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U.S. Department of Transportation

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T313:

Applying Your Test Plan to Environmental Sensor Stations (ESS) Based on NTCIP 1204 v04 ESS Standard

Instructor

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Learning Objectives

Describe the **role of test plans** and the testing to be undertaken

Identify **key elements** of NTCIP 1204 v04 relevant to the test plan

Describe the **application** of a good test plan to an ESS system being procured

Describe the **testing** of an ESS using standard procedures

Learning Objective 1

Describe the **role of test plans** and the testing to be undertaken

What Is an Environmental Sensor Station (ESS)?

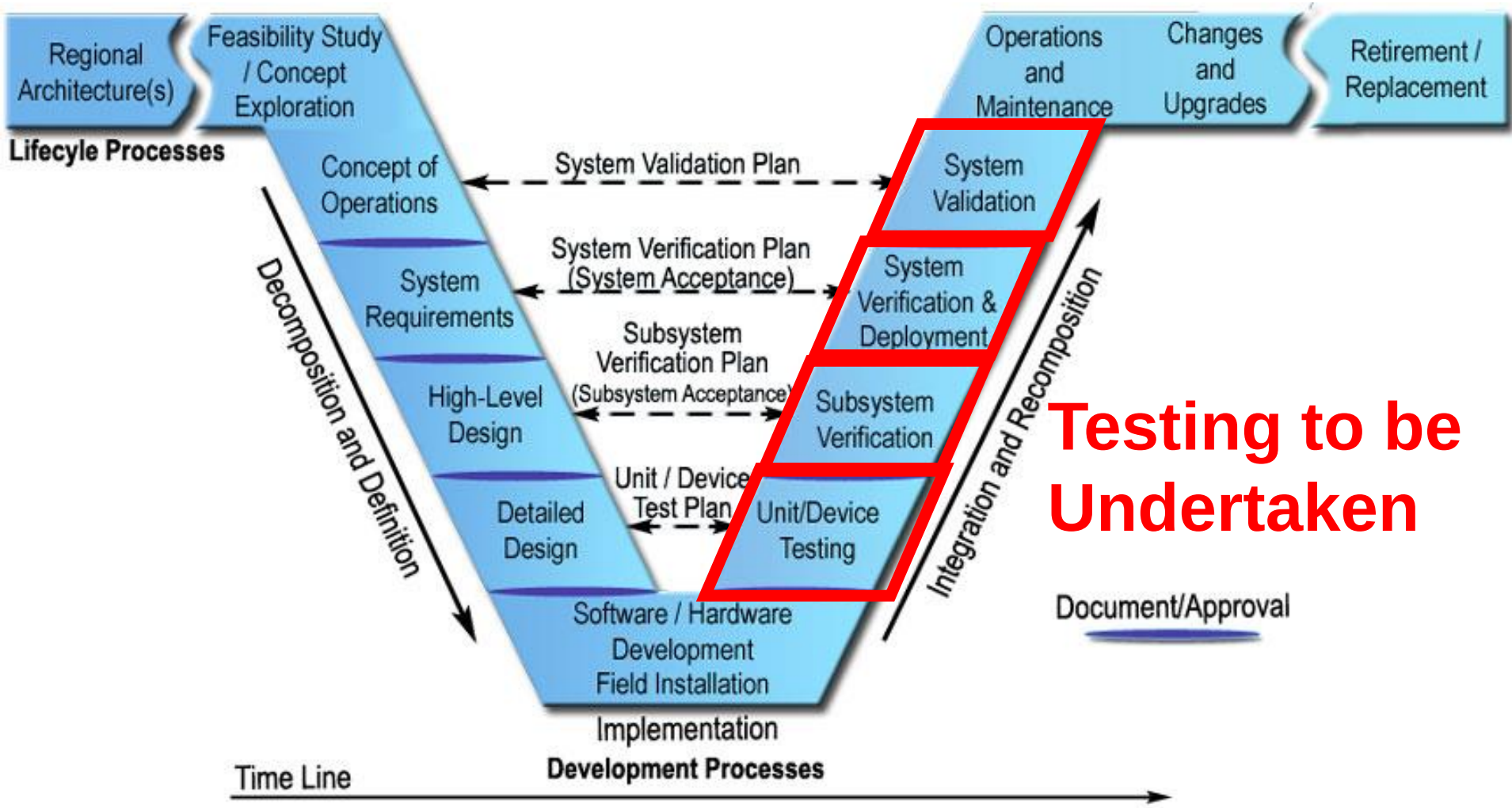
ESS Capabilities

- May remotely monitor:
  - Wind speed and direction
  - Temperature, humidity, and pressure
  - Precipitation type and rate
  - Snow accumulation
  - Visibility
  - Pavement conditions
  - Radiation
  - Water level
  - Air quality
- Can also support:
  - Snapshot cameras
  - Pavement treatment systems
- "Station" may be mobile

Source: Intelligent Devices, Inc.

