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S T U D E N T S U P P L E M E N T

RITA Intelligent Transportation Systems
Joint Program Office

T313 Applying Your Test Plan to the NTCIP 1204 v03 ESS Standard

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PURPOSE

This supplement provides additional information for the Professional Capacity Building (PCB) Module T313, Applying Your Test Plan to the NTCIP 1204 v03 ESS Standard.

Module T313 provides participants with the information needed to assist agencies on how to create a test plan specific to their Environmental Sensor Station (ESS) needs, based on the NTCIP 1204 standard.

This module helps the participant understand the elements of the ESS standard that are required to apply test plans to verify that the agency's ESS system meets the design specifications and is conformant to the NTCIP 1204 standard while following standard testing methodologies. An example is provided in the module.

NTCIP 1204 Environmental Sensor Station History

- NTCIP 1204 v01 was approved in 1998. It was not created using the Systems Engineering Process (SEP) and so does not include user needs or requirements. Conformance is defined by means of conformance groups.
- NTCIP 1204 v01 Amendment 1 was approved in 2001 and addressed user comments.
- NTCIP 1204 v02 was accepted in 2005 as a recommended standard. This version was created using the SEP and so includes:
 - Concept of Operations
 - Functional Requirements
 - Dialogs
 - Protocol Requirements List (PRL)
 - Requirements Traceability Matrix (RTM)
- NTCIP 1204 v03 was accepted in 2008 as a recommended standard. This version added:
 - Test cases and test procedures
 - Requirement to Test Case Traceability Matrix (RTCTM)

Presentation Example

The functional requirement “Retrieve Wind Data” is an example of how to use the NTCIP 1204 v03 standard to test that a functional requirement has been fulfilled. The full details of this requirement, including the description, implementation, and selection of the requirement, along with the test design, test case, and test procedure specifications for this requirement, are provided below.

The functional requirement is:

3.5.2.3.2.2 Retrieve Wind Data
 Upon request, the ESS shall return the current wind speed and direction for each wind sensor connected to the ESS.

In the Requirements Traceability Matrix (RTM), this functional requirement traces to the following design:

Table 29 Requirements Traceability Matrix (RTM)

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

The dialog referenced in the RTM is used to retrieve objects that are in tabular form:

F.4.6 Generic Retrieve Table Dialog

NOTE—This is a generic dialog that is referenced by requirements in the RTM with specific object names.

The list of objects provided by the specific dialog shall include:

- a) An object that indicates the number of rows in the table;
- b) The object(s) that serve as the index field of the table row; and
- c) The list of columnar objects to be retrieved from the table.

The standardized dialog for a management station to retrieve a table shall be as follows:

- a) The management station shall GET the number of rows in the table; and
- b) For each row of the table, the management station shall GET all objects referenced by the specific dialog that references this generic dialog, except for the number of rows object and the index object(s).

Sample object is windSensorSpotSpeed. The object definition is as follows:

```

5.6.10.6 Wind Sensor Spot Speed
windSensorSpotSpeed OBJECT-TYPE
SYNTAX INTEGER (0..65535)
ACCESS read-only
STATUS mandatory
DESCRIPTION "<Definition>The wind speed in tenths of meters per
second measured by the wind sensor. For mobile platforms, the wind
speed shall be corrected for vehicle movement.
<SetConstraint>read-only
<DescriptiveName>WindSensor.spotSpeed: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"
 ::= { windSensorEntry 6 }

```

The Retrieve Wind Data requirement can be selected by the agency by means of the Protocol Requirements List, as follows:

User Need ID	User Need	FR ID	Functional Requirement	Conformance	Project Requirement	Additional Project Requirements
2.5.2	Sensor Manager Features			O.1 (1..*)	Yes / No	
2.5.2.1 (Weather)	Monitor Weather Conditions			O.2 (1..*)	Yes / No / NA	
2.5.2.1.1 (Pressure)	Monitor Atmospheric Pressure			O.3 (1..*)	Yes No NA	
		3.5.2.3.2.1	Retrieve Atmospheric Pressure	M	Yes NA	
		3.6.1	Required Number of Atmospheric Pressure Sensors	M	Yes NA	The ESS shall support at least ____ atmospheric pressure sensors.
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 <u>1</u> wind sensors.

