Welcome

Ken Leonard, Director
ITS Joint Program Office
Ken.Leonard@dot.gov

www.pcb.its.dot.gov
T304:
Applying Your Test Plan to Field Management Stations (FMS) – Part 1 Signal System Masters (SSM) Based on NTCIP 1210 Standard v01
Instructor

Raman K. Patel, Ph.D., P.E.

President
RK Patel Associates, Inc.
New York City, NY, USA
Learning Objectives

Describe within the context of the system lifecycle the role of a test plan and testing to be undertaken.

Recognize the purpose, structure, and content of well-written test documentation for an SSM based on IEEE 829-2008 formats.

Explain how to develop the complete test documentation package for an SSM specification based on NTCIP 1210 Standard v01.

Describe the testing of an SSM using a sample test document.
Learning Objective 1

Describe within the context of the system lifecycle the role of a test plan and testing to be undertaken.
How Is an SSM Used in a Traffic Management System?

Role of a Signal System Master (SSM)

**SSM** is a Portion of a Field Management Station (FMS)

SSM Coordinates Signal System Locals-SSLs (Intersection Controllers)

Source: FHWA
How Is an SSM Used in a Traffic Management System?

How an SSM Is Used Within the Typical Physical Architecture

Source: NTCIP 1210, Fig. 3, p. 13
Purpose of Testing an SSM

Testing is a process that uses a documented test plan.

Verify that an SSM fulfills each requirement stated in the test plan.

Was the system built right?

Source: FHWA

Source: ITE OET-Patel
Purpose of Testing an SSM

Testing Methods Used for Conformance Verification

Visual Observation

Demonstration

Source: Cumberland CO, NJ

Source: NYCDOT-Patel

Source: Henry Liu, University of Minnesota

Testing Using Testing Documentation

Source: NYCDOT-Patel
Purpose of Testing an SSM

System Lifecycle and Testing to Be Undertaken

Documentation Preparation - specification

Communications interface Level Tests to be undertaken

System Lifecycle
Verification Methods Specific to SSM Functions

Unit/Device (Bench) Testing

- SSM under test in a lab or workshop environment
- Testing with PC-based test software
- Exercise of the SSM data elements and dialogs to check conformity with standard

Cautionary Word on Unit Testing

- Need to prioritize tests by failure consequences, amount of time (available to test), and boundary test, as opposed to trying to test over 100% span

- NTCIP 1210 v01 data elements are exercised for key functionality to the extent possible
Verification Methods Specific to SSM Functions

Subsystem Verification  
(Is the system being “built right”?)

SSM requirements will be tested to ensure that the SSM communicates with SSLs properly, including use of central software.

### 3.3.1 Support Basic Communications

Requirements for making requests follow.

**3.3.1.1 Accept Data from the TMS**
The SSM shall accept data (e.g., configuration data, commands, etc.) from the TMS.

**3.3.1.2 Deliver Data to the TMS**
The SSM shall deliver data (e.g., configuration data, status, etc.) to the TMS. If not specified, the response start time shall be not greater than 2000 milliseconds.

**3.3.1.3 Explore SSM Data by the TMS**
The SSM shall allow the TMS to discover what data and data instances are supported by the SSM. If not specified, the response start time shall be not greater than 2000 milliseconds.

**3.3.1.4 Accept Data from the SSLs**
The SSM shall accept data (e.g., configuration data, status, etc.) from the SSLs.

**3.3.1.5 Deliver Data to the SSLs**
The SSM shall deliver data (e.g., configuration data, commands, etc.) to the SSLs.
System Verification Ensures That the Entire System Meets System Requirements—the Physical Architecture
Verification Methods Specific to SSM Functions

System Validation Shows Whether the “Right” System Is Built

Implemented system is validated against specified user needs to support system operators, including communications.

Source: City of Lexington, KY
Which is **NOT** part of the testing process in a system lifecycle?

**Answer Choices**

a) Test planning

b) Preparation of test documentation

c) Test execution and reporting

d) Identification of system requirements
Review of Answers

a) Test planning

Incorrect. Test planning is done when system requirements have begun.

b) Preparation of test documentation

Incorrect. Test documents are created during high-level design and detailed design.

c) Test execution and reporting

Incorrect. Test execution and reporting are done at each level of the testing workflow using test documentation.

d) Identification of system requirements

Correct! Identification of system requirements is NOT a part of the testing process.
Learning Objectives

Describe within the context of the system lifecycle **the role of a test plan** and testing to be undertaken.

