



W E L C O M E



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

# Welcome



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

United States Department of Transportation

OFFICE OF THE ASSISTANT SECRETARY FOR RESEARCH AND TECHNOLOGY

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Joint Program Office

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**WHAT'S NEW**

New Web-Based Training from ITS Joint Program Office

- Connected Vehicle Reference Implementation Architecture Training now available

New NHI Course

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

New ITS Case Study Available

- National ITS Architecture

Added to T3 Archive

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

Welcome to ITS Professional Capacity Building

The ITS PCB Program is the U.S. Department of Transportation's leading program for delivering ITS training and learning resources to the nation's ITS workforce.

**FREE TRAINING**

The ITS PCB Program and partners offer many free ITS training courses.

- Web and Blended Courses from CITE
- ITS Standards Training
- Upcoming T3 Webinars

**[wwwpcb.its.dot.gov](http://wwwpcb.its.dot.gov)**

# A C T I V I T Y



# **T204 Part 2 of 2: How to Develop Test Procedures for an ITS Standards-Based Test Plan**



# Instructor



**Dave Miller,**  
**Chair: NEMA / AASHTO / ITE**  
**Joint Committee on ATC**  
**Chair: 3TS Technical Committee**

**Principal Systems Engineer  
Siemens Industry, Inc.  
RC-US MO MM-ITS R&D  
Austin, Texas, USA**

# Target Audience

- Test personnel responsible for developing Test Procedures
- Maintenance staff using Test Procedures for trouble shooting
- System developers
- Procurement
- Private and public sector users, including manufacturers

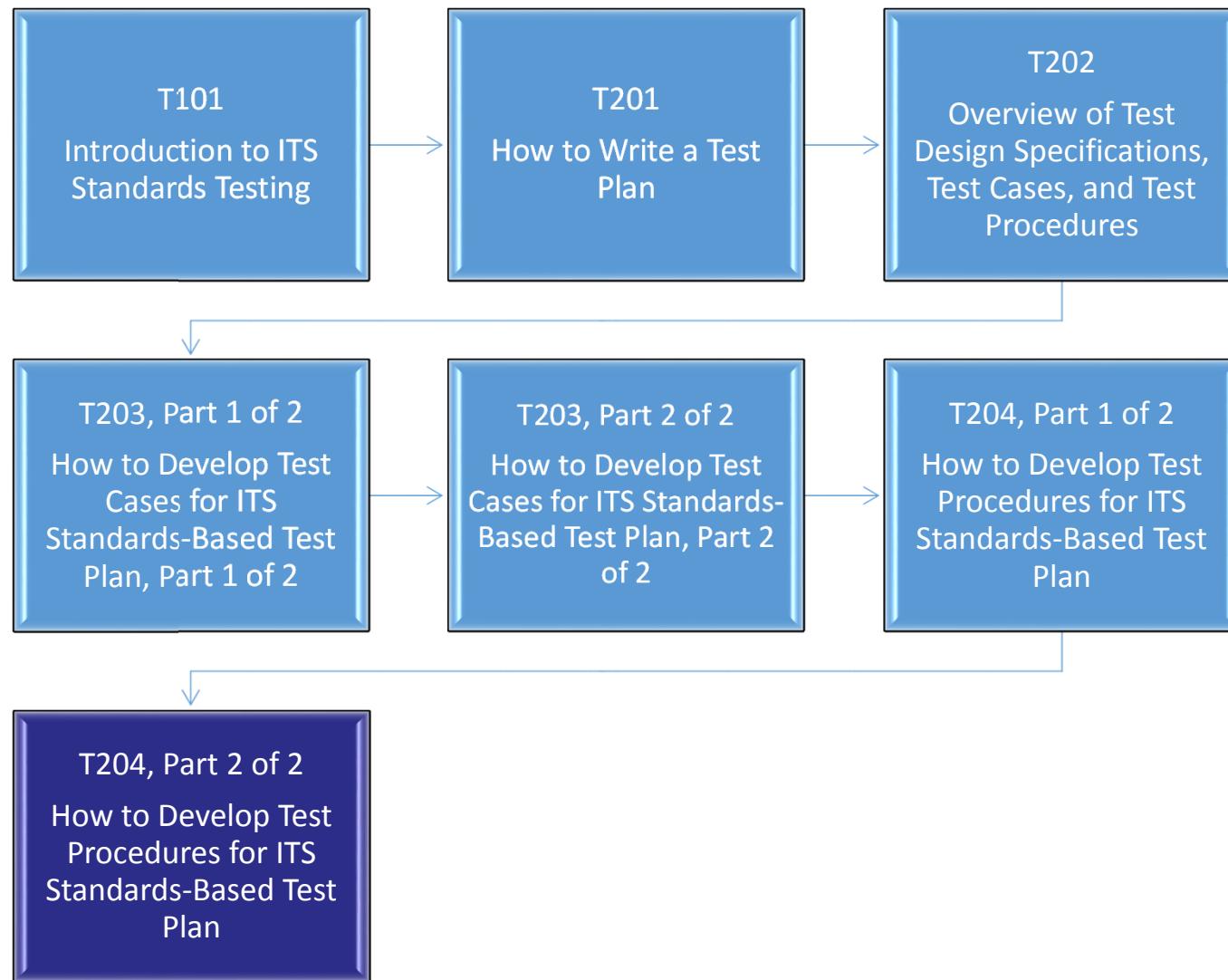


# Recommended Prerequisites

- 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
- T203 Part 2 of 2: How to Develop Test Cases for an ITS Standards-Based Test Plan, Part 2 of 2
- T204 Part 1 of 2: How to Develop Test Procedures for an ITS Standards-Based Test Plan, Part 1 of 2



# Curriculum Path (Testing)



# Acronyms and Terminology Used

Term / Acronym	Definition
C2F	Center-to-Field
DMS	Dynamic Message Sign
MIB	Management Information Base
MSO	Manufacturer Specific Object
RTCTM	Requirements to Test Case Traceability Matrix
RTM	Requirements Traceability Matrix
TCS	Test Case Specification
TDS	Test Design Specification
TMDD	Traffic Management Data Dictionary
TP	Test Plan
TPG	Test Procedure Generator
TPRTM	Test Procedure to Requirements Traceability Matrix
TPS	Test Procedure Specification



# Learning Objectives

## Part 1 of 2

1. Recognize the purpose and structure of a test procedure
2. Identify the role of a Test Procedure Specification (TPS) within a test plan and the overall testing process
3. Synchronize the test procedure specification to the contract terms and conditions for successful contract execution
4. Write the reports produced at the end of testing and understand their relationship to successful procurement contracts
5. Use tools to develop the test procedures for a sample TPS structure

## Part 2 of 2

6. Use the Test Procedure Generator (TPG) to generate test procedures for a variety of equipment
7. Adapt the generated test procedures to procurement contract terms and conditions for successful project conclusion
8. Develop complex test procedures that pull together National Transportation Communications for Intelligent Transportation Systems Protocol (NTCIP) elements using the TPG



# What We Have Learned in Part 1

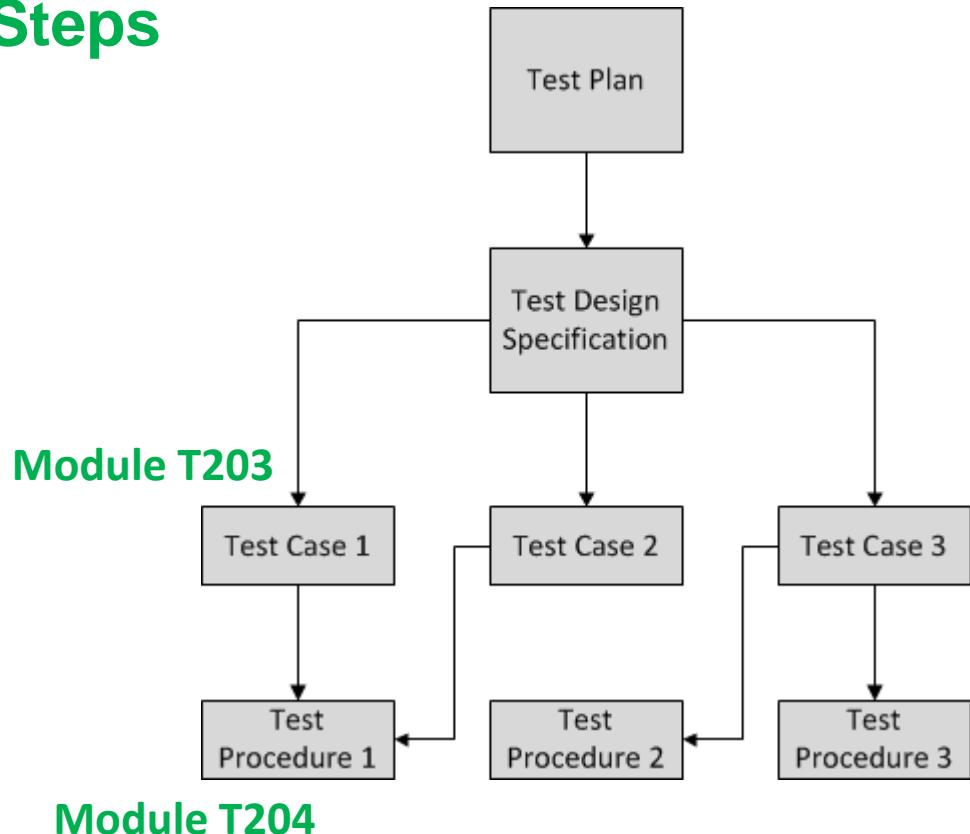
- 1) Test Procedure Specification (TSP) inputs are test cases used to create outputs of expected results and anomaly reports of unexpected results in IEEE 829 standard format.
- 2) A test design specification details what a test is to demonstrate; a test case specification specifies inputs, predicted results, and conditions, while a test procedure defines the steps to perform the test.
- 3) Contract Terms and Conditions should be viewed from the project's end including test case specifications and test procedures.
- 4) A master test report measures project success to stated goals.
- 5) Test Procedure Generator (TPG) is an automated tool that generates XML scripts using consistent key words for interoperability.