The test cases that are required to show conformance to NTCIP can be found indexed by the Functional Requirement ID in the Requirements to Test Case Traceability Matrix (RTCTM):

NTCIP 1204 v03 - Protocol Requirements 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 <u>1</u> wind sensors.

NTCIP 1204 v03 - Requirements to Test Case Traceability Matrix (RTCTM)

Requirement		Test Case	
ID	Title	ID	Title
		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

Test Plan from a Sample Project

Test plan identifier

TP-C-ESS-1

Introduction

This test plan has been developed to define the process that the agency will use for the design approval test to ensure that the ESS provided by the manufacturer fulfills all project requirements related to NTCIP 1204.

Test Items

This test plan will test the NTCIP-related operation of an ESS. The version and revision of the equipment to be tested shall be recorded on the test item transmittal.

Features to be tested

All requirements selected in the NTCIP 1204 Final Completed Protocol Requirements List (PRL) shall be tested.

Features not to be tested

Features that are not defined in NTCIP 1204 are not directly covered by this test plan. These features typically include, but are not limited to:

- Lower-layer communication protocol details
- Environmental operating requirements
- Construction and material requirements
- Power anomaly requirements
- Performance requirements
- Security requirements

While some aspects of these features may be tested (e.g., all NTCIP 1204 communications rely upon the basic operation of lower-layer protocols; tests may include verification of those performance requirements defined in NTCIP 1204; etc.), this test plan does not focus on these types of requirements because they are not the focus of NTCIP 1204.

Approach

This test is to be performed on a single item and will be valid for the remaining items submitted under contract with the agency that have the same firmware version number.

The test analyst will perform each selected test case from the ESS test procedures. A test case shall be deemed to be selected if it traces from a requirement selected in the final completed PRL. The tracing of requirements to test cases is provided in Appendix A of the sample test case specification, which follows from the Requirements to Test Cases Traceability Matrix (RTCTM) of NTCIP 1204 v03.

Item Pass/fail criteria

In order to pass the test, the ESS shall pass all test procedures included in this test plan without demonstrating any characteristic that fails to meet project requirements.

Suspension criteria and resumption requirements

The test may be suspended, at the convenience of test personnel, between the performances of any two test procedures. The test shall always resume at the start of a selected test procedure.

If any modifications are made to the ESS, a complete regression test may be required in order to pass this test plan.

Test deliverables

The test manager will ensure that the following documents are developed and entered into the configuration management system upon their completion:

- TP-C-ESS-1, the NTCIP 1204 test plan (this document)
- TCS-C-ESS-1, the NTCIP 1204 test case specifications
- The specific versions of all documents referenced by these documents, including, but not limited to:
 - *NTCIP 1201*
 - *NTCIP 1204*
 - *NTCIP 1102*
 - *NTCIP 1103*
- The test log; an example format is provided in Annex C
- The test summary; an example format is provided in Annex D
- Any and all test incident reports; an example format is provided in Annex E

All test documentation will be made available to both the agency and the developer. All test documentation will be made available in a widely recognized computer file format such as Microsoft Word or Adobe Acrobat. In addition, the files from the test software shall be provided in their native file format as defined by the test software.

