and output specifications
- Identified and documented **value constraints** from data concept definitions and completed the test **input and output specifications**
- **Developed the test case**

Summary of Learning Objective #5

Handle Standards That Are With and Without Test Documentation

- Learn how to develop test cases where test documentation is **not included** in the standard: **Case Study-1: NTCIP 1205 CCTV**
- Learn how to develop test cases where test documentation **is included** in the standard: **Case Study-2: NTCIP 1204 ESS**
- Learn how to develop test cases where test documentation is **not included** in the standard: **Case Study-3: TMDD (C2C)**

Learning Objective #6: Develop a Requirements to Test Case Traceability Matrix (RTCTM)

- How does RTCTM fit in a test coverage?
- Discuss format of a RTCTM
- Discuss the importance of testing every requirement at least once

How Does RTCTM fit in a Test Coverage?

- Generally, test coverage can be viewed as an indication of the degree to which the test item has been "covered" by the test cases
- The test items in the **Test Case Specification (TCS)** represent the **requirements** to be verified in the deployed system with a RTCTM
  - A simple inspection that all the requirements you intend to test are accounted for in the RTCTM is sufficient
  - Generally, each requirement is tested for a **positive test case** and a **negative test case** (to verify that error conditions are handled properly)

Format of an RTCTM

Source: NTCIP 1204 v03 ESS Standard

Requirement		Test Case	
ID	Title	ID	Title
		C.2.3.2.8	Configure Passive Ice Detection Logic
3.5.2.1.9	Configure Snapshot Camera		
		C.2.3.2.9	Configure Snapshot Camera

Requirement, ID and Title are taken from the project PRL (C2F) or NRTM (C2C)

Unique Test Case ID and Title are assigned by the user

Each Test Case verifies whether a stated requirement is implemented in a working system properly.

How Each Requirement is Handled

Example:

3.5.2.1.9 Configure Snapshot Camera (From ESS PRL)

Upon request, the ESS shall store a textual description of the location to which the camera points and the filename to be used when storing new snapshots.

Relevant Objects for Value constraints (from ESS RTM)

- Object ID Add'l Requirements/Object
  - 5.16.3.1 essSnapshotCameraIndex
  - 5.16.3.2 essSnapshotCameraDescription
  - 5.16.3.6 essSnapshotCameraFilename

RTCTM connects a Requirement ID to a Test Case ID:

3.5.2.1.9	Configure Snapshot Camera	
	C.2.3.2.9	Configure Snapshot Camera

Example of RTCTM

Source: NTCIP 1204 v03 ESS Standard

Requirement		Test Case	
ID	Title	ID	Title
		C.2.3.2.8	Configure Passive Ice Detection Logic
3.5.2.1.9	Configure Snapshot Camera		
		C.2.3.2.9	Configure Snapshot Camera
3.5.2.3	Sensor Data Retrieval Requirements		
3.5.2.3.1	Retrieve Weather Profile with Mobile Sources		
		C.2.3.3.1	Retrieve Weather Profile with Mobile Sources
3.5.2.3.2	Monitor Weather Condition		
3.5.2.3.2.1	Retrieve Atmospheric Pressure		
		C.2.3.3.2	Retrieve Atmospheric Pressure
3.5.2.3.2.2	Retrieve Wind Data		
		C.2.3.3.3	Retrieve Wind Data
3.5.2.3.2.3	Retrieve Temperature		
		C.2.3.3.4	Retrieve Temperature
3.5.2.3.2.4	Retrieve Daily Minimum and Maximum Temperature		
		C.2.3.3.5	Retrieve Daily Minimum and Maximum Temperature
3.5.2.3.2.5	Retrieve Humidity		
		C.2.3.3.6	Retrieve Humidity
3.5.2.3.2.6	Monitor Precipitation		
3.5.2.3.2.6.1	Retrieve Precipitation Presence		

Let's Build an RTCTM for the CCTV Case Study

- Step 1: Identify Requirements.
- Step 2: Identify Test Case(s) that will verify the requirements.
- Step 3: Add a RTCTM Entry.