Recognize the **purpose, structure, and content** of well-written test documentation for an SSM based on **IEEE 829-2008 formats**.
Learning Objective 2

Recognize the **purpose, structure, and content** of well-written test documentation based on **IEEE 829-2008 formats**
Objectives of the SSM Testing Documentation

1. Outline What to Test
2. State Clearly How to Test
3. Report Results/Outcomes During/After Test
4. Use IEEE 829-2008 Formats
What Is a Test Plan?

From IEEE 829-2008 Standard

- Test Plan is a document describing:
  - Scope (technical management)
  - Approach
  - Resources needed
  - Schedule to complete

- Test Plan identifies
  - Test items
  - Features to be tested
  - Testing tasks
  - Risks requiring contingency plan
Structure of a Test Plan

From IEEE 829-2008 Standard

Sets overall workflow context

- Integrity level scheme and choice
- Overall test processes, activities, and tasks
- Test levels and documents

- Scope of test level
- Resources
- Test method(s)

A Master Test Plan may not always be required!
Structure of a Test Plan

MTP Structure Provides for Workflow for Multiple Devices

Level Test Plan for SSM Communications Interface

- SSM Unit Test Plan
- SSM Subsystem Integration Test Plan
- SSM Acceptance Test Plan

Level Test Plan for SSLs Intersection Functions

- SSL Unit Test
- SSL Subsystem Integration Test Plan
- SSL Subsystem Integration Test Plan
SSM Test Plan Structure Based on IEEE 829-2008

Test Plan describes the Overall Approach to SSM Testing.

Test Design specifies the details of the test approach – **what is to be tested**. It is shown here for Unit Test – similar designs exist for Integration Test and Acceptance Test.

Test Case specification outlines a set of test inputs, execution conditions, and expected results (outputs).

Test Procedure specification defines the steps to execute a test.
Content of a Test Plan

Level Test Plan (LTP) Outline per IEEE 829-2008

- **Introduction**
  - Document identifier, scope, and references
  - Level in the overall sequence (First Unit Test…)
  - Test classes and test conditions

- **Details of the Level Test Plan**
  - Test items and their identifiers
  - Protocol Requirements List (PRL) for NTCIP 1210 objects and dialogs (may include RTCTM)
  - Features to be tested/not to be tested
  - Test approach
  - Pass/fail criteria
  - Suspension criteria and requirements to resume testing
  - Test deliverables
Content of a Test Plan

Level Test Plan (LTP) Outline per IEEE 829-2008

- **Test Management**
  - Planned activities and tasks
  - Test progression
  - Environment/infrastructure
  - Responsibilities/authorities
  - Interfaces among stakeholders
  - Resources and training
  - Schedules, estimates, and costs
  - Risk(s) and contingencies

- **General**
  - Quality assurance procedures
  - Metrics for specific measures
  - Glossary
  - Document change procedures and history
Content of a Test Plan

Sample Outline of Test Design as Per IEEE 829-2008

| 1. Introduction                      |  |  |  |
|--------------------------------------|  |  |  |
| 1.1. Document identifier             |  |  |  |
| 1.2. Scope                           |  |  |  |
| 1.3. References                      |  |  |  |
| 2. Details of the Level Test Design  |  |  |  |
| 2.1. Features to be tested           |  |  |  |
| 2.2. Approach refinements            |  |  |  |
| 2.3. Test identification             |  |  |  |
| 2.4. Feature pass/fail criteria      |  |  |  |
| 2.5. Test deliverables               |  |  |  |
| 3. General                           |  |  |  |
| 3.1. Glossary                        |  |  |  |
| 3.2. Document change procedures      |  |  |  |

PRL-Provided Requirements are traced to a test Case

<table>
<thead>
<tr>
<th>Req. ID</th>
<th>Req.</th>
<th>Test Case ID</th>
<th>Test Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.2.2.1</td>
<td>Explore SSL Data</td>
<td>TC3.4.3.1.6-1</td>
<td></td>
</tr>
</tbody>
</table>