Testing tasks

Table A-1: Testing Tasks

Task #	Task Name	Predecessor	Responsibility	NTCIP Knowledge Level (low =1 to high = 5)
1	Finalize Test Plan	Finalize Completed PRL	Test Manager	2
2	Complete the Test Item Transmittal Form and transmit the component to the Test Group	Implement ESS Standard	Developer	1
3	Perform Tests and produce Test Log and Test Incident Reports	2	Test Analyst	5
4	Resolve Test Incident Reports	3	Developer, Test Manager	2
5	Repeat Steps 2–4 until all test procedures have succeeded	4	N/A	N/A
6	Prepare the Test Summary report	5	Test Analyst	2
7	Transmit all test documentation to the Agency Project Manager	6	Test Manager	1

Environmental needs

All test cases covered by this test plan require the device under test to be connected to a test application as depicted in Figure A-1. A data analyzer may also be used to capture the data exchanged between the two components. The test environment should be designed to minimize any complicating factors that may result in anomalies unrelated to the specific test case. Failure to isolate such variables in the test environment may result in false results to the test. For

example, the device may be conformant with the standard, but communication delays could result in timeouts and be misinterpreted as failures.

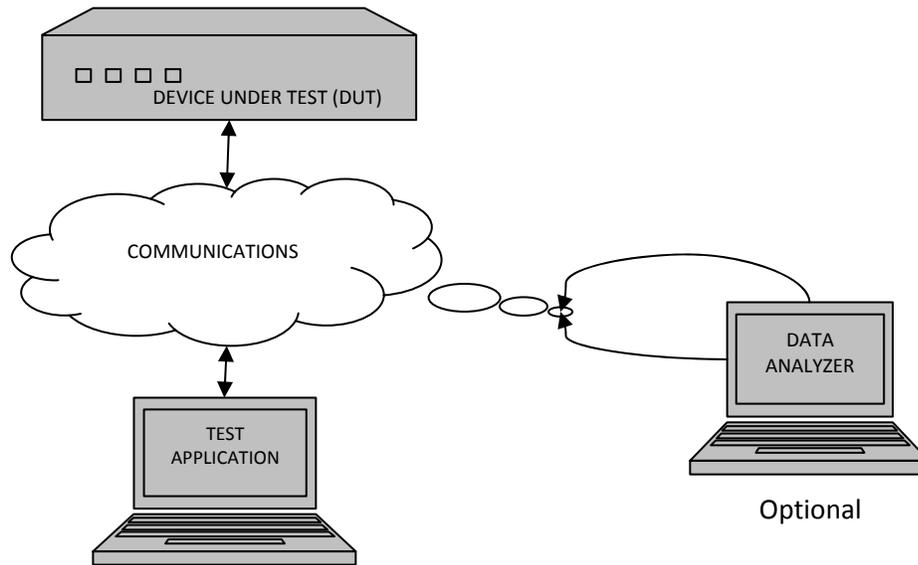


Figure A-1: Field Device Test Environment

The specific test software and data analyzer to be used are identified in the tools clause of the approach section of this test plan.

The tests will be performed at the Agencies' facility. This location will provide the following:

- Access to power outlets for the test equipment
- Workspace for the Test Analyst that is protected from the elements

Tools

The following software will be used for the testing:

- *NTESTER Version 2.0*
- *FTS for NTCIP*

For testing the wind sensor, a means of simulating wind speed will be required.

Communications environment

All tests shall be performed using the following communications environment, unless otherwise defined in the specific test procedure.

Connection Type: *RJ-45 Ethernet*

Subnet Profile: *NTCIP 2104 – Ethernet*

Transport Profile: *NTCIP 2202 – Internet*

Read Community Name: *public*

Write Community Name: *administrator*

Timeout Value: *200 ms*

Responsibilities

The following roles are defined in this test plan:

- Agency project manager – The agency project manager shall be responsible for:
 - Approving the test plan
 - Working with the test manager to address any concerns (e.g., balancing the desire for a perfect implementation against the political pressure to finish the project)
 - Providing the test environment

- Witnessing the performance of the tests
- Receiving and checking the test results
- Final acceptance of the component
- Test analyst – The test analyst shall be responsible for:
 - Designing any custom test procedures
 - Preparing the test environment
 - Executing the tests according to the test plan
- Test manager – The test manager shall be responsible for:
 - Managing the overall testing process and the test personnel
 - Finalizing the test plan
 - Providing the test tools
 - Checking the test results
- Developer – The developer shall be responsible for:
 - Providing the test items with their associated transmittal reports
 - Ensuring that the test personnel are able to properly connect the equipment
 - (Optionally) witnessing the performance of the tests
 - Checking the test results
 - Resolving any areas of non-conformance identified