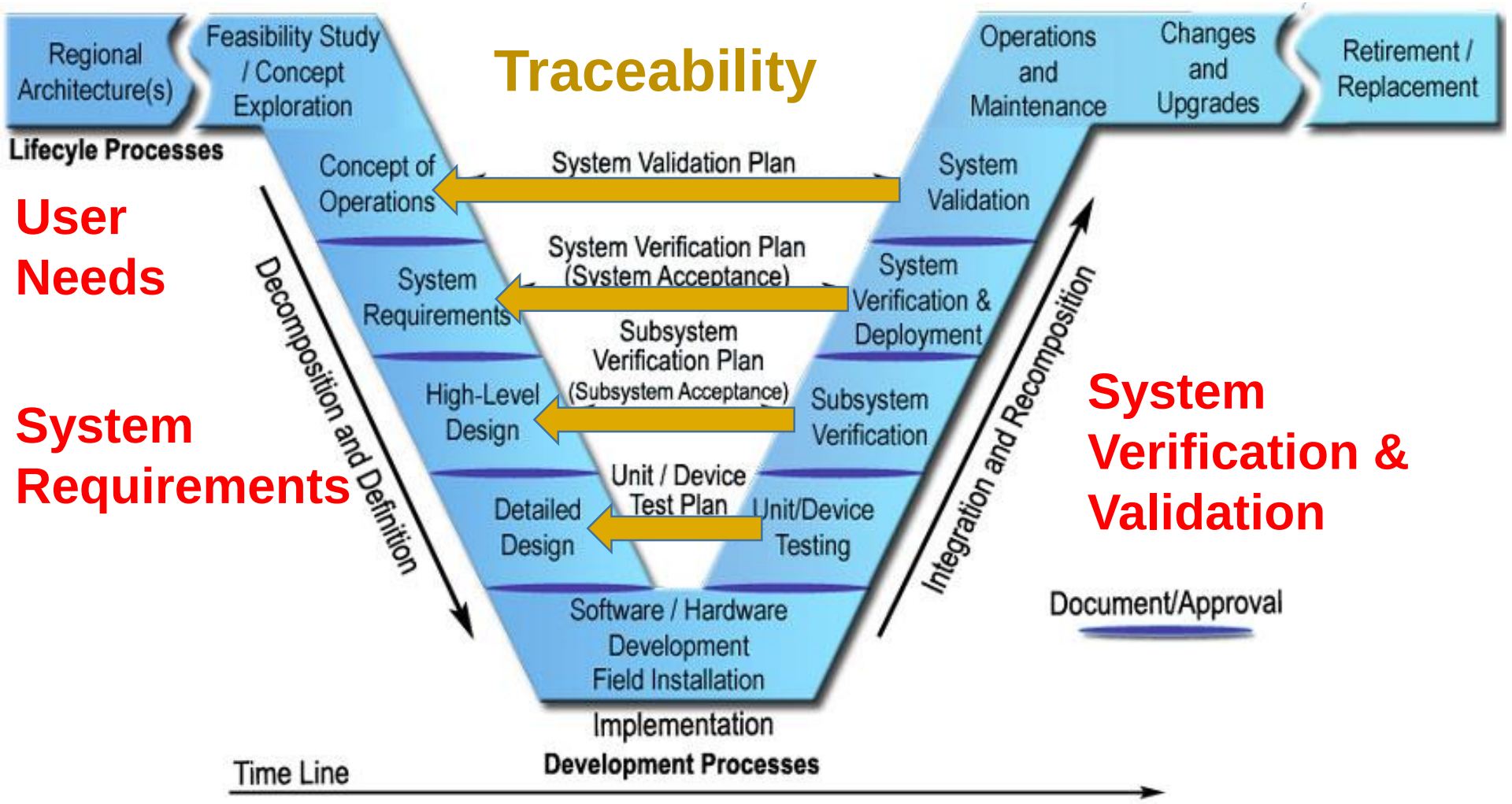
Review System Lifecycle

Testing and the System Lifecycle



Why We Test

To Confirm That the System Will Work as Intended



Why We Test

To Confirm That the System Will Work as Intended

Testing can **objectively ensure** that a system is:

- **Validated**: Solves the right problem
  - Satisfies the user needs
- **Verified**: Solves the problem right (correctly)
  - Satisfies the system requirements as designed

NTCIP standardizes user needs and requirements

NTCIP Testing **verifies**

- **Compliance**: Supports selected needs and requirements
- **Conformance**: Implements per standardized design

Test Documentation

There's a Standard for That!

Test Plan → Test Design → Test Cases → Test Procedures → Execute → Test Reports

Testing is a general Information Technology need

Topic of IEEE 829-2008

IEEE Standard for Software and System Test Documentation

ESS Test Plan

Test Plan Overview

Test Plan | Test Design | Test Cases | Test Procedures | Execute | Test Reports

A Test Plan answers the key questions

ESS Test Plan

Who Is Responsible for Testing Tasks?

Different people may:

- Provide items to be tested
- Provide the test facility
- Set up the test environment
- Perform and report on the test

Each requires unique skills and resources

NTCIP Testing may be performed by:

- Agency: May not know NTCIP details
- Vendor: Conflict of interest issues
- 3rd Party: May be difficult to access

ESS Test Plan

What Items Will Be Tested?

Different test plans will typically be used to test:

- Software modules
- Components
- The system as a whole

NTCIP Testing generally tests one component

NTCIP 1204 testing generally tests either:

- The ESS (the controller and connected sensors), or
- The manager that communicates with the ESS

ESS Test Plan

What Requirements Will Be Tested?

Different test plans may be used to test:

- Communications
- Functionality
- Performance
- Hardware
- Environmental

NTCIP Testing: testing of communication interface

Test Plan should identify what else will be tested

- Will sensor values be compared against actual conditions?
- Will communication response times be measured?
- Will communications be tested with power outages?

ESS Test Plan

When Will It Be Tested?

Right side of the V-diagram

Each stage may have one or more test plans

NTCIP testing

- Typically during subsystem verification
- May be included in other stages

ESS Test Plan

Where Will It Be Tested?

Need to describe the test environment:

- Bench: limited sensor data
- Laboratory: simulated data (price?)
- Real-world: real data
  - Difficult to test limits
  - Safety implications?

Location of tester

- Local testing: Lower response times
- Remote testing: Lower costs?

NTCIP 1204 testing may use any

- Trade-offs should be considered

ESS Test Plan

Why Is It Being Tested?

Verify conformance

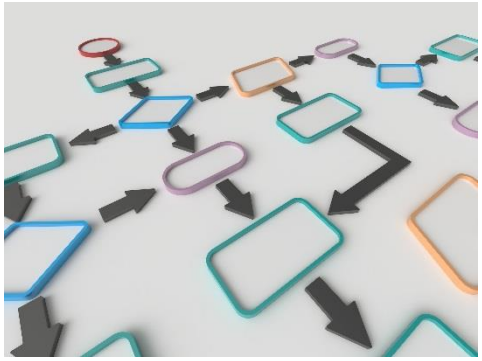
Verify compliance (project-specific?)

Other practical reasons

- Requirement for acceptance
  - Pay item
  - Approval to move to next phase of project
- Troubleshooting

ESS Test Plan

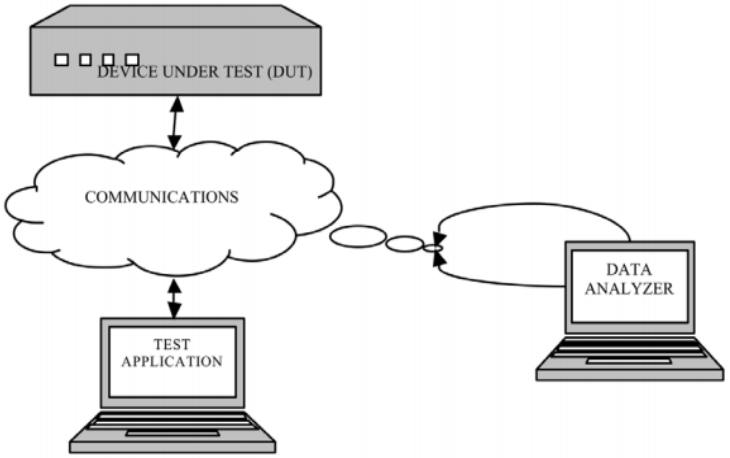
How Will It Be Tested?