Verify max number of intersections
## Sample Outline of Test Case as Per IEEE 829-2008

<table>
<thead>
<tr>
<th>Test Case</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ID: TCx.x</td>
<td></td>
</tr>
<tr>
<td><strong>Objective:</strong></td>
<td>State which requirement(s) will be verified: testing a dialog correct sequence or correct structure and content of data</td>
</tr>
<tr>
<td><strong>Inputs:</strong></td>
<td>Input variable needed for testing</td>
</tr>
<tr>
<td><strong>Outcome(s):</strong></td>
<td>Expected results-behavior, errors</td>
</tr>
<tr>
<td><strong>Environmental Needs</strong></td>
<td>Test Set Up</td>
</tr>
<tr>
<td><strong>Intercase Dependencies</strong></td>
<td>Test cases that must be executed prior to this test case</td>
</tr>
</tbody>
</table>
## Content of a Test Plan

### Sample Outline of a Test Procedure from NTCIP 1203 v03

<table>
<thead>
<tr>
<th>Step</th>
<th>Test Procedure</th>
<th>Results</th>
<th>Additional References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CONFIGURE: Determine the maximum period of time that the pixel test should require (based on manufacturer documentation). RECORD this information as: Pixel Test Time.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>CONFIGURE: Determine the maximum period of time that the message display pixel test should require (based on manufacturer documentation). RECORD this information as: Message_Display_Test_Time.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>SET-UP: Ensure that all pixels are functioning prior to this test.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>SET the following object(s) to the value(s) shown:&lt;br&gt;<code>pixelTestActivation.0 = 'test'</code>(3)&lt;br&gt;NOTE--Valid enumerated values are defined in Section 5.11.2.4.3 (Pixel Test Activation Parameter).</td>
<td>Pass / Fail (Section 3.5.3.1.1.2)</td>
<td>Section 4.2.4.2 Step-a</td>
</tr>
<tr>
<td>5</td>
<td>GET the following object(s):&lt;br&gt;<code>pixelTestActivation.0</code></td>
<td>Pass / Fail (RFC 1157)</td>
<td>Section 4.2.4.2 Step-b</td>
</tr>
<tr>
<td>6</td>
<td>IF the RESPONSE VALUE for pixelTestActivation.0 equals 'test' (3), then GOTO Step 5; otherwise, GOTO Step 7.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NOTE--If the RESPONSE VALUE remains at 'test' (3) for more than Pixel Test Time seconds, this test fails.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Content of a Test Plan

Documentation for Test Reporting

Test Plan Execution (Process)

Level Test Log (LTL)
- Chronological record of execution of tests

Anomaly Report (AR)
- Event during the testing process that requires investigation

Level Interim Test Status Report (LITSR)
- Summarizes the results of the testing activities

Level Test Report (LTR)
- Summarizes the results/evaluations/recommendations
Which is NOT included in a structure of a test plan?

Answer Choices

a) Test logs
b) Test design
c) Test case with inputs/outputs
d) Test procedures with steps
a) Test logs

Correct! Test logs are not part of the structure of a test plan. Test logs are developed during and after test execution as part of test reports. This is per the IEEE 829-2008 standard.

b) Test design

Incorrect. The statement is true. Test design provides details on what to test.

c) Test case with inputs/outputs

Incorrect. The statement is true. Test cases detail inputs/outputs.

d) Test procedures with steps

Incorrect. The statement is true. One or more steps are outlined to actually conduct the test.
Learning Objectives

Describe within the context of the system lifecycle the role of a test plan and testing to be undertaken.

Recognize the purpose, structure, and content of well-written test documentation for an SSM based on IEEE 829-2008 formats.