# Part 1 Discussed the Role of TPS Within Test Plan & Testing Process

## Reviewed Test Workflow Steps

- Overall test plan
- Test Design Specification (TDS)
- Multiple test cases per test design specification
- Multiple test procedures
  - Each test procedure may cover one independent test case
  - Each test procedure may cover multiple dependent test cases



# **Learning Objective #6: Use the Test Procedure Generator (TPG) to Generate Test Procedures for a Variety of Equipment**

- NTCIP 8002 Annex B1
- Role of TPG
- TPG successful installation
- Example test procedures for NTCIP 1203 v03 Dynamic Message Sign (DMS)



## **NTCIP 8002 Annex B1 Guidance**

- NTCIP 8002 Annex B1 defines content outline and clause numbering
  - Section numbering
  - Clause and subclause numbering
  - Annex numbering
  - Clause and subclause subject content
  - Labels and tags used with each subclause
- Applicable to NTCIP 12xx-series Device Data Dictionary Standards



## Role of Test Procedure Generator

- The TPG guides the development of test procedures for selected requirements in NTCIP Center-to-Field (C2F) Standards
- NTCIP C2F Standards developers can import their draft standard into the TPG to see a report of noncompliance to NTCIP 8002 Annex B1
- The report identifies breaks in traceability between requirements and design detail

Name	Mnemonic	Specification Number	Version Number	Source
Microsoft Windows 7 Operation System	Windows 7 SP 1	Service Pack 1	2009	Microsoft Corp
Microsoft Word 2010, Professional Edition	Word 2010	14.0.7128.5000 or greater <b>32-bit</b>	Microsoft Word 2010, Professional Edition	Microsoft Corp

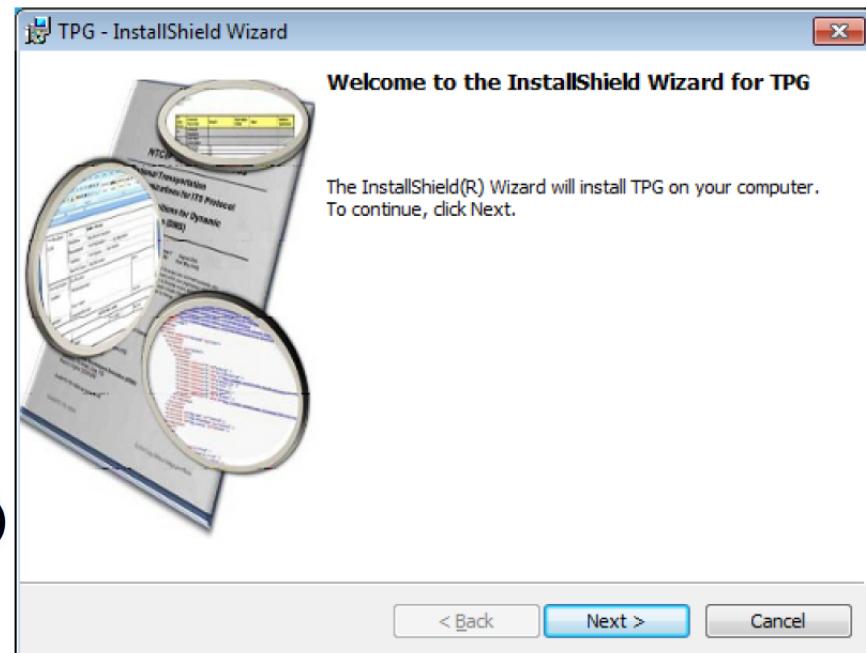
# TPG Successful Installation

## TPG Shortcut, NTCIP Standards, and Test Procedure Directories



### Center-to-Field (C2F) Test Procedure Generator (TPG)

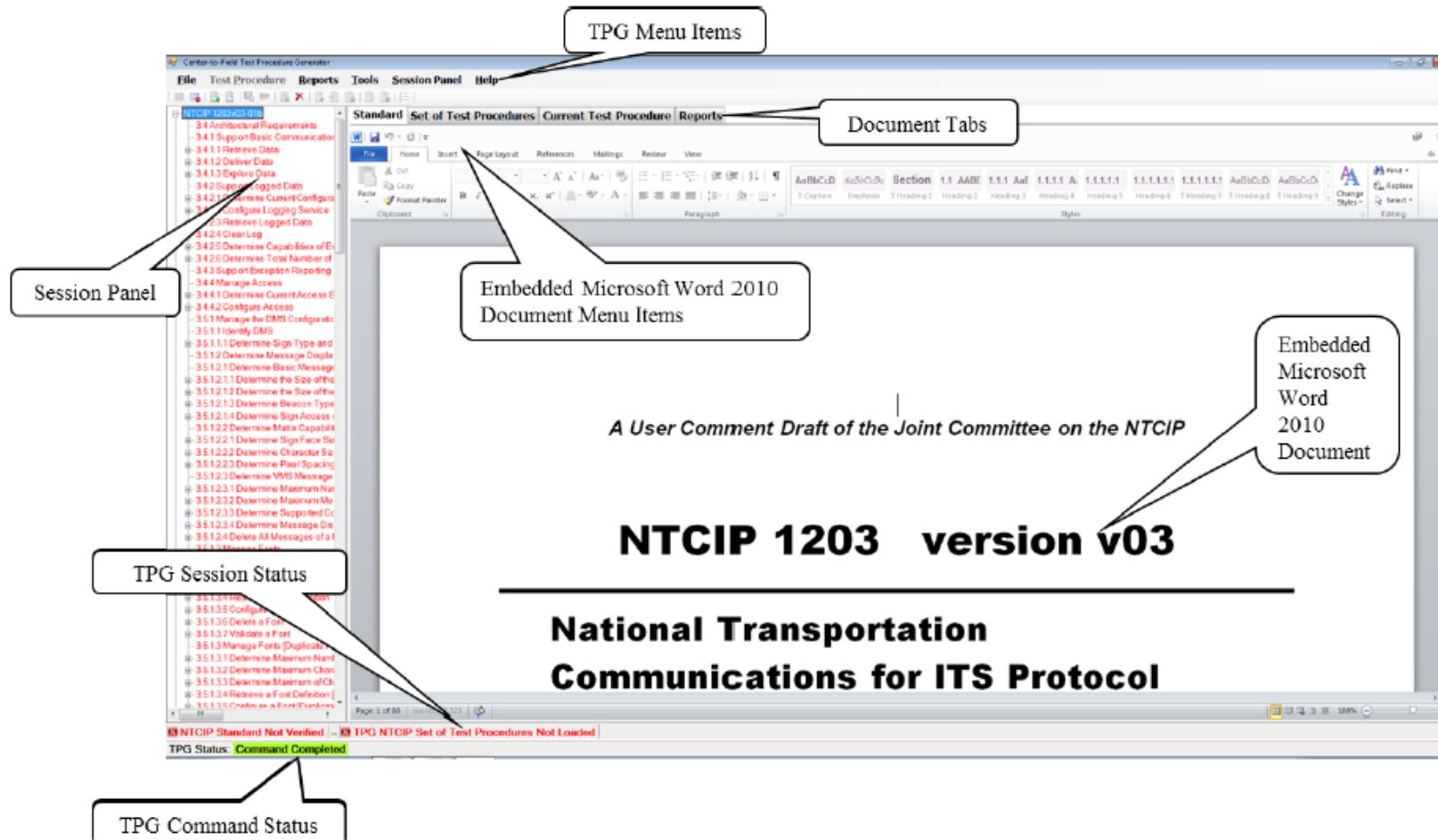
- C:\NTCIP Standards
  - Default Directory where TPG looks for the NTCIP Standards
- C:\Set of Test Procedures
  - Default directory where TPG loads and stores test procedures



Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# TPG Successful Installation (cont.)

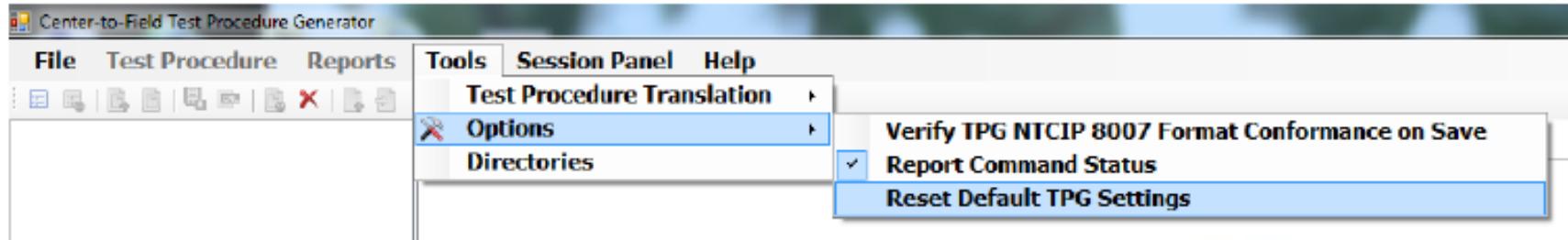
## TPG Graphical User Interface (GUI)



Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# Example Test Procedure

## Reset the TPG Environment

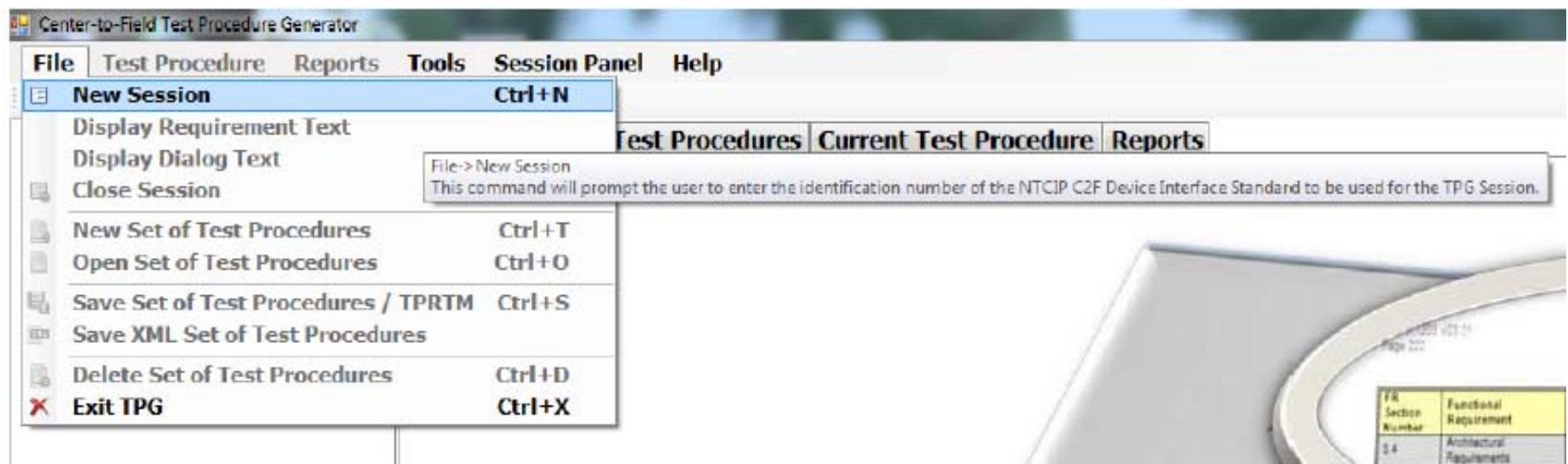


- “Tools → Options → Reset Default TPG Settings” resets:
  - Standard number used
  - Major Version
  - Minor Version
  - Revision Letter
  - NTCIP Standard Default File Path
  - Set of Test Procedures Default File Path

Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# Example Test Procedure (cont.)

## Begin a New TPG Session

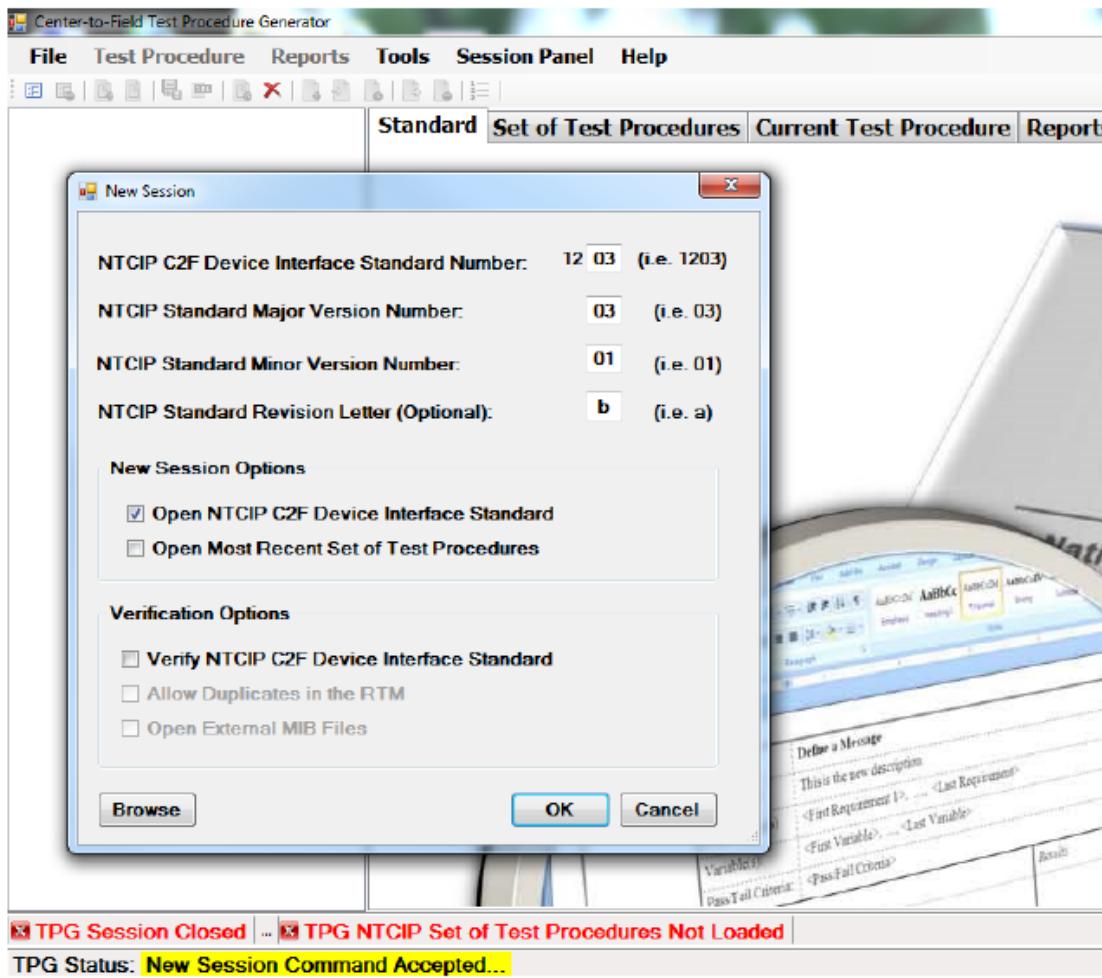


- “File → New Session”:
  - Define and Open the NTCIP C2F Standard to be used

Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# Example Test Procedure (cont.)

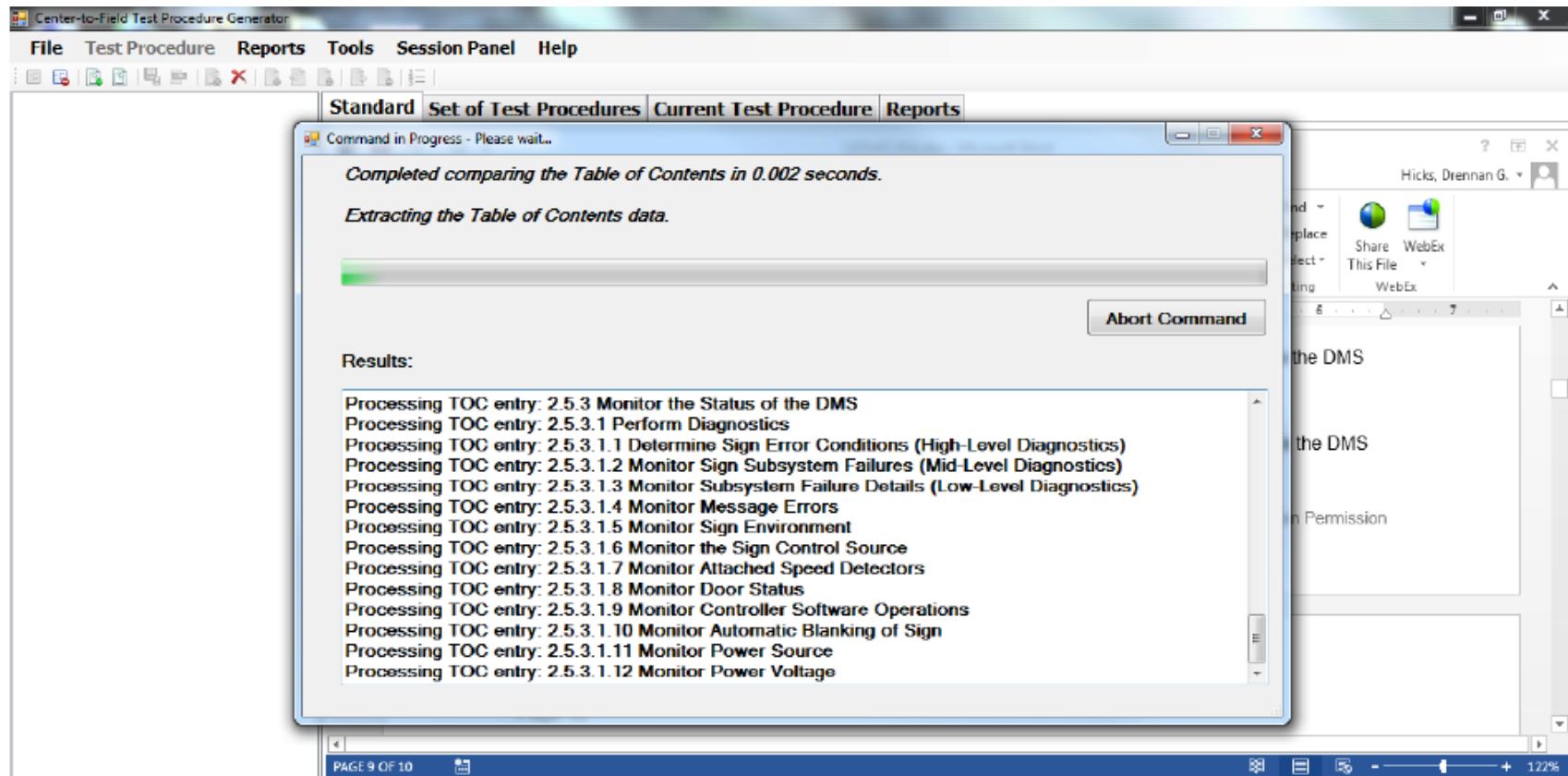
## Select the C2F Standard



Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# Example Test Procedure (cont.)