Test plan describes tools required

NTCIP testing uses test software

- Performs role of one component
- Often automates portion of step-by-step procedures
- May be supplemented by data analyzer



Source: NTCIP 8007

ESS Test Plan

Master Test Plan

NTCIP Test Plan is a Level Test Plan

Often multiple Level Test Plans in a project

Master Test Plan defines how various Levels fit together

- Purpose of each level test plan
- Order in which they are performed

ESS Test Documentation

Test Design / Test Case / Test Procedure

Test Design

- Maps features to be tested to test cases
- Makes any refinements to test approach

Test Cases

- Specifies
  - Inputs
  - Outputs
  - Refinements

Test Procedures

- Step-by-step instructions

Standardized in Annex C of NTCIP 1204 v04

- Reduces effort to customize

Customized in your test plan

- Specify which requirements will be tested

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Question

Which of the following most accurately describes a benefit of having standardized NTCIP test documentation included in NTCIP 1204 v04?

Answer Choices

a) Eliminates the need for customized test documentation

b) Reduces the effort to customize test documentation

c) Ensures that all devices conform to the standard

d) Eliminates the need for additional tools to perform testing

Review of Answers

a) Eliminates the need for customized test documentation

Incorrect. Test plans are still needed to customize testing to each specific project.

b) Reduces the effort to customize test documentation

Correct! Most of the documentation has been standardized.

c) Ensures that all devices conform to the standard

Incorrect. Each device still needs to be tested to verify conformance.

d) Eliminates the need for additional tools to perform testing

Incorrect. Testing will still rely on tools to communicate with the device under test.

Learning Objectives

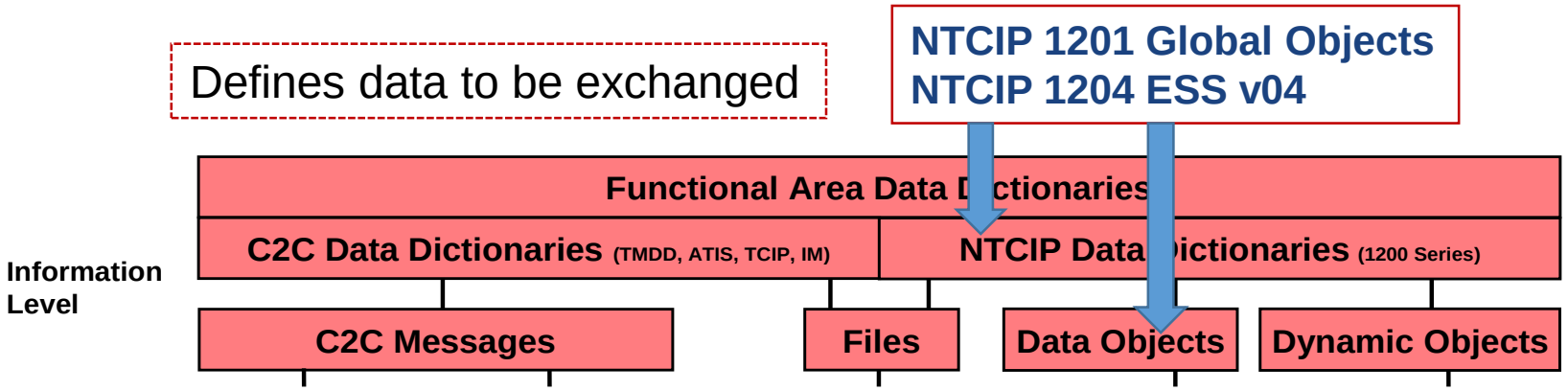
Describe the **role of test plans** and the testing to be undertaken

Identify **key elements** of NTCIP 1204 v04 relevant to the test plan

Learning Objective 2

Identify **key elements** of NTCIP 1204 v04 relevant to the test plan

Relationship Among NTCIP Standards



How data is exchanged

Source: NTCIP Guide

Structure of NTCIP 1204 v04

NTCIP 1204 v04 Outline (Body)