Build RTCTM for CCTV Case Study Requirements

Rq. ID	Requirement	Dialog	Object Reference and Title NTCIP 1205 Section 3
3.3.3	Status condition within the device	D.1 Generic SNMP GET Interface	
3.3.3.2	Temperature		3.7.5 alarmTemperatureCurrentValue
3.3.3.2	Pressure		3.7.6 alarmPressureHighLowThreshold 3.2.7 alramPressureCurrentValue
3.3.3.2	Washer fluid		3.7.8 alarmWasherFluidHighLowThreshold 3.2.9 alarmWasherCurrentValue
3.3.3.3	ID Generator		3.11 cctv label Objects

Requirements

Ignore Design Content Information
for the purposes of developing the RTCTM

Build RTCTM for CCTV Case Study Test Case

Test Case	
ID: TC001	Title: Request Status Condition within the Device Dialog Verification (Positive Test Case)
Objective:	To verify system interface implements (positive test case) requirements for a sequence of OBJECT requests for: • 3.7.5 alarmTemperatureCurrentValue • 3.7.6 alarmPressureHighLowThreshold • 3.7.7 alarmPressureCurrentValue • 3.7.8 alarmWasherFluidHighLowThreshold • 3.7.9 alarmWasherCurrentValue • 3.11 cctv label Objects The test case verifies that the data value of the OBJECTs requested are within specified ranges. The object identifier (OID) of each object requested is the only input required. An output specification is provided to show valid value constraints per the NTCIP 1205 v01 object definitions.
Inputs:	The object identifier of each object requested is needed.
Outcome(s):	All data are returned and verified as correct per the OBJECT constraints of NTCIP 1205 v01. See Test Case Output Specification TCOS001 – Status Condition within the Device (Positive Test Case)
Environmental Needs:	When testing for alarm temperature current value, set up is needed to measure temperature.
Tester/Reviewer	M.I.
Special Procedure Requirements:	None
Intercase Dependencies:	None

Build RTCTM for CCTV Case Study

Requirements to Test Case Traceability Matrix			
Requirement		**Test Case**	
ID	**Title**	**ID**	**Title**
3.3.3	Status Condition within the Device		
		TC001	Title: Request Status Condition within the Device Dialog Verification (Positive Test Case)

Importance of RTCTM

- Every ITS project's testing documentation (Test Plan) must have RTCTM included.
- RTCTM allows testing personnel to focus on each functionality (requirement), one at a time, ensuring performance as intended by the user.
- RTCTM brings users, developers, and testers on a level field for a successful outcome.
- Without RTCTM, verification-validation will NOT occur properly.

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The Requirements to Test Case Traceability Matrix relates to which of the following?

Answer Choices

a) Requirements and design
b) Test cases and requirements
c) Needs and requirements
d) None of the above

Review of Answers

a) Requirements and design

Incorrect. The RTM relates requirements and design content

b) Test cases and requirements

Correct! The RTCTM relates test cases and the requirements the test cases verify.

c) Needs and requirements

Incorrect. The PRL or NRTM relates needs and requirements.

d) None of the above

Incorrect. The correct answer is b) above.

Summary of Learning Objective #6

Develop a Requirements to Test Case Traceability Table (RTCTM)

- How does RTCTM fit in a test coverage?
- Discuss format of a RTCTM
- Discuss the importance of testing every requirement at least once

Learning Objective #7: Identify Types of Testing

- **Function Test**
  - Positive Test
  - Negative Test
  - Boundary Test
- **Performance Test**
- **Load Test**
- **Stress Test**
- **Benchmark Test**
- **Integration Test**
- **System Acceptance Test**

Types of Testing

Function Test

- The function test verifies that the system interprets inputs correctly, performs a desired outcome, and returns a correct response
- Positive testing invokes a system function to verify proper response
- Negative testing invokes a system error to verify that the system responds properly to errors
- The boundary tests are constructed to test the inputs and outputs of a system at the extremes in terms of value and size ranges
- The boundary test is a form of positive and negative testing

Types of Testing (cont.)

Performance Test

- Constructed to verify performance requirements of a system; for example, those specific to system timing
- Testing that verifies that round-trip communications (messaging) occurs within a specified amount of time
- Testing that verifies completion of a function within a specified amount of time; for example, a calculation or a query
- Special consideration must be given during performance testing to verify and log the start and end time of the test

Types of Testing (cont.)

Load Test

- A load test is constructed to place a demand on a system or device, and measure its response
- Load testing is performed to determine a system's behavior under both normal and anticipated peak load conditions
- Helps to identify the maximum operating capacity of an application as well as any bottlenecks, and determines which element is causing degradation
- Special consideration must be given to identification of the metrics used to measure the system's capacity

Types of Testing (cont.)

Stress Test

- A stress test is a type of load test constructed to measure the system at peak load and overload conditions
- The stress load is usually so great that error conditions are the expected result
- Special consideration may be given to system recovery, and re-start after a stress load causes a system failure

Types of Testing (cont.)

Other Testing

- **Benchmark testing** is used to identify that a system achieves a defined level of functionality and performance
  - For example, prior to system integration testing, certain key sub-systems should achieve a certain benchmark of performance and function
- **Certification testing** is a form of benchmark testing
  - Special attention must be given to ensure that systems (perhaps of different vendors or agencies) are treated equally during the test. A summary benchmark score may be used to rank results

Types of Testing (cont.)