Explain how to develop the complete test documentation package for an SSM specification based on NTCIP 1210 Standard v01.
Explain how to develop the complete documentation package for an SSM specification based on NTCIP 1210 Standard v01
Key Elements of NTCIP 1210 Standard v01 Tied to a Test Plan

Identify Key Elements Used in Preparation of a Test Plan

- User Needs
- Requirements
- Objects
- Dialogs

- Protocol Requirements List (PRL) Module A304a
- Requirements Traceability Matrix (RTM) Module A304b
2.5.2 Manage SSLs
These features are to be tested to verify capability to upload-download-retrieve data. Must be selected YES.
Key Elements of NTCIP 1210 Standard v01 Tied to a Test Plan

Use the Project RTM to Identify Objects to Be Verified

<table>
<thead>
<tr>
<th>Functional Requirement Reference</th>
<th>Functional Requirement</th>
<th>Dialog Reference</th>
<th>Object Reference</th>
<th>Object</th>
<th>Comments (Informative)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.2.1</td>
<td>Synchronize SSM Clock with TMS</td>
<td>4.1.3</td>
<td>1201.2.4.1</td>
<td>globalTime</td>
<td></td>
</tr>
<tr>
<td>3.4.2.2.1</td>
<td>Determine SSLs Currently Connected</td>
<td>4.2.2.3</td>
<td>5.2.1</td>
<td>maxIntersections</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.2.2.1.3</td>
<td>intersectionSection</td>
<td></td>
</tr>
<tr>
<td>3.4.2.2.2</td>
<td>Determine Pattern Selection Capabilities</td>
<td>4.2.6.3</td>
<td>5.1.1</td>
<td>maxSections</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.23.1</td>
<td>algorithmSupport</td>
<td></td>
</tr>
</tbody>
</table>

Dialog

4.2.2.3 SSM Intersection / Section Assignment Dialog

The standardized dialog for a TMS to determine the SSLs assigned to a Section within an SSM shall be as follows:

5.2.1 Maximum Number of Intersections

maxIntersections OBJECT-TYPE SYNTAX INTEGER (8..255)

A Test Case Will Be Created Using RTM to Verify Range Values
Develop an **SSM Test Plan**

- Describes the Scope, Approach, Resources, and Schedule for the testing

- Some of the testing aspects covered:
  - Item(s) to be tested
  - Features to be tested
  - Features not to be tested
  - Testing tasks to be performed
  - Personnel responsible for each task
  - Risks associated with the plan
Developing Test Design, Test Cases, and Test Procedures

Develop an SSM Test Design Using PRL

- Specifies the detailed approach (design) for exercising a collection of tests
- Identifies the features to be tested by the test design
- Identifies the requirements to be tested by the test design
- Identifies the tests (test cases) associated with the design
Developing Test Design, Test Cases, and Test Procedures

Develop SSM Test Cases Using Project PRL/RTM

SSM Test Cases
- Defines a test case identified by a test design specification
- Input and output specifications

Agency SSM Specification

PRL: Requirement to be tested, additional specs

NTCIP 1210 v01

RTM: Data objects to be tested for test case

MIB: Standard values for data objects
Developing SSM Test Procedures

SSM Test Procedures specify the steps for executing one or more test cases.

**Agency SSM Specification**

**PRL:** Requirements to be tested, add't'l specs

**NTCIP 1210 v01**

**RTM:** Data objects and dialogs to be tested

**MIB:** Standard values for data objects

**SSM Test Procedures**
# Test Case for Intersection Unit Control Status

(See Module T203 Parts 1 and 2 for Formats)

<table>
<thead>
<tr>
<th>ID: TC001</th>
<th>Title: Request Status Condition within the Device Dialog Verification (Positive Boundary Test Case)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective:</strong></td>
<td>To verify system interface implements (positive test case) requirements for a sequence of OBJECT requests for:</td>
</tr>
<tr>
<td></td>
<td>The test case verifies that the SSM returns an appropriate value given valid data content for the OBJECTs requested at valid value ranges. An output specification is provided, showing valid value constraints per the NTCIP 1210 v01 object definitions.</td>
</tr>
<tr>
<td><strong>Inputs:</strong></td>
<td>Step through each object and set a value at the valid value range for the object. For example: Set object 5.8.1.1.5 <code>intersectionUnitControlStatus</code> to ‘1’ (which is just at the valid value range of 1 to 8 inclusive)</td>
</tr>
<tr>
<td></td>
<td>Set object 5.8.1.1.5 <code>intersectionUnitControlStatus</code> to ‘8’ (which is just at the valid value range of 1 to 8 inclusive)</td>
</tr>
<tr>
<td><strong>Outcome(s):</strong></td>
<td>The SSM responds with valid status objects. See Test Case Output Specification TCOS001 – Status Condition within the Device (Boundary Positive Test Case)</td>
</tr>
<tr>
<td><strong>Environmental Needs:</strong></td>
<td>No additional needs outside of those specified in the test procedure</td>
</tr>
<tr>
<td><strong>Special Procedural Requirements:</strong></td>
<td>None</td>
</tr>
<tr>
<td><strong>Intercase Dependencies:</strong></td>
<td>None</td>
</tr>
</tbody>
</table>
Developing an SSM RTCTM