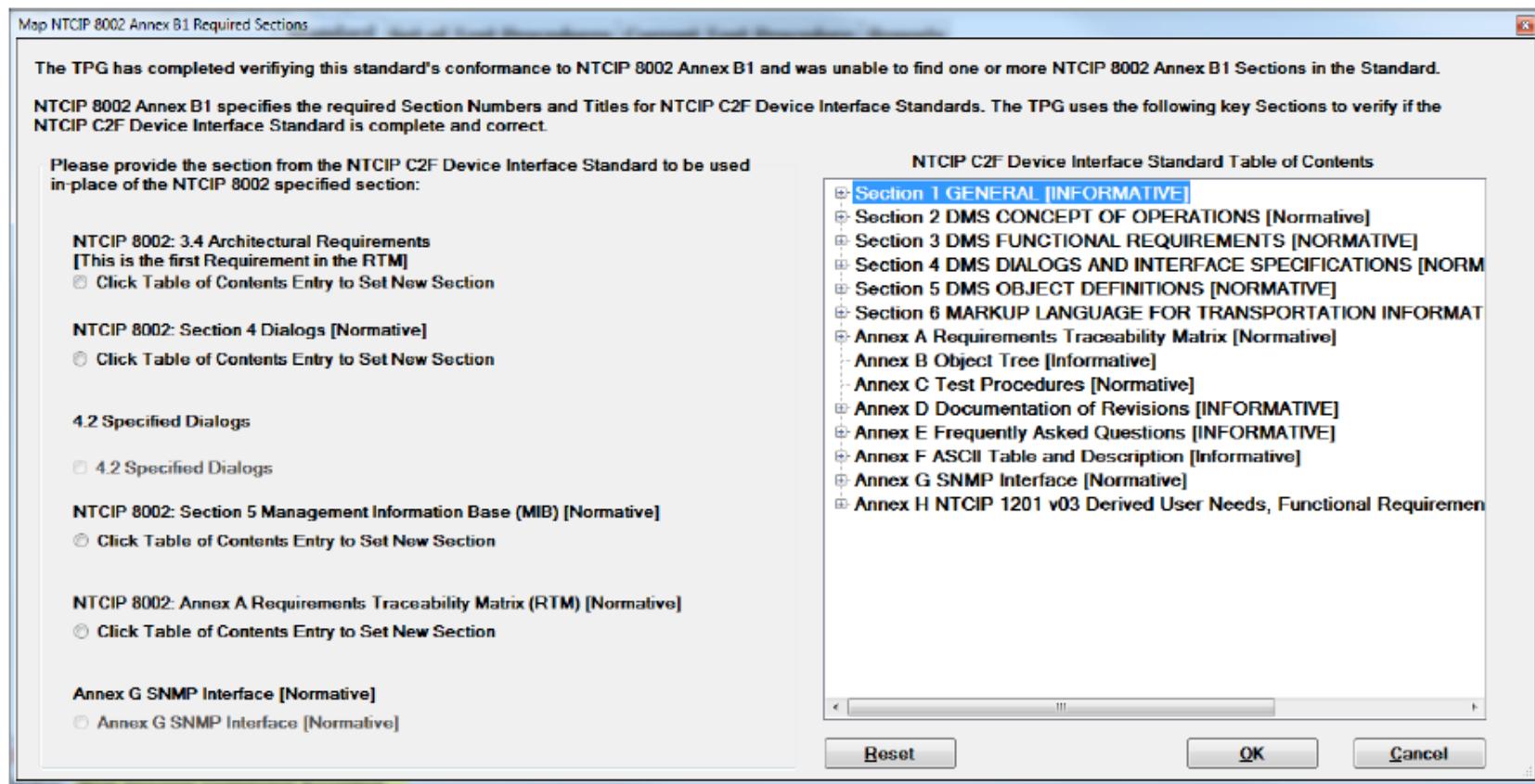
## Processing the Entries



Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# Example Test Procedure (cont.)

## Map NTCIP 8002 Annex B1 Required Sections



Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# Example Test Procedure (cont.)

## Map NTCIP 8002 Annex B1 Undefined Sections

Map NTCIP 8002 Annex B1 Required Sections

The TPG has completed verifying this standard's conformance to NTCIP 8002 Annex B1 and was unable to find one or more NTCIP 8002 Annex B1 Sections in the Standard.

NTCIP 8002 Annex B1 specifies the required Section Numbers and Titles for NTCIP C2F Device Interface Standards. The TPG uses the following key Sections to verify if the NTCIP C2F Device Interface Standard is complete and correct.

Please provide the section from the NTCIP C2F Device Interface Standard to be used in-place of the NTCIP 8002 specified section:

NTCIP 8002: 3.4 Architectural Requirements  
[This is the first Requirement in the RTM]  
 3.4 Architectural Requirements

NTCIP 8002: Section 4 Dialogs [Normative]  
 Section 4 DMS DIALOGS AND INTERFACE SPECIFICATIONS [NORMATIVE]

4.2 Specified Dialogs  
 4.2 Specified Dialogs

NTCIP 8002: Section 5 Management Information Base (MIB) [Normative]  
 Section 5 DMS OBJECT DEFINITIONS [NORMATIVE]

NTCIP 8002: Annex A Requirements Traceability Matrix (RTM) [Normative]  
 Annex A Requirements Traceability Matrix [Normative]

Annex G SNMP Interface [Normative]  
 Annex G SNMP Interface [Normative]

NTCIP C2F Device Interface Standard Table of Contents

- Section 1 GENERAL [INFORMATIVE]
- Section 2 DMS CONCEPT OF OPERATIONS [Normative]
- Section 3 DMS FUNCTIONAL REQUIREMENTS [NORMATIVE]
  - 3.1 Tutorial
  - 3.2 Scope of the Interface [Informative]
  - 3.3 Protocol Requirements List
  - 3.4 Architectural Requirements
  - 3.5 Data Exchange Requirements
  - 3.6 Supplemental Requirements
- Section 4 DMS DIALOGS AND INTERFACE SPECIFICATIONS [NORMATIVE]
- Section 5 DMS OBJECT DEFINITIONS [NORMATIVE]
- Section 6 MARKUP LANGUAGE FOR TRANSPORTATION INFORMATION
- Annex A Requirements Traceability Matrix [Normative]
- Annex B Object Tree [Informative]
- Annex C Test Procedures [Normative]
- Annex D Documentation of Revisions [INFORMATIVE]
- Annex E Frequently Asked Questions [INFORMATIVE]
- Annex F ASCII Table and Description [Informative]
- Annex G SNMP Interface [Normative]
- Annex H NTCIP 1201 v03 Derived User Needs, Functional Requirements

Reset      OK      Cancel

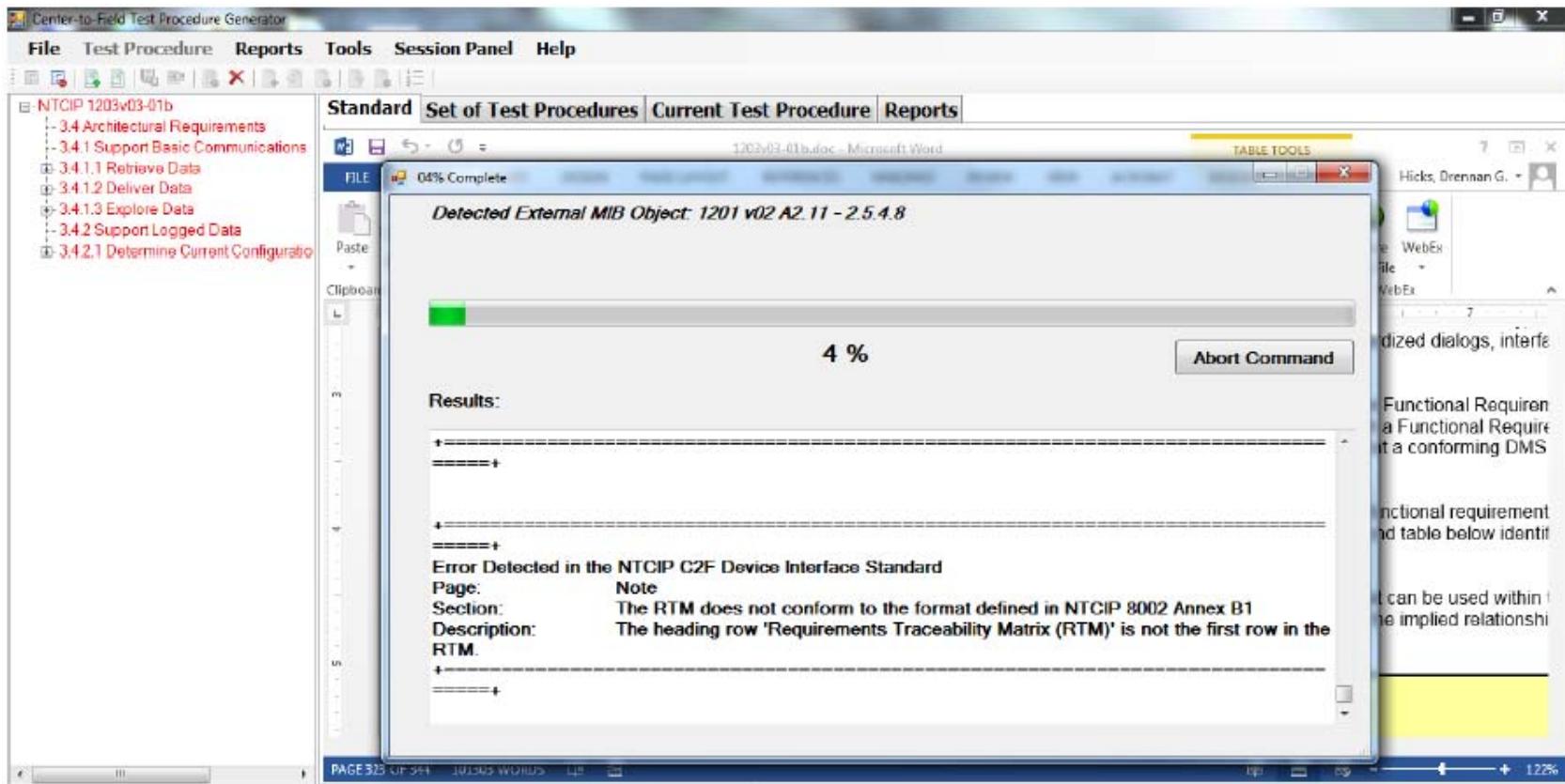
Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015