1. General
2. Concept of Operations
3. Functional Requirements
4. Dialogs
5. Management Information Base

Structure of NTCIP 1204 v04

NTCIP 1204 v04 Outline (Annexes)

A. Requirements Traceability Matrix

B. Object Tree

C. Test Procedures

D. Documentation of Revisions

E. User Requests

F. Generic Clauses

G. SNMP Interface

H. Controller Configuration Objects

Elements Related to Testing

NTCIP 1204 v04 Outline

1. General
2. Concept of Operations — User Needs, PRL
3. Functional Requirements — Requirements
4. Dialogs — Design
5. Management Information Base — Design
A. Requirements Traceability Matrix — RTM
B. Object Tree
C. Test Procedures — Test Design, Cases, Procedures
D. Documentation of Revisions
E. User Requests
F. Generic Clauses
G. SNMP Interface
H. Controller Configuration Objects

Elements Related to Testing

Test Plan

Specific for each project

Outline defined by IEEE 829-2008

- Example in Student Supplement

Features to be tested based on PRL

- Section 2 of NTCIP 1204 v04

SUPPLEMENT

Elements Related to Testing

PRL (Section 2)

Protocol Requirements List (PRL)					
User Need ID	User Need	R ID	Functional Requirement	Conformance	Support
2.5.2.1.1	Monitor Atmospheric Pressure			O.5 (1..*)	Yes / No / NA
		3.5.2.1.10.1 (PressLoc)	Retrieve Atmospheric Pressure Metadata - Location	O	Yes / No / NA
		3.5.2.1.10.2	Retrieve Atmospheric Pressure Metadata - Sensor Information	O	Yes / No / NA
		3.5.2.1.10.3	Configure Atmospheric Pressure Metadata - Location	PressLoc:O	Yes / No / NA
		3.5.2.3.2.10	Retrieve Atmospheric Pressure	M	Yes / NA
		3.6.1	Required Number of Atmospheric Pressure Sensors	M	Yes / NA

- Agency completes the PRL for each project
  - Identifies the specific requirements that must be supported
  - All selected requirements should be tested at some point

Elements Related to Testing

Test Design Specification (Annex C)

Requirement		Test Case	
ID	Title	ID	Title
3.5.2.1.6	Configure Pavement Sensor		
		C.2.3.2.6	Configure Pavement Sensor
3.5.2.1.7	Configure Subsurface Sensor - Text Description		
		C.2.3.2.7	Configure Subsurface Sensor
3.5.2.1.8	Configure Passive Ice Detection Logic		
		C.2.3.2.8	Configure Passive Ice Detection Logic

- Format conforms to NTCIP 8007 (See Module T202)
- Standard traces requirements to test cases
- If requirement is selected in PRL, each traced test case should be performed
- Project test plan should reference the table and note any exceptions taken

Elements Related to Testing

Test Case Specification (Annex C)

Test Case: 3.4	**Title:**	*Retrieve Air Temperature*	
	Description:	*This test case verifies that the ESS allows a management station to determine the current temperature from a temperature sensor.*	
	Variables:	*Required_Temperature_Sensors*	*PRL 3.6.3*
	Pass/Fail Criteria:	*The device under test (DUT) shall pass every verification step included within the Test Case to pass the Test Case.*	

Standard defines each test case with inputs and outputs

Project NTCIP Test Plan should:

- Reference these definitions
- Identify the input values that will be used for the tests
  - E.g., How many temperature sensors are required?

Elements Related to Testing

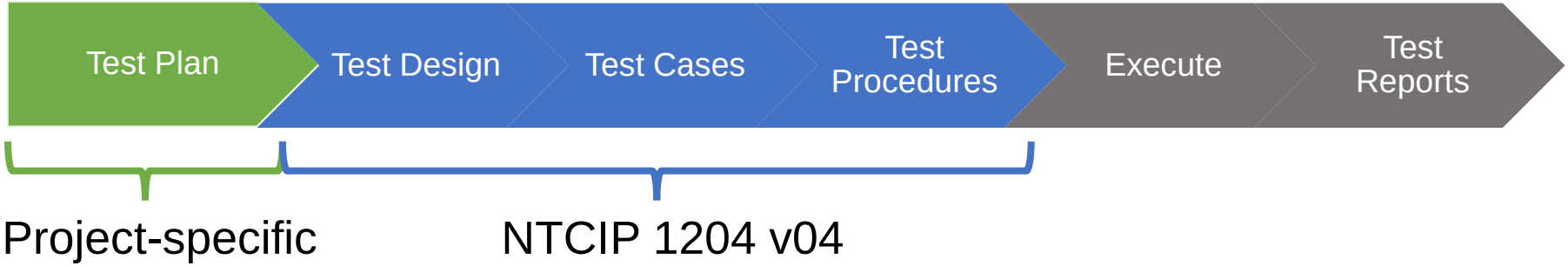
Test Procedures (Annex C)