- An RTCTM is a table that provides traceability from requirements to test cases to test procedures.
- Each SSM Test Design (Test Plan) has an RTCTM.

<table>
<thead>
<tr>
<th>Req. ID</th>
<th>Req.</th>
<th>Test Case ID</th>
<th>Test Case</th>
<th>Test Proc ID</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.2.2.1</td>
<td>Explore SSL Data by the TMS</td>
<td>TC3.4.3.1.6-1</td>
<td>Verify maximum intersections</td>
<td>TP3.4.3.1.6-1</td>
<td>Verify object range 8-40</td>
</tr>
</tbody>
</table>
Develop Requirements to Test Case Traceability Matrix (RTCTM) for an SSM

**RTCTM Lists Test Procedures for Each Test Case**

- RTCTM has one or more Test Cases to verify conformance to NTCIP 1210 v01
- RTCTM lists one or more **Test Procedures** to verify object range

<table>
<thead>
<tr>
<th>Req. ID</th>
<th>Req. Case ID</th>
<th>Test Case</th>
<th>Test Proc ID</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.2.2.1</td>
<td>Explore SSL Data by the TMS</td>
<td>TC3.4.3 .1.6-1</td>
<td>Verify maximum intersections (SSLs)</td>
<td>TP3.4.3.1.6-1</td>
</tr>
</tbody>
</table>
### Test Case/Test Procedures

<table>
<thead>
<tr>
<th>Test Case: TC1.1</th>
<th>Title:</th>
<th>Test the Boundaries</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>This test case verifies the maximum number of SSMs that can be SET by the central station. The test is conducted just below, just above, and exactly at the boundary.</td>
<td></td>
</tr>
<tr>
<td><strong>Variables</strong></td>
<td>Max SSMs</td>
<td>From project requirements</td>
</tr>
<tr>
<td></td>
<td>Max SSMs - 1</td>
<td>From the test plan</td>
</tr>
<tr>
<td></td>
<td>Max SSMs +1</td>
<td>From the test plan</td>
</tr>
<tr>
<td><strong>Pass/Fail Criteria</strong></td>
<td>1. The DUT shall accept data at Max SSMs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. The DUT shall accept data at Max SSMs - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. The DUT shall return an error at Max SSMs +1</td>
<td></td>
</tr>
</tbody>
</table>

Steps are formal executions and results oriented (must have an outcome)

<table>
<thead>
<tr>
<th>Step</th>
<th>Test Procedure</th>
<th>Expected Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Configure: SET the Max SSMs = 8, record the DUT response</td>
<td>Responds with Max SSMs = 8</td>
</tr>
<tr>
<td>2</td>
<td>SET the number of SSMs = 1, record the DUT response</td>
<td>Response = 1</td>
</tr>
<tr>
<td>3</td>
<td>SET the number of SSMs = 2, record the DUT response</td>
<td>Response = 2</td>
</tr>
<tr>
<td>4</td>
<td>SET the number of SSMs = 10, record the DUT response</td>
<td>Error, exceeds Max SSMs = 8</td>
</tr>
</tbody>
</table>
Introduction to the Test Procedure Generator (TPG) and How to Use It for SSM Testing

Test Procedure Generator (TPG)

- TPG is a **software** that guides the development of the test procedures
- Used for Center to Field (C2F) devices
- Relatively new product

- v2.1 downloadable at:
  [https://www.standards.its.dot.gov/DeploymentResources/TPGdownload](https://www.standards.its.dot.gov/DeploymentResources/TPGdownload)
Introduction to the Test Procedure Generator (TPG) and How to Use It for SSM Testing