## Example Test Procedure (cont.)

### Create Requirements Traceability Matrix (RTM)

- TPG verifies the content of the mapping, then constructs the RTM



Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# A C T I V I T Y



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## **How does TPG relate to NTCIP 8002?**

### **Answer Choices**

- a) Draft standards are verified to NTCIP 8002 compliance
- b) Unbroken traceability from requirements through testing
- c) Uniformity of test procedure content and numbering
- d) All of the above



## Review of Answers



- a) Draft standards are verified to NTCIP 8002 compliance

*Incorrect. All are true.*



- b) Unbroken traceability from requirements through testing

*Incorrect. All are true.*



- c) Uniformity of test procedure content and numbering

*Incorrect. All are true.*



- d) All of the above

***Correct! All of the above answers describe how the TPG relates to NTCIP 8002.***

# Example: Test Procedure for a DMS

Open the NTCIP 1203 v03 DMS Standard

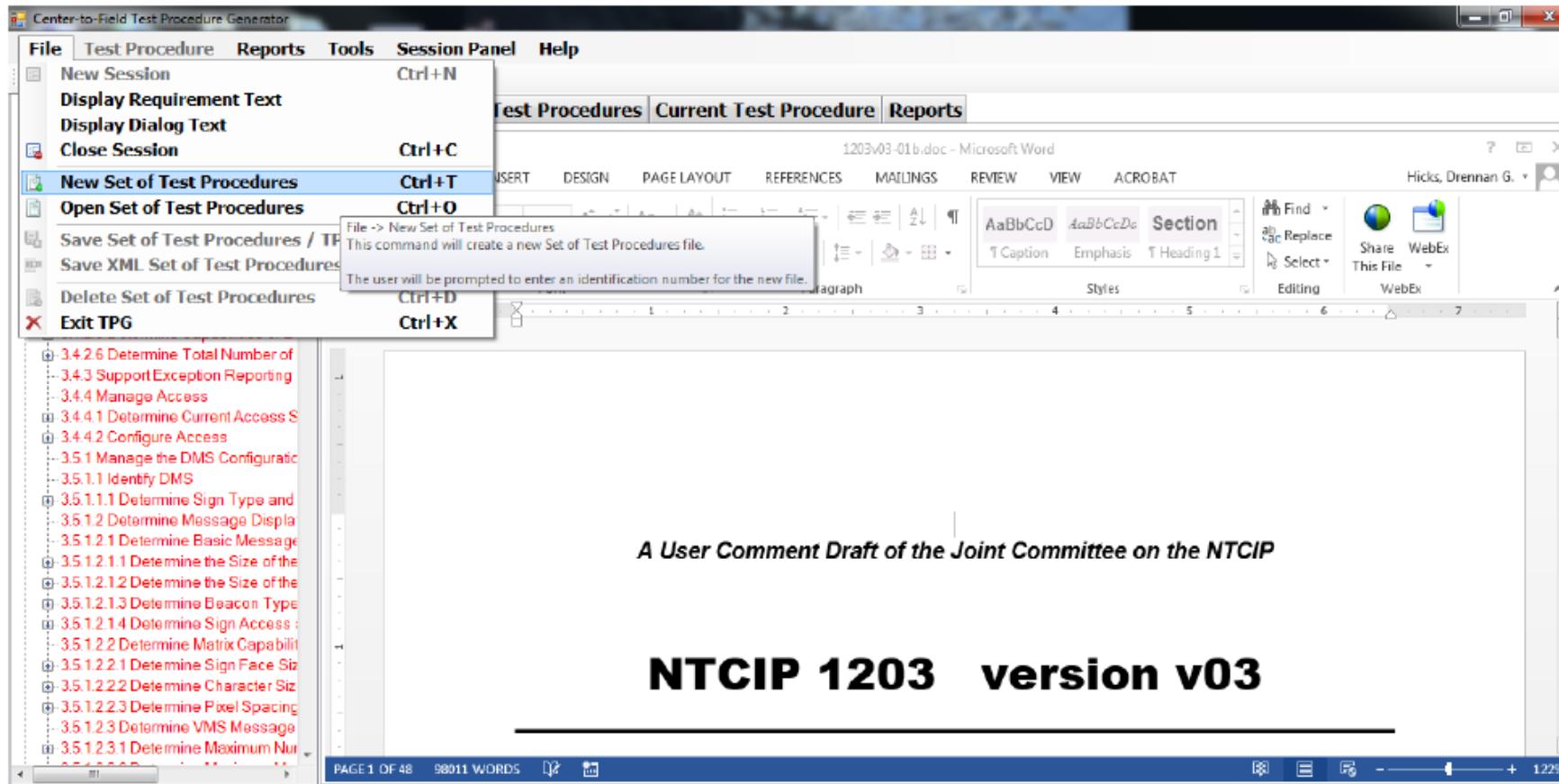
The screenshot shows the 'Center-to-Field Test Procedure Generator' application window. The menu bar includes File, Test Procedure, Reports, Tools, Session Panel, and Help. The ribbon tabs are Standard, Set of Test Procedures, Current Test Procedure, and Reports. The current tab is 'Standard'. The main content area displays the title 'NTCIP 1203v03-01b' and the subtitle 'National Transportation Communications'. Below the subtitle, the text 'PAGE 1 OF 10 1096 WORDS' is visible. On the left, a tree view shows the structure of the test procedures, starting with 'NTCIP 1203v03-01b' and its sub-sections: 3.4 Architectural Requirements, 3.4.1 Support Basic Communication, 3.4.1.1 Retrieve Data, 3.4.1.2 Deliver Data, 3.4.1.3 Explore Data, 3.4.2 Support Logged Data, 3.4.2.1 Determine Current Configuration, 3.4.2.2 Configure Logging Service, 3.4.2.3 Retrieve Logged Data, 3.4.2.4 Clear Log, 3.4.2.5 Determine Capabilities of Existing System, 3.4.2.6 Determine Total Number of Devices, 3.4.3 Support Exception Reporting, 3.4.4 Manage Access, 3.4.4.1 Determine Current Access Settings, 3.4.4.2 Configure Access, 3.5.1 Manage the DMS Configuration, 3.5.1.1 Identify DMS, 3.5.1.1.1 Determine Sign Type and Configuration, 3.5.1.1.2 Determine Message Display, 3.5.1.2 Determine Basic Message Types, 3.5.1.2.1 Determine the Size of the Message, 3.5.1.2.2 Determine the Size of the Message, 3.5.1.2.3 Determine Beacon Type, 3.5.1.2.4 Determine Sign Access, 3.5.1.2.5 Determine Matrix Capability, 3.5.1.2.6 Determine Sign Face Size, 3.5.1.2.7 Determine Character Size, 3.5.1.2.8 Determine Pixel Spacing, 3.5.1.2.9 Determine VMS Message Types, 3.5.1.2.10 Determine Maximum Number of Messages, and 3.5.1.2.11 Determine Maximum Number of Characters per Message.

Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015



# Example: Test Procedure for a DMS (cont.)

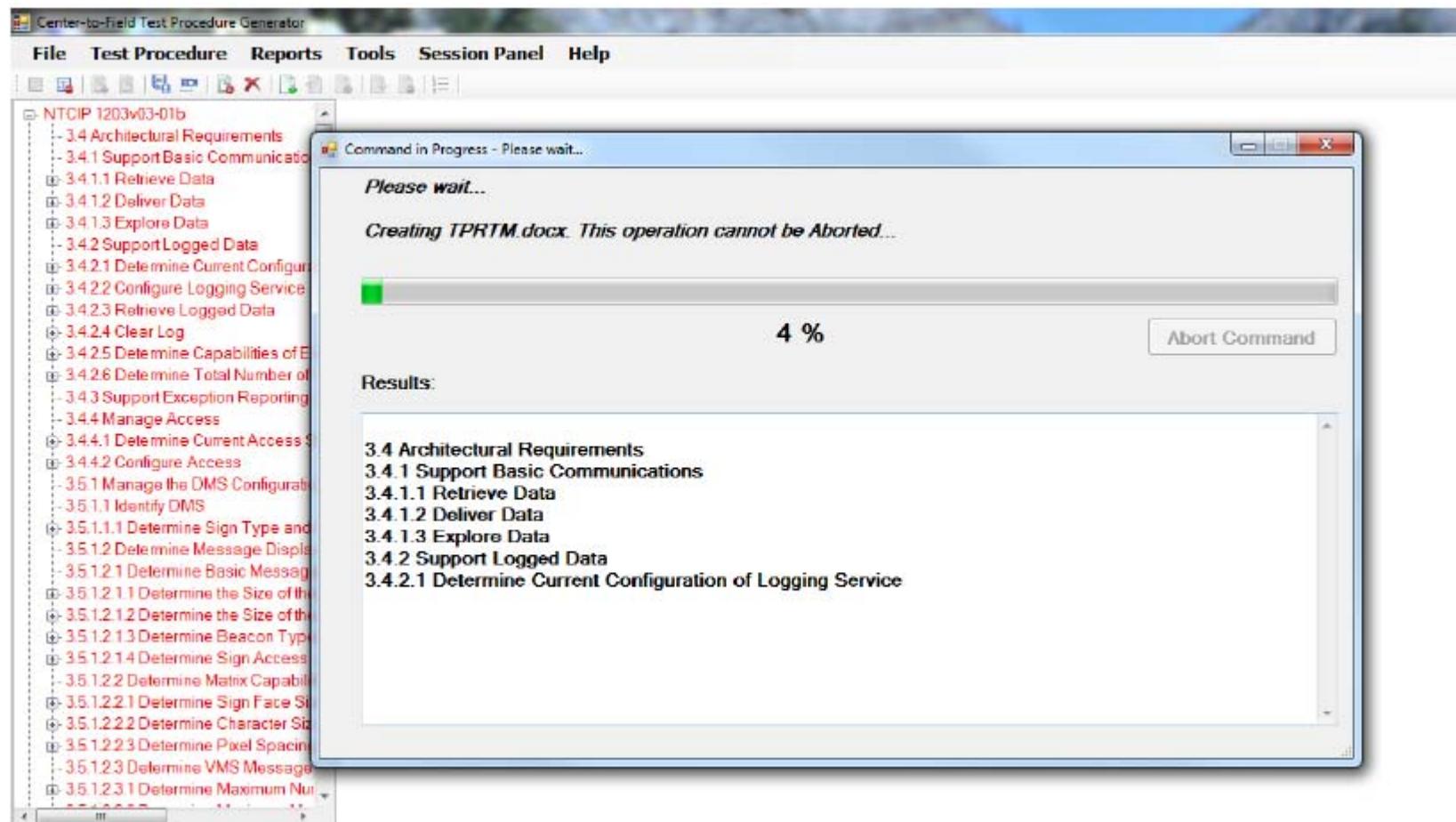
## Create a New Set of Test Procedures



Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

## Example Test Procedure for a DMS (cont.)

### Create Test Procedure Requirements Traceability Matrix



Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# Example Test Procedure for a DMS (cont.)

## Set of Test Procedures

The screenshot shows a Microsoft Word document titled "TPG NTCIP 1203v03-01b Set of Test Procedures DRAFT v7.docx - Microsoft Word". The document contains the following text:

**NTCIP 1203v03-01b**

---

**National Transportation Communications  
for ITS Protocol**

---

**NTCIP 8007 Conformant Set of Test Procedures  
Version 7 - Jun 15, 2015**

---

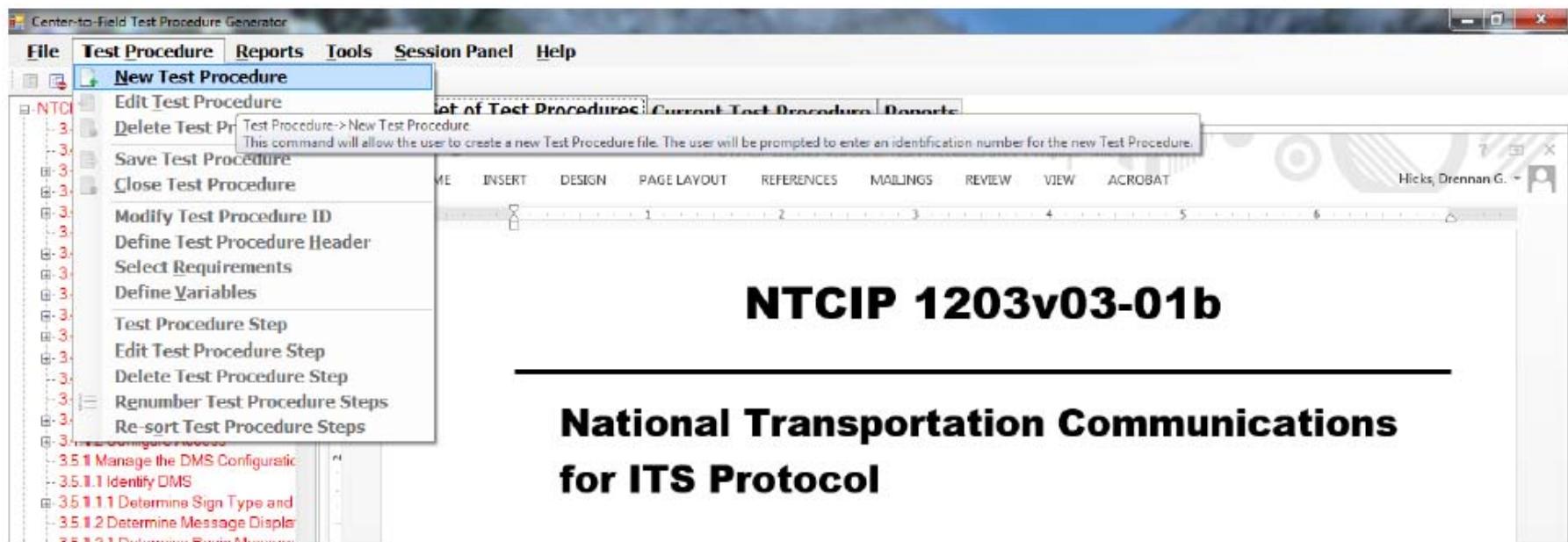
The left side of the screen shows the software's interface with a tree view of test procedures and a toolbar.

Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015



# Example Test Procedure for a DMS (cont.)

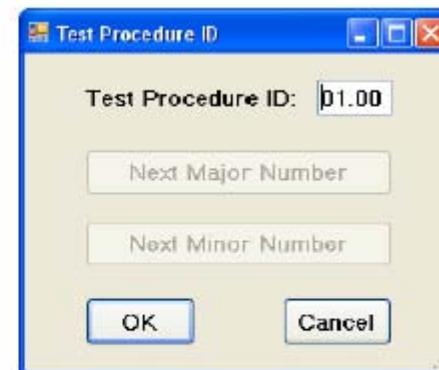
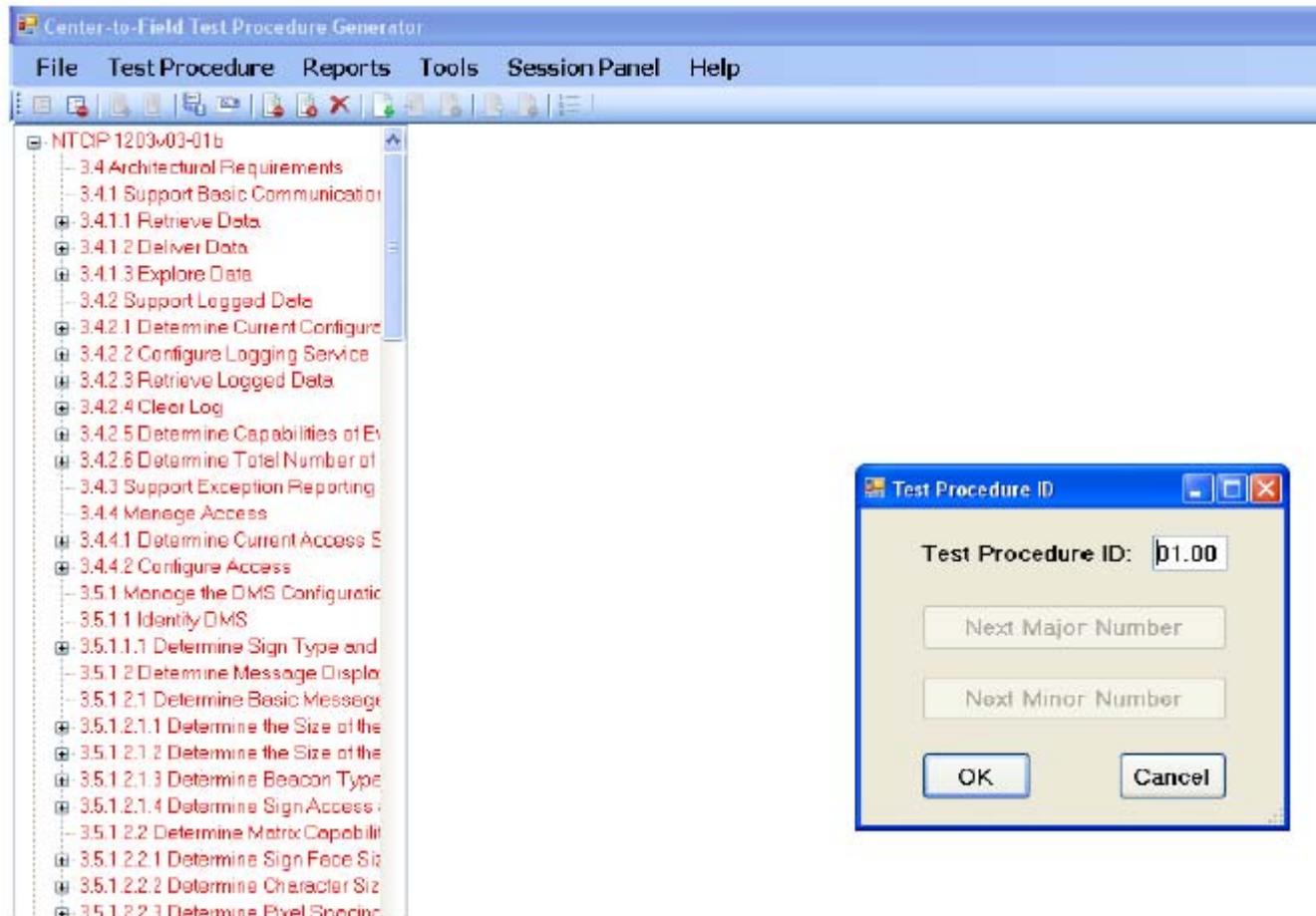
## Create a New Test Procedure



Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# Example Test Procedure for a DMS (cont.)