Staffing and training needs

The following staffing is expected for this test plan:

- Agency project manager – 1
- Test manager – 1
- Developer – 1

If the agency project manager is not familiar with NTCIP testing, he or she should become familiar with NTCIP 9012 and FHWA guidance on the procurement of ITS systems. The test manager and test analyst must be familiar with how to use the test software. Many software systems come with extensive online help, but the test personnel may also need detailed knowledge of the NTCIP standards to fully perform their duties.

Schedule

Testing will commence within two weeks of the receipt of the hardware from the manufacturer. The testing is expected to take one week followed by one additional week of work to prepare the report.

Risks and contingencies

If the ESS repeatedly fails the testing procedures, it may be returned to the manufacturer for repair. The decision to return the ESS is at the discretion of the project committee. The developer of the ESS shall correct any problems identified with the ESS. Upon completion of the modifications, the developer shall resubmit the component for another complete test consisting of all test cases.

Approvals

Test Manager

Date

Agency Project Manager

Date

Developer

Date

Sample Test Design Specification

Test Design Specification Identifier

TDS-C-ESS-1

This Test Design Specification follows from Test Plan TP-C-ESS-1.

Features to be tested

The features selected for testing are in accordance with the completed project Protocol Requirements List (PRL). An excerpt showing the requirements for wind data is shown below.

User Need ID	User Need	FR ID	Functional Requirement	Conformance	Project Requirement	Additional Project Requirements
2.5.2	Sensor Manager Features			O.1 (1..*)	Yes / No	
2.5.2.1 (Weather)	Monitor Weather Conditions			O.2 (1..*)	Yes / No / NA	
2.5.2.1.1 (Pressure)	Monitor Atmospheric Pressure			O.3 (1..*)	Yes / No / NA	
		3.5.2.3.2.1	Retrieve Atmospheric Pressure	M	Yes / NA	
		3.6.1	Required Number of Atmospheric Pressure Sensors	M	Yes / NA	The ESS shall support at least ____ atmospheric pressure sensors.
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 <u>1</u> wind sensors.

Approach Refinements

Wind speed is to be simulated by means of rotating the propeller of the wind sensor by means of a calibrated rotating device.

Test Identification

For testing wind speed, two test cases are to be performed: 3.5.2.3.2.2-1 Retrieve Wind Data - Calm, and 3.5.2.3.2.2-2 Retrieve Wind Data - Hurricane.

Feature Pass/Fail Criteria

In order to pass, the ESS shall pass all test cases included in this test design without demonstrating any characteristic that fails to meet project requirements.

Sample Test Case Specification

Test Case Specification Identifier

TCS-C-ESS-1

Objectives

These test cases are to be used to verify conformance of the ESS with NTCIP 1204 v03. They specify the input and output parameters for use with the NTCIP 1204 v03 test procedures.

Test Items

These test cases will provide details of the tests to be performed to verify conformance of the ESS with NTCIP 1204 v03. The items selected for testing are in accordance with the completed project Protocol Requirements List (PRL).

Input Specifications

The individual input specifications for each test case are given in Appendix A.

Output Specifications

The individual output specifications for each test case are given in Appendix A.

Environmental Needs

All Test Cases require the device under test to be connected to a test application as depicted in Figure A-1. A data analyzer may also be used to capture the data exchanged between the two components. The test environment should be designed to minimize any complicating factors that may result in anomalies unrelated to the specific test case. Failure to isolate such variables in the test environment may result in false results to the test. For example, the device may be conformant with the standard, but communication delays could result in timeouts and be misinterpreted as failures.