How to Use the Test Procedure Generator (TPG)

- Install the TPG Software
- Import the Standard, and the TPG will process the requirements, objects, dialogs, and RTM
- Create “Set of Test Procedures” (Note: This feature will allow a user to begin to develop test procedures)
- Develop Test Procedures (covered in detail on the next slide)
Introduction to the Test Procedure Generator (TPG) and How to Use It for SSM Testing

Test Procedure with the TPG by User

- Defines the title, description, and pass/fail criteria in the header information
- Selects the requirements to be tested (TPG has imported the list from the standard)
- Creates the variables to be used in the test procedure (the TPG uses the objects imported from the standard)
- Develops the detailed steps using the TPG tools
Introduction to the Test Procedure Generator (TPG) and How to Use It for SSM testing

TPG Benefits

- Test procedures come from the agency specification, NOT from vendors:
  - Reduces developmental risks, effort, and the cost
  - Ensures traceability, and conformance to the Center to Field (C2F) Standards such as DMS, ESS, and SSM
  - Helps determine compliance to extended standard
  - Promotes interoperable C2F systems
- Creates in-house expertise
What is the primary purpose of RTCTM?

Answer Choices

a) Sets the testing workflow sequences
b) Correlates User Needs to Requirements
c) Contains only test cases
d) Traces Requirement to Test Case to Test Procedure
Review of Answers

a) Sets the testing workflow sequences

Incorrect. Testing workflow is part of the Level Test Plans.

b) Correlates User Needs to Requirements

Incorrect. User Needs to Requirements are part of the Protocol Requirements List (PRL).

c) Contains only test cases

Incorrect. It contains test cases and test procedures for each test case.

d) Traces Requirement to Test Case to Test Procedures

Correct! RTCTM depicts the Test Cases that will be used to verify each Requirement with test procedures.
Learning Objectives

Describe within the context of the system lifecycle the role of a test plan and testing to be undertaken.

Recognize the purpose, structure, and content of well-written test documentation for an SSM based on IEEE 829-2008 formats.

Explain how to develop the complete test documentation package for an SSM specification based on NTCIP 1210 Standard v01.

Describe the testing of an SSM using sample test document.
Learning Objective 4

Describe the Testing of an SSM Using Sample Test Document
Walk Through a Sample SSM Test Plan

Where Is the SSM Test Plan Located?

General Procurement Contract Documents

Communications Interface Specifications

I. General
II. SSM User Needs
III. SSM Functional Req.
IV. SSM Project PRL, RTM
V. Testing Documentation
Walk Through a Sample SSM Test Plan

Description of an SSM Testing Setup

What to test: verifies features, requirements

Records results and outcomes

Testing Documentation

Test Plan.

Finds Errors

SSM

TEST

Results Reports

Optional
How Is the SSM Test Plan Developed?

Test documentation is developed for a given project using IEEE Std 829-2008 formats.

Test Design and a Test Plan can be in **one document** for a single test design.

Test Cases and Test Procedures can be combined in **one document**.
Walk Through a Sample SSM Test Plan

Test Plan Outline

Key Parts

1. Introduction
2. Details of Unit Testing
   2.1 Test items and their identifiers
   2.2 RTCTM (Test Design/Test Procedures)
   2.3 List of SSM Features to be tested (PRL)
   2.4 Objects to be tested (RTM)
   2.5 Approach
   2.6 Item Pass/Fail criteria
   2.7 Suspension Criteria and Resumption Requirements

Forms basis for what to test

SUPPLEMENT
Walk Through a Sample SSM Test Plan

Test Plan Outline

Key Parts (cont.)

2.8 Test Deliverables (Before Testing)

- SSM Communication Test Plan
- SSM Communication Test Designs
- SSM Communication Test Cases
- SSM Communication Test Procedures

Reporting Results (During/After Testing)

- SSM Communication Test Logs
- SSM Communication Test Incident Reports
- SSM Communication Interim Test Status Reports
- SSM Communication Test Test Reports
CASE STUDY
The City of Midsize: SSM Communications Interface Specification

- Central TMS requires NTCIP 1210 v01 communications interface with response time of 600 msecs.