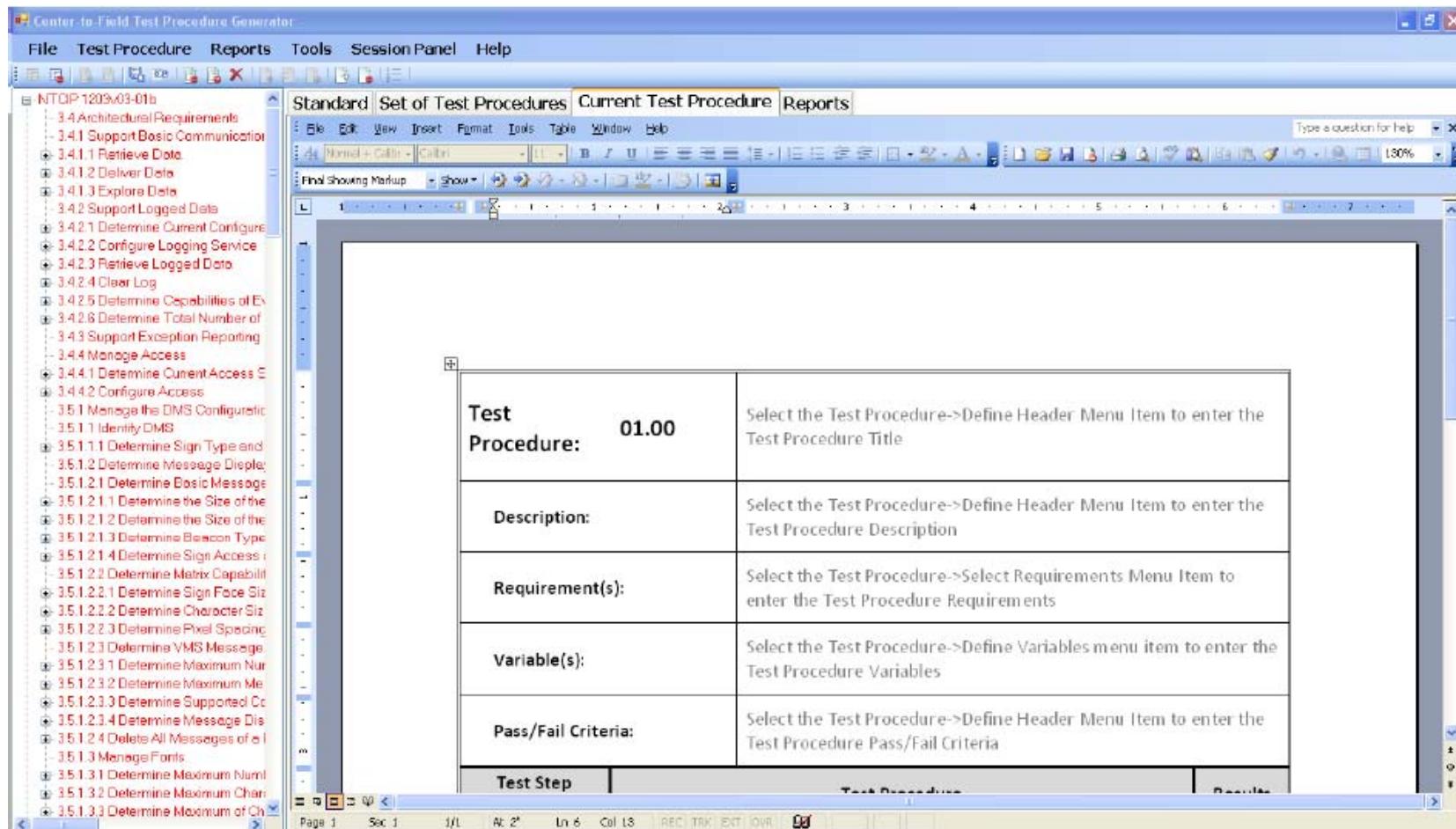
## Test Procedure ID



Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# Example Test Procedure for a DMS (cont.)

## Test Procedure File



Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015



# Example Test Procedure for a DMS (cont.)

## Test Procedure Header

The screenshot shows the 'Center-to-Field Test Procedure Generator' application window. The 'Test Procedure' menu is open, and the 'Define Test Procedure Header' option is selected. A tooltip provides information about this command: 'This command will allow the user to define and edit the Test Procedure title, description, and Pass/Fail criteria.' The main workspace displays a table with four rows:

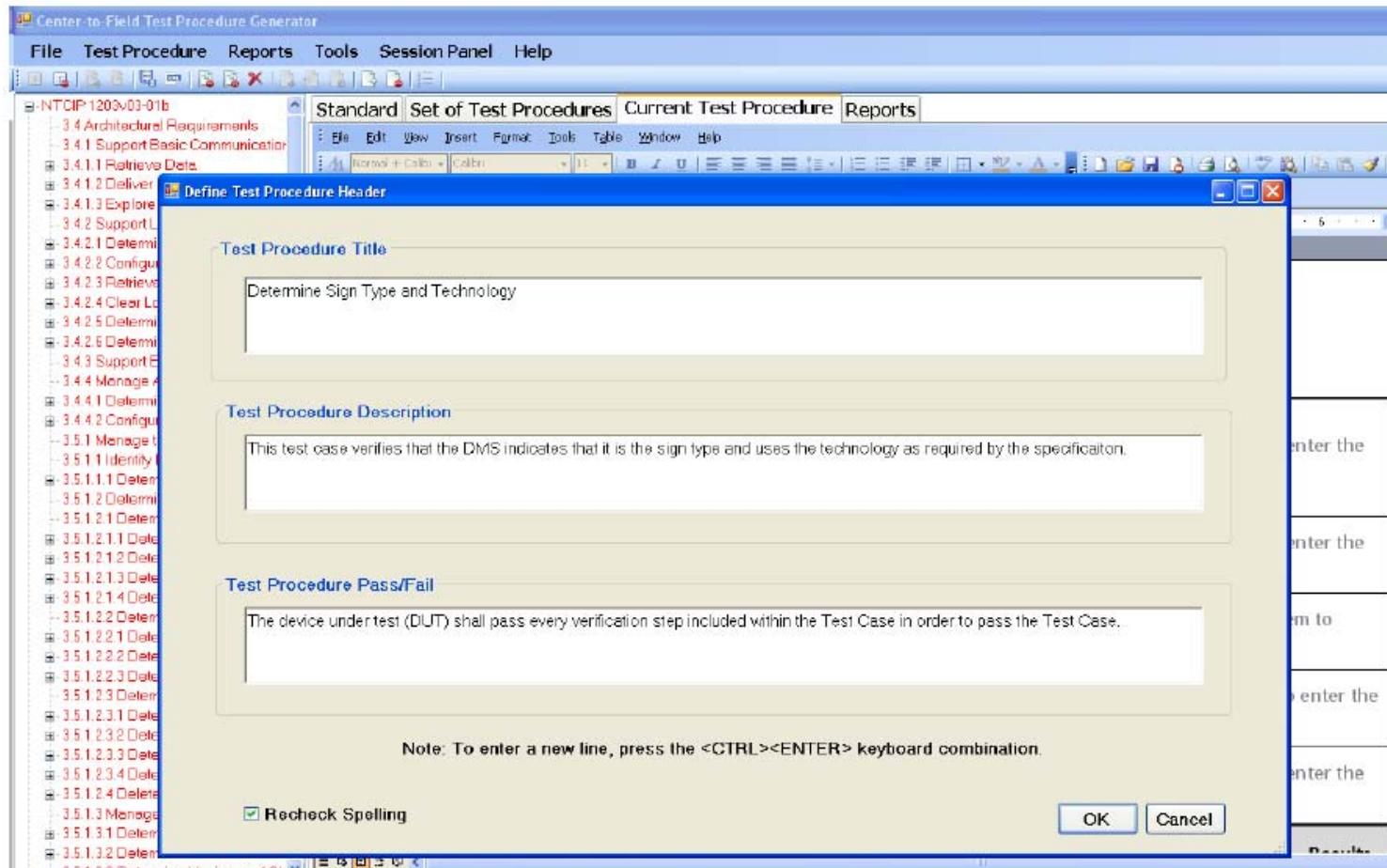
<b>Test Procedure:</b>	<b>01.00</b>	Select the Test Procedure->Define Header Menu Item to enter the Test Procedure Title
<b>Description:</b>		Select the Test Procedure->Define Header Menu Item to enter the Test Procedure Description
<b>Requirement(s):</b>		Select the Test Procedure->Select Requirements Menu Item to enter the Test Procedure Requirements
<b>Variable(s):</b>		Select the Test Procedure->Define Variables menu item to enter the Test Procedure Variables

Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015



# Example Test Procedure for a DMS (cont.)

## Populate the Test Procedure Header



Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# Example Test Procedure for a DMS (cont.)

## Populate the Test Procedure Header

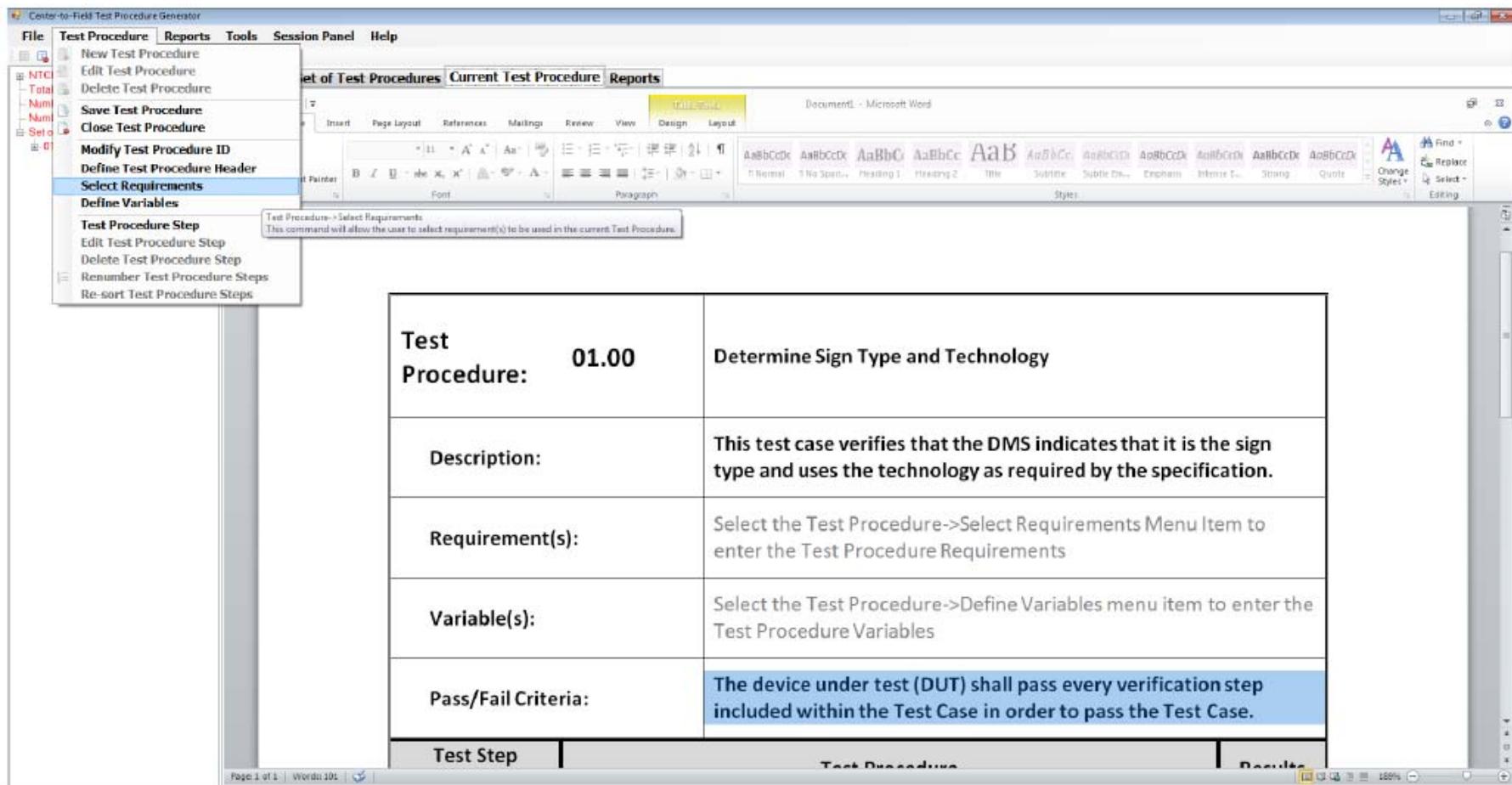
<b>Test Procedure:</b>	01.00	Determine Sign Type and Technology
<b>Description:</b>	This test case verifies that the DMS indicates that it is the sign type and uses the technology as required by the specification.	
<b>Requirement(s):</b>	Select the Test Procedure->Select Requirements Menu Item to enter the Test Procedure Requirements	
<b>Variable(s):</b>	Select the Test Procedure->Define Variables menu item to enter the Test Procedure Variables	
<b>Pass/Fail Criteria:</b>	The device under test (DUT) shall pass every verification step included within the Test Case in order to pass the Test Case.	
Test Step Number	Test Procedure	Results
Test Procedure Results		
Tested By:	Date Tested:	Pass/Fail

Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015



# Example Test Procedure for a DMS (cont.)

## Select the Requirements



The screenshot shows the software interface for 'Center-to-Field Test Procedure Generator'. The menu bar includes 'File', 'Test Procedure', 'Reports', 'Tools', 'Session Panel', and 'Help'. The 'Test Procedure' menu is open, showing options like 'New Test Procedure', 'Edit Test Procedure', and 'Select Requirements'. The 'Select Requirements' option is highlighted with a blue selection bar. A tooltip below the menu item reads: 'Test Procedure->Select Requirements. This command will allow the user to select requirement(s) to be used in the current Test Procedure.' The main workspace displays a Microsoft Word document titled 'Document1 - Microsoft Word'. The document contains a table with the following data:

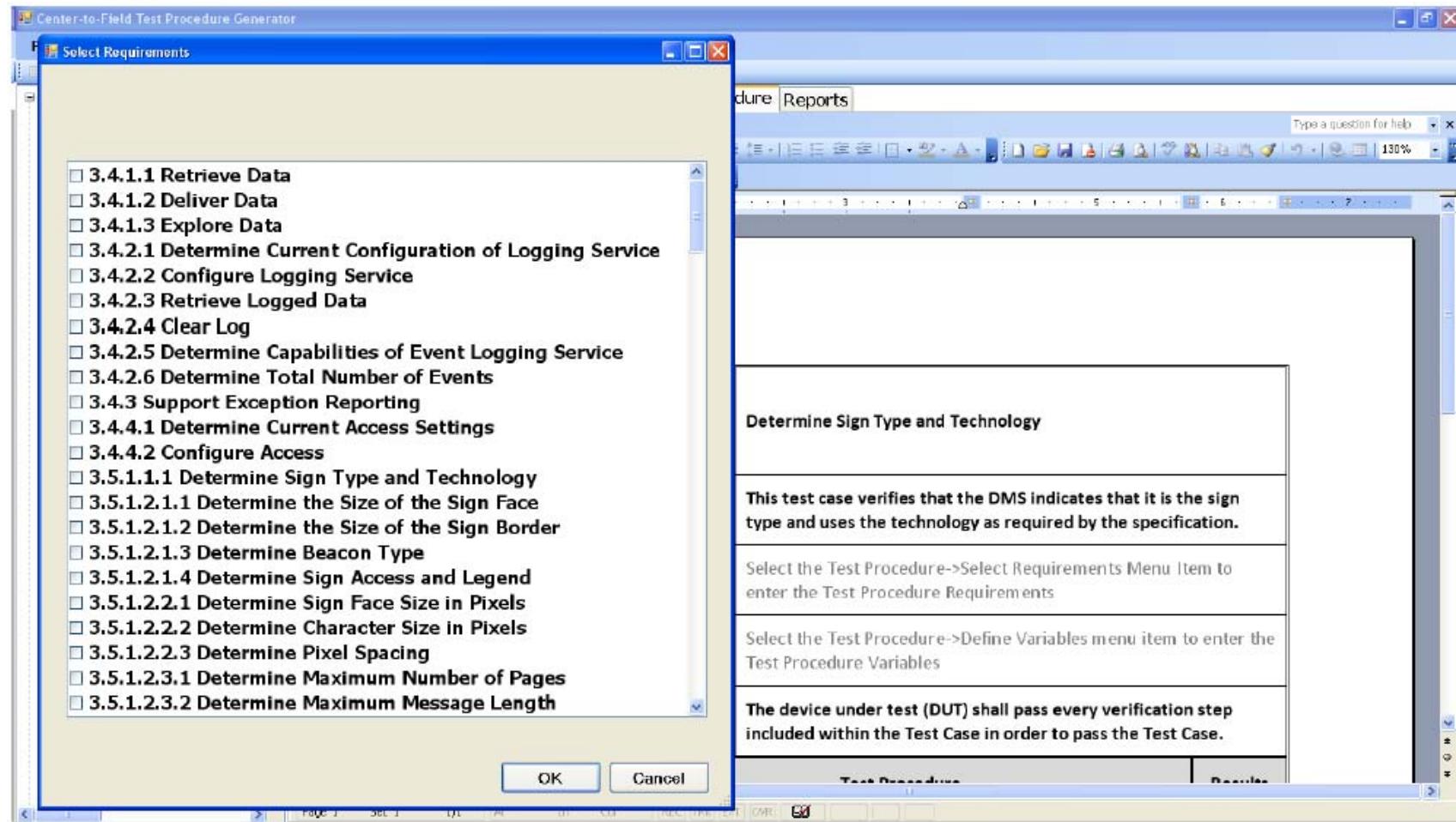
<b>Test Procedure:</b>	<b>01.00</b>	Determine Sign Type and Technology
<b>Description:</b>	This test case verifies that the DMS indicates that it is the sign type and uses the technology as required by the specification.	
<b>Requirement(s):</b>	Select the Test Procedure->Select Requirements Menu Item to enter the Test Procedure Requirements	
<b>Variable(s):</b>	Select the Test Procedure->Define Variables menu item to enter the Test Procedure Variables	
<b>Pass/Fail Criteria:</b>	The device under test (DUT) shall pass every verification step included within the Test Case in order to pass the Test Case.	
<b>Test Step</b>	<b>Test Procedure</b>	<b>Results</b>

Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015



# Example Test Procedure for a DMS (cont.)