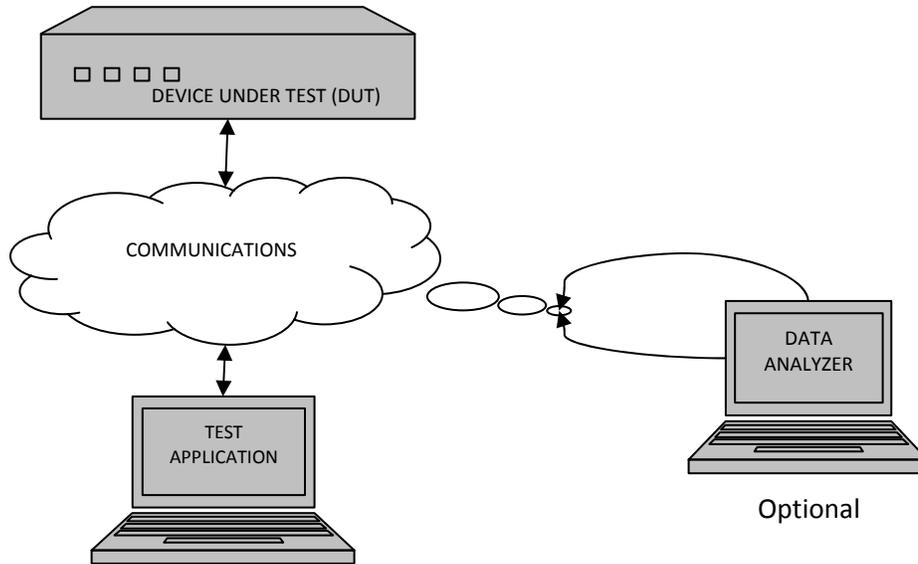


Figure A-1: Field Device Test Environment

The specific test software and data analyzer to be used are identified in the tools clause of the approach section of the test plan.

The tests will be performed at the ESS manufacturer's facility. This location will provide the following:

- Access to power outlets for the test equipment
- Workspace for the test analyst that is protected from the elements

For testing the wind sensor, a means of simulating wind speed will be required.

Special Procedural Requirements

No special procedural requirements exist.

Intercase Dependencies

Intercase dependencies are as detailed in NTCIP 1204 v03.

Appendix A:

The table below provides the inputs and expected results for two conditions of wind speed.

Functional Requirement 3.5.2.3.2.2 - Retrieve Wind Data

Wind speeds are to be simulated by means of rotating the propeller at a variable calibrated rate.

NTCIP 1204 Test Case	Simulated Wind Speed	windSensorSpotSpeed.n	windSensorSituation.n
C.2.3.3.3	0 km/h	0	3 (calm)
C.2.3.3.3	> 118 km/h	> 118	11 (hurricaneForceWinds)

From NTCIP 1204 v03, Test Case C.2.3.3.3 is used to test the requirement 3.5.2.3.2.2 - Retrieve Wind Data. Note that this Test Case will be performed twice: once simulating calm conditions (Test Case 3.5.2.3.2.2-1) and once simulating hurricane-force wind conditions (Test Case 3.5.2.3.2.2-2).

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 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 (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 5.2.	
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)
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)
5.5	VERIFY that the RESPONSE VALUE for windSensorAvgDirection.N is greater than or equal to 0.	Pass / Fail (Sec. 5.6.10.5)
5.6	VERIFY that the RESPONSE VALUE for windSensorAvgDirection.N is less than or equal to 361.	Pass / Fail (Sec. 5.6.10.5)
5.7	VERIFY that the RESPONSE VALUE for windSensorAvgDirection.N is APPROPRIATE.	Pass / Fail (Sec. 5.6.10.5)
5.8	VERIFY that the RESPONSE VALUE for windSensorSpotSpeed.N is greater than or	Pass / Fail