- One SSM monitors/controls maximum of 10 SSLs located.

- Traffic responsive strategy covers 30 SSLs spread over three sections.

- Existing communication interconnect is declared adequate for the controllers.

- Project PRL and RTM are also included in the specification.
Walk Through a Sample SSM Test Plan

What Are the Project Parameters?

1 SSM controls 10 SSLs
30 SSLs
3 SSM to be tested
3 Sections
## PRL Example: What Needs to Be Tested/Not to Be Tested

<table>
<thead>
<tr>
<th>User Need ID</th>
<th>User Need</th>
<th>FR ID</th>
<th>Functional Requirement</th>
<th>Conformance</th>
<th>Support</th>
<th>Additional Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5.1.1</td>
<td>Configure Cycle Timers and Unit Backup Time</td>
<td>M</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3.4.2 Manage the SSM Configuration

| 3.4.2.2.1   | Determine SSLs Currently Connected | M              | Yes                                                         |             |         |                           |
| 3.4.2.2.2   | Determine Pattern Selection Capabilities | M              | Yes                                                         |             |         |                           |
| 3.4.2.2.3   | Determine SSM Section Characteristics | M              | Yes                                                         |             |         |                           |
| 3.4.2.2.4.1 | Configure Cycle Timer Reference | O              | Yes / No                                                    |             |         |                           |
| 3.4.2.2.4.2 | Determine Cycle Timer Capability | O              | Yes / No                                                    |             |         |                           |
| 3.4.2.2.5   | Determine SSM Software Version | M              | Yes / No                                                    |             |         |                           |

- will be tested
- will NOT be tested
Find Object Ranges from Project RTM to Prepare Test Cases

<table>
<thead>
<tr>
<th>Functional Requirement Reference</th>
<th>Functional Requirement</th>
<th>Dialog Reference</th>
<th>Object Reference</th>
<th>Object</th>
<th>Comments (Informative)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.2.1</td>
<td>Synchronize SSM Clock with TMS</td>
<td>4.1.3</td>
<td>1201.2.4.1</td>
<td>globalTime</td>
<td></td>
</tr>
<tr>
<td>3.4.2.2.1</td>
<td>Determine SSLs Currently Connected</td>
<td>4.2.2.3</td>
<td>5.2.1</td>
<td>maxIntersections</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.2.2.1.3</td>
<td>intersectionSection</td>
<td></td>
</tr>
<tr>
<td>3.4.2.2.2</td>
<td>Determine Pattern Selection Capabilities</td>
<td>4.2.6.3</td>
<td>5.1.1</td>
<td>maxSections</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.23.1</td>
<td>algorithmSupport</td>
<td></td>
</tr>
</tbody>
</table>

5.2.1 Maximum Number of Intersections

maxIntersections
SYNTAX
OBJECT-TYPE
INTEGER
(8..255)

Recall, case study has 10 SSLs requirement here
Recall, Case Study has 10 SSLs:

Test Procedure will be carried out to check boundary condition at 10, just below at 8, and just above at 12.
Testing for Boundary Conditions

- All boundary conditions are tested:
  - Just below each limit
  - Just above each limit
  - Exactly on each limit

- Boundary is valid, SSM should:
  - Process successfully
  - Respond accordingly

- If error conditions occur, SSM should:
  - Respond with error message
  - Remain in normal operation
  - No communications loss
Results - Error Conditions

How Are we Checking for Error Conditions?

- **Positive testing for:**
  - Validating input values, dialogs, and sequences per test procedure
  - Expected outputs from SSM - Device Under Test (DUT)

- **Negative testing for:**
  - Asserting invalid input values, dialogs, or sequences per the test procedure
  - Errors are examined for next action on test continuity
# Results - Error Conditions

## Testing for Value Outside Valid Boundary Range

<table>
<thead>
<tr>
<th>ID: TC001</th>
<th>Title: Request Status Condition within the Device Dialog Verification (Positive Boundary Test Case)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective:</strong></td>
<td>To verify system interface implements (positive test case) requirements for a sequence of OBJECT requests for:</td>
</tr>
</tbody>
</table>

The test case verifies that the SSM returns an appropriate value given valid data content for the OBJECTs requested at valid value ranges. An output specification is provided, showing valid value constraints per the NTCIP 1210 v01 object definitions.