Step	Test Procedure	Device
1	CONFIGURE: Determine the number of temperature sensors required by the specification (PRL 3.6.3). RECORD this information as: »Required_Temperature_Sensors	
2	GET the following object(s): »essNumTemperatureSensors.0	Pass / Fail (RFC 1157)
3	VERIFY that the RESPONSE VALUE for essNumTemperatureSensors.0 is greater than or equal to Required_Temperature_Sensors.	Pass / Fail (Sec. 3.6.3)
4	Determine a random number between 1 and Required_Temperature_Sensors. RECORD this information as: »Subject_Sensor	
5	GET the following object(s): »essAirTemperature.Subject_Sensor	Pass / Fail (Sec. 3.5.2.3.2.3)

- Standard defines test procedures for each test case and indicates the requirements tested at specific points
- Project NTCIP Test Plan should reference the procedures

Elements Related to Testing

Test Preparation Documentation



Test preparation documentation is defined by properly linking

- Project-specific test plan to…
- NTCIP 1204 v04

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Question

Which statement most closely describes the documentation that a project should prepare before conducting NTCIP 1204 v04 testing?

Answer Choices

a) Just reference Annex C of NTCIP 1204 v04

b) Develop a test plan with appropriate additions to link to NTCIP 1204 v04

c) Develop a test plan and set of test procedures with appropriate additions to link to NTCIP 1204 v04

d) Develop all documents defined by IEEE 829-2008

Review of Answers

a) Just reference Annex C of NTCIP 1204 v04

Incorrect. Annex C does not define project-specific details such as when, what, who, where, how, and why.

b) Develop a test plan with links to NTCIP 1204 v04

Correct! Most of the documentation is done; you just customize to your project with a test plan with some links.

c) Develop a test plan and set of test procedures with links

Incorrect. The test design specification is already defined in the Requirements to Test Case Traceability Matrix.

d) Develop all documents defined by IEEE 829-2008

Incorrect. Most of this documentation has been standardized.

Learning Objectives

Describe the **role of test plans** and the testing to be undertaken

Identify **key elements** of NTCIP 1204 v04 relevant to the test plan

Describe the **application** of a good test plan to an ESS system being procured

Learning Objective 3

Describe the **application** of a good test plan to an ESS system being procured

Example ESS Site

Typical ESS

- NTCIP 1204 v04 has mandatory and optional user needs
- A typical ESS might include:
  - Wind sensor
  - Temperature sensor
  - Humidity sensor
  - Air pressure sensor
  - Precipitation sensor
  - Multiple pavement sensors
  - Multiple subsurface sensors
  - Camera

Other Modules That Assist in Defining Requirements

Sample PRL Selections for Site

2.5.2.1.2	Monitor Winds			O.5 (1..*)	(Yes) / No / NA	
		3.5.2.1.2 (Wind)	Retrieve Metadata for Each Wind Sensor - Text Description	O	Yes / (No) / NA	
		3.5.2.1.11.1 (WindLoc)	Retrieve Metadata for Each Wind Sensor - Location	O	Yes / (No) / NA	
		3.5.2.1.11.2	Retrieve Metadata for Each Wind Sensor - Sensor Information	O	(Yes) / No / NA	
		3.5.2.1.11.3	Configure Wind Sensor Metadata - Location	Wind:O; WindLoc:O	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 ____ (1..255:Default=1) wind sensors.

- Each user need has optional and mandatory requirements
- PRL allows user to select standardized requirements from list using standardized rules
- Modules A313a and A313b provide more information on PRL
- Student Supplement contains a complete PRL

SUPPLEMENT

Understanding Test Case Traceability

Test Design Specification

Requirement		Test Case	
ID	Title	ID	Title
3.5.2.3.2.2	Retrieve Wind Data		
		C.2.3.3.3	Retrieve Wind Data

Requirements to Test Case Traceability Table

- Contained in NTCIP 1204 v04 Annex C Clause C.2.2
- Identifies test cases for each requirement

Understanding Test Case Traceability

Test Case Specification

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 to pass the Test Case.*	

Clause C.2.3.3.3 of NTCIP 1204 v04

- Defines the test case with inputs (variables) and outputs (criteria)
- In order to perform the test, we need to know the number of sensors
  - Sample PRL for Requirement 3.6.2 defines this to be 1
- Test procedures are shown immediately under this description

Create a Test Plan for ESS

Contents of an NTCIP Test Plan

Complete draft test plan in Student Supplement

Why	Test Plan Identifier
	Scope
What	Items to be tested
	Features to be tested
	Features not to be tested
How	Approach
	Item Pass/Fail Criteria
	Suspension Criteria
	Test Deliverables
	Testing Tasks
Where	Environment/Infrastructure
Who	Responsibilities and Authority
	Staffing and Training Needs
When	Schedule, Estimates and Cost
	Risk and Contingencies
	Glossary

Create a Test Plan for ESS

Why

Objectives

- What is the primary purpose of the test
- What happens upon successful completion

Project Background

- Allows reader to understand the context of the test

Scope

- Explain that this will be an NTCIP test

References

Create a Test Plan for ESS

What

Items to be tested

- Identify the device that will be tested

Features to be tested

- Identify the requirements that will be tested

Features not to be tested

- Explain the limitations of the testing

Create a Test Plan for ESS

How

Approach
- Define inputs (variables)
- What happens if there is a failure (regression)

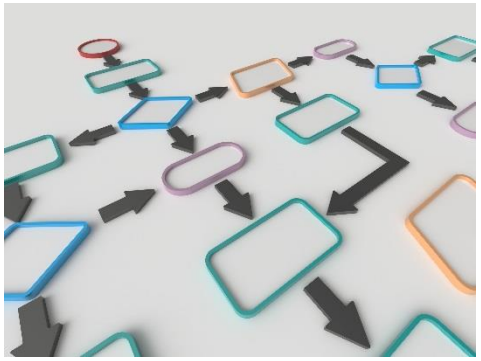
Item Pass/Fail Criteria (Outputs)
- Identify what constitutes a failure

Suspension Criteria
- Identify restrictions on stopping and starting tests

Test Deliverables
- What deliverables will be produced

Testing Tasks
- What tasks need to be done

Procedures defined separately



Create a Test Plan for ESS

Where

Environment/Infrastructure

- How will equipment be connected
  - Remote, local, combination
- Other needs
  - Tables
  - Chairs
  - Protection from elements
  - Power

Create a Test Plan for ESS

Who

Identify who is responsible for what

Identify level of effort needed

Create a Test Plan for ESS

When

Schedule

How is schedule impacted if things go wrong

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Question

Which of the below is not included in a test plan?

Answer Choices

a) Identification of who will perform the testing

b) Identification of which features will be tested

c) Identification of the reason for the test

d) Identification of the steps used to test the device

Review of Answers

a) Identification of who will perform the testing

Incorrect. The test plan should identify who is responsible for testing.

b) Identification of which features will be tested

Incorrect. The test plan should identify which features will be tested.

c) Identification of the reason for the test

Incorrect. The test plan should identify the reason the test is being planned.

d) Identification of the steps used to test the device

Correct! The test procedures are defined in a separate document.

Learning Objectives

Describe the **role of test plans** and the testing to be undertaken

Identify **key elements** of NTCIP 1204 v04 relevant to the test plan

Describe the **application** of a good test plan to an ESS system being procured

Describe the **testing** of an ESS using standard procedures

Learning Objective 4

Describe the **testing** of an ESS using standard procedures

Explain a Sample Test Procedure

Test Case Specification

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 to pass the Test Case.*	

- What is “wind information”?

Explain a Sample Test Procedure

Requirement

3.5.2.3.2.2 Retrieve Wind Data

Upon request, the ESS shall return the following information for each wind sensor reporting to the ESS:

a) The average wind speed recorded during the 2 minutes preceding the observation in tenths of meters per second;

b) The average direction the wind is blowing from, as recorded during the 2 minutes preceding the observation, measured clockwise in degrees from true north;

c) The current wind speed in tenths of meters per second;

d) The current direction the wind is blowing from, measured clockwise in degrees from true north;

e) The maximum wind gust recorded during the 10 minutes preceding the observation in tenths of meters per second;

f) The direction of the maximum wind gust recorded during the 10 minutes preceding the observation, measured in degrees clockwise from true north; and

g) The assessment of the wind situation from a staffed station as defined by the Beaufort Wind Scale in the Glossary of Meteorology. Valid values are: other, unknown, calm, light breeze, moderate breeze, strong breeze, gale, moderate gale, strong gale, storm winds, hurricane force winds, and gusty winds.

Explain a Sample Test Procedure

Overview

Procedures are defined in Annex C of standard

- Saves agencies from having to develop their own
- Allows for off-the-shelf automation of testing

Sample is “Test Case C.2.3.3.3 Retrieve Wind Data” used in the previous example

Explain a Sample Test Procedure

Retrieve Wind Data

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 (Sec. 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 (Sec. 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 (Sec. 3.5.2.3.2.2)

Explain a Sample Test Procedure

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Explain a Sample Test Procedure

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Explain a Sample Test Procedure

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Explain a Sample Test Procedure

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2	GET the following object(s): »windSensorTableNumSensors.0	Pass / Fail (Sec. 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 (Sec. 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 (Sec. 3.5.2.3.2.2)

Explain a Sample Test Procedure

Retrieve Wind Data

5.2	VERIFY that the RESPONSE VALUE for windSensorAvgSpeed.N is greater than or equal to 0.	Pass / Fail (Sec. 5.6.10.4)
5.3	VERIFY that the RESPONSE VALUE for windSensorAvgSpeed.N is less than or equal to 65535.	Pass / Fail (Sec. 5.6.10.4)
5.4	VERIFY that the RESPONSE VALUE for windSensorAvgSpeed.N is APPROPRIATE.	Pass / Fail (Sec. 5.6.10.4)

Some VERIFY steps can be easily **automated**

Others require **human interaction**

Other Types of Test Steps

Other Step Types in NTCIP 1204 v04

DELAY <for a period of time>

PERFORM <another test procedure>

SET <one or more objects to defined values>

IF <condition> <true branch> **ELSE** <false branch>

Analyze and Record Test Results

Reported Failures

Errors can be from a number of sources

- Errors in the **implementation**
- **User** Errors:
  - Incorrectly **configured** inputs at start of test
  - Incorrectly **evaluating** a test step
- **Equipment** malfunction
- Errors in the **procedure**
- Errors in the **standard**

Maturity of standards reduce the risks in last two areas

Once an error is identified

- Investigate and if valid, report the issue

Benefits of Automated Testing

Automation Is Essential

Automation can dramatically accelerate the testing process

Reduces probability of errors in testing

- A new source of potential error
- But reduces potential for user error
- Correct once and reuse

Some steps still require manual verification

ACTIVITY

STANDARDS ITS TRAINING

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

Question

Which of the below is not a type of step used in NTCIP 1204 v04 testing?

Answer Choices

a) UPDATE

b) SET

c) VERIFY

d) IF

Review of Answers

a) UPDATE

Correct! There is no definition for "UPDATE" in NTCIP 1204 v04 testing.

b) SET

Incorrect. A SET request can be used to alter the value of a parameter in the ESS.

c) VERIFY

Incorrect. A VERIFY step can be used to ensure that the device is responding properly.

d) IF

Incorrect. An IF step can be used to branch the procedure logic based on the evaluation of a condition.

Module Summary

Describe the **role of test plans** and the testing to be undertaken

Identify **key elements** of NTCIP 1204 v04 relevant to the test plan

Describe the **application** of a good test plan to an ESS system being procured

Describe the **testing** of an ESS using standard procedures

We Have Now Completed the ESS Curriculum

Module 11: A313a: Understanding **User Needs** for ESS Systems Based on NTCIP 1204 v04 Standard

Module 15: A313b: Specifying **Requirements** for ESS Systems Based on NTCIP 1204 v04 Standard

Module 18: T313: Applying Your **Test Plan** to ESS Based on NTCIP 1204 v04 ESS Standard

Thank you for completing this module.

Feedback

Please use the Feedback link below to provide us with your thoughts and comments about the value of the training.

Thank you!