Other Testing: Integration Tests

- Used to test how well system elements work together as a whole
- Used to test operation of system elements when other system elements are not working properly or absent
- Special consideration may be given to document results of how well the system operates under degraded operation (i.e., one or more sub-system elements has stopped working or is absent)

Types of Testing (cont.)

Other Testing: System Acceptance Tests

- Test cases can be used to verify the functions and performance of a system
- Special consideration may be given to the parties that must attend, witness, and sign-off on the test
- Disputes related to payment may be avoided if proper witnessing and sign-off on acceptance testing is documented properly

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Which of the following is used to test error handling of a system?

Answer Choices

a) System acceptance test

b) Negative test

c) Periodic maintenance test

d) Unit test

Review of Answers

a) System acceptance test

Incorrect. This test is not intended specifically to test for error handling.

b) Negative test

Correct! A negative test is designed to test error handling by the system.

c) Periodic maintenance test

Incorrect. This test is not intended specifically to test for error handling.

d) Unit test

Incorrect. This is a function test to a subsystem or unit of the system.

Summary of Learning Objective #7

Identify Types of Testing

- **Function Test**
  - Positive Test
  - Negative Test
  - Boundary Test
- **Performance Test**
- **Load Test**
- **Stress Test**
- **Benchmark Test**
- **Integration Test**
- **System Acceptance Test**

Learning Objective #8: Recognize the Purpose of the Test Log and Test Anomaly Reports

- Outline test reporting guidance by IEEE 829-2008
- Discuss the test log:
  - Identify data, information, and files; signatures need to be captured during the test
- Discuss test anomaly report:
  - Identify what failed and investigation necessary to provide quality feedback to system developers/maintainers
- More detailed information is provided in Module T204: How to Develop Test Procedures for an ITS Standards-based Test Plan

Impacts of Failure of a Test Case

- Ideally, your test plan will include language to describe what investigation should occur in the event of a failure or error
- In the event of a failure relatable to a test case, test anomaly report should include specific details
- In many cases, the test engineers and/or developers of the system being tested and who are present during the test will have a sense of where the problem lies, and will be able to investigate and quickly isolate the problem, describe it, and hand off the problem to development staff
- Other cases may involve a more prolonged investigation into the nature of the problem

Test Log

- The purpose of the test log is to provide a chronological record of relevant details about the execution of tests
- Capture data, information files used, and locations
- Date and times of execution of tests
- The test plan should spell out the detail of what should be logged

Test Anomaly Report

- **Test anomaly report** documents any event that occurs during the testing process that requires investigation (Previous IEEE 829 version called it **incident report**)
- We can also refer to test anomaly report as a problem, test incident, defect, trouble, issue, anomaly, or error report

Summary of Learning Objective #8

Understand the Purpose of the Test Log and Test Anomaly Reports

- Outline test reporting guidance by IEEE Std 829-2008
- Discuss the test log:
  - Identify data, information, and files; signatures need to be captured during the test
- Discuss test anomaly report:
  - Identify what failed and investigation necessary to provide quality feedback to system developers/maintainers

What We Have Learned

1) Showed that some standards have test documentation, some do not, and how to deal with the gaps.
2) Showed elements of a requirements to test case traceability matrix and how it can be structured to account for all requirements and all test cases.
3) Learned how to document and handle impact of test case failures.
    1) What to document in the test log.
    2) What to document in the test anomaly report.
4) Learned about types of testing.

What We Have Learned (cont.)

5) Process to gather information and develop a test case:

a) Identify user needs

b) Identify requirements

c) Develop test case objective

d) Identify design content

e) Document value constraints

f) Complete test case

What We Have Learned (cont.)

6) Test reports for documenting test case failure
   a) Test log
   b) Test anomaly report

What We Have Learned (cont.)

7) Test cases can be re-used in different types of testing:

a) Function test

b) Performance test

c) Load test

d) Stress test

e) Benchmark test

f) Integration test

g) System acceptance test

Resources

1. IEEE Std 829-2008 IEEE Standard for Software and System Test Documentation
2. IEEE Std 610-1990 Standard Glossary of Software Engineering Terminology
3. NTCIP 8007 Testing and Conformity Assessment Documentation within NTCIP Standards Publications
4. A317a: Understanding User Needs for CCTV Systems Based on NTCIP 1205 Standard
5. A317b: Understanding Requirements for CCTV Systems Based on NTCIP 1205 Standard
6. NTCIP 1205 v01 CCTV Standard
7. NTCIP 1204 v03 Environmental Sensor Station Interface Standard
8. Traffic Management Data Dictionary Version 3.03
9. PCB Testing Modules: T311 DMS; T313 ESS; and T321 TMDD
10. Student Supplement (Combined for Part 1 and 2).

QUESTIONS?

STANDARDS ITS TRAINING

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