5.9	VERIFY that the RESPONSE VALUE for windSensorSpotSpeed.N is less than or equal to 65535.	Pass / Fail (Sec. 5.6.10.6)
5.10	VERIFY that the RESPONSE VALUE for windSensorSpotSpeed.N is APPROPRIATE.	Pass / Fail (Sec. 5.6.10.6)
5.11	VERIFY that the RESPONSE VALUE for windSensorSpotDirection.N is greater than or equal to 0.	Pass / Fail (Sec. 5.6.10.7)
5.12	VERIFY that the RESPONSE VALUE for windSensorSpotDirection.N is less than or equal to 361.	Pass / Fail (Sec. 5.6.10.7)
5.13	VERIFY that the RESPONSE VALUE for windSensorSpotDirection.N is APPROPRIATE.	Pass / Fail (Sec. 5.6.10.7)
5.14	VERIFY that the RESPONSE VALUE for windSensorGustSpeed.N is greater than or equal to 0.	Pass / Fail (Sec. 5.6.10.8)
5.15	VERIFY that the RESPONSE VALUE for windSensorGustSpeed.N is less than or equal to 65535.	Pass / Fail (Sec. 5.6.10.8)
5.16	VERIFY that the RESPONSE VALUE for windSensorGustSpeed.N is APPROPRIATE.	Pass / Fail (Sec. 5.6.10.8)
5.17	VERIFY that the RESPONSE VALUE for windSensorGustDirection.N is greater than or equal to 0.	Pass / Fail (Sec. 5.6.10.9)
5.18	VERIFY that the RESPONSE VALUE for windSensorGustDirection.N is less than or equal to 361.	Pass / Fail (Sec. 5.6.10.9)
5.19	VERIFY that the RESPONSE VALUE for windSensorGustDirection.N is APPROPRIATE.	Pass / Fail (Sec. 5.6.10.9)
5.20	VERIFY that the RESPONSE VALUE for windSensorSituation.N is greater than or equal to 1.	Pass / Fail (Sec. 5.6.10.10)
5.21	VERIFY that the RESPONSE VALUE for windSensorSituation.N is less than or equal to 12.	Pass / Fail (Sec. 5.6.10.10)
5.22	VERIFY that the RESPONSE VALUE for windSensorSituation.N is APPROPRIATE.	Pass / Fail
Test Case Results		
Tested By:		Date Tested:
		Pass / Fail
Test Case Notes:		

Glossary

The following is a glossary of terms that are used throughout the module.

Test Case	<p>A document that specifies the actual inputs, predicted results, and set of execution conditions for a test. It also identifies constraints on the test procedures resulting from use of that specific test case.</p> <p>NOTE—See IEEE 829 for a more detailed discussion of test cases.</p>
Test Design Specification	<p>Per IEEE 829, “A document specifying the details of the test approach for a ... feature or combination of ... features and identifying the associated tests.” For testing NTCIP conformance, this document includes the completed Protocol Requirements List and Requirements to Test Cases Traceability Matrix.</p>
Test Plan	<p>A document that prescribes the scope, approach, resources, and schedule of the testing activities. It identifies the items to be tested, the features to be tested, the testing tasks to be performed, the personnel responsible for each task, and the risks associated with the plan.</p>
Test Procedure	<p>A document that specifies a sequence of actions for the execution of a test. The test procedures test the implementation of the requirement. Test procedures are separated from test design as they are intended to be followed step by step and should not have extraneous detail.</p>

References

Environmental Sensor Stations

- **NTCIP 1204 Version v03.08, National Transportation Communications for ITS Protocol, Object Definitions for Environmental Sensor Stations (ESS)** (www.ntcip.org)
- **NTCIP 1201 Version v03.13a, National Transportation Communications for ITS Protocol, Global Object Definitions** (www.ntcip.org)
- **NTCIP 8007 Version 1.21, National Transportation Communications for ITS Protocol, Testing and CA Documentation within NTCIP Standards** (www.ntcip.org)
- **NTCIP 9001 Version v04, National Transportation Communications for ITS Protocol, The NTCIP Guide** (www.ntcip.org)

Systems Engineering

- **Systems Engineering Guidebook for Intelligent Transportation Systems Version 3.0 (The "V" Systems Engineering Model)** (<http://ops.fhwa.dot.gov/publications/seitsguide/seguide.pdf>)

Testing

- **IEEE Std 829-1998, Standard for Software Test Documentation, IEEE 1998.**