<table>
<thead>
<tr>
<th><strong>Inputs:</strong></th>
<th>Step through each object and set a value at the valid value range for the object. For example: Set object <strong>5.8.1.1.5 intersectionUnitControlStatus</strong> to ‘9’ (which is outside the valid value range of 1 to 8 inclusive)</th>
</tr>
</thead>
</table>

The SSM responds with an error status. See object ssmBlockErrorStatus. See Test Case Output Specification TCOS001 – Status Condition within the Device (Boundary Negative Test Case)

<table>
<thead>
<tr>
<th>Environmental Needs:</th>
<th>No additional needs outside of those specified in the test procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special Procedural Requirements:</td>
<td>None</td>
</tr>
<tr>
<td>Intercase Dependencies:</td>
<td>None</td>
</tr>
</tbody>
</table>
### PRL Example: What Needs to Be Tested: Mandatory Requirements

<table>
<thead>
<tr>
<th>User Need ID</th>
<th>User Need</th>
<th>FR ID</th>
<th>Functional Requirement</th>
<th>Conformance</th>
<th>Support</th>
<th>Additional Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4.1</td>
<td>Provide Live Data</td>
<td></td>
<td></td>
<td>M</td>
<td>Yes</td>
<td>All are to be tested</td>
</tr>
<tr>
<td>3.3.1.1</td>
<td>Accept Data from the TMS</td>
<td>M</td>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.3.1.2</td>
<td>Deliver Data to the TMS</td>
<td>M</td>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.3.1.3</td>
<td>Explore SSM Data by the TMS</td>
<td>M</td>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.3.3.1</td>
<td>Determine Access Settings</td>
<td>M</td>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.3.3.2</td>
<td>Configure Access</td>
<td>M</td>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Communications Testing Tools Available

- Many generic Simple Network Management Protocol (SNMP) test tools available for Ethernet communications
- Data Analyzers
- NTCIP Testing Tools
  - Test both Ethernet and serial communications
  - Test all objects within the MIB with Set/Get operations
  - Verify that read-only objects are not settable
  - Logs and reports (various levels)
Testing Tools

Where to Find Additional Test Procedure Information

Additional Information on Test Procedures:

- NTCIP 1203 v03 DMS Standard, Annex C
- NTCIP 1204 v03 ESS Standard, Annex C
- Module T313: Applying Your Test Plan to NTCIP 1204 ESS
- Test Procedure Generator (TPG v2.1)
ACTIVITY
Which is NOT a valid statement related to an SSM testing documentation?

Answer Choices

a) Test plan contains an overall testing approach
b) Test design contains project RTCTM
c) Test procedures are provided by the manufacturer
d) Test procedure includes error detection
Review of Answers

a) Test plan contains an overall testing approach
   *Incorrect. The statement is true. A plan has an overall approach and scope.*

b) Test design contains project RTCTM
   *Incorrect. RTCTM correlates requirements, test cases, and set procedures to verify a requirement.*

c) Test procedures are provided by the manufacturer
   *Correct! The statement is NOT true. ONLY agency specification specifies test procedures.*

d) Test procedure includes error detection
   *Incorrect. The statement is true. The test includes both positive and negative testing for expected and unexpected results, respectively.*
Module Summary

Describe within the context of the system lifecycle the role of a test plan and testing to be undertaken.

Recognize the purpose, structure, and content of well-written test documentation for an SSM based on IEEE 829-2008 formats.

Explain how to develop the complete test documentation package for an SSM specification based on NTCIP 1210 Standard v01.

Describe the testing of an SSM using sample test document.
We Have Now Completed the SSM Curriculum

**Module A304a**: Understanding *User Needs* for Field Management Stations - Part 1 Object Definitions for Signal System Masters (SSM) Based on NTCIP 1210 Standard

**Module A304b**: Specifying *Requirements* for Field Management Stations - Part 1 Object Definitions for Signal System Masters (SSM) Based on NTCIP 1210 Standard

**Module T304**: Applying Your *Test Plan* to Field Management Stations - Part 1 Signal System Masters (SSM) Based on NTCIP 1210 Standard v01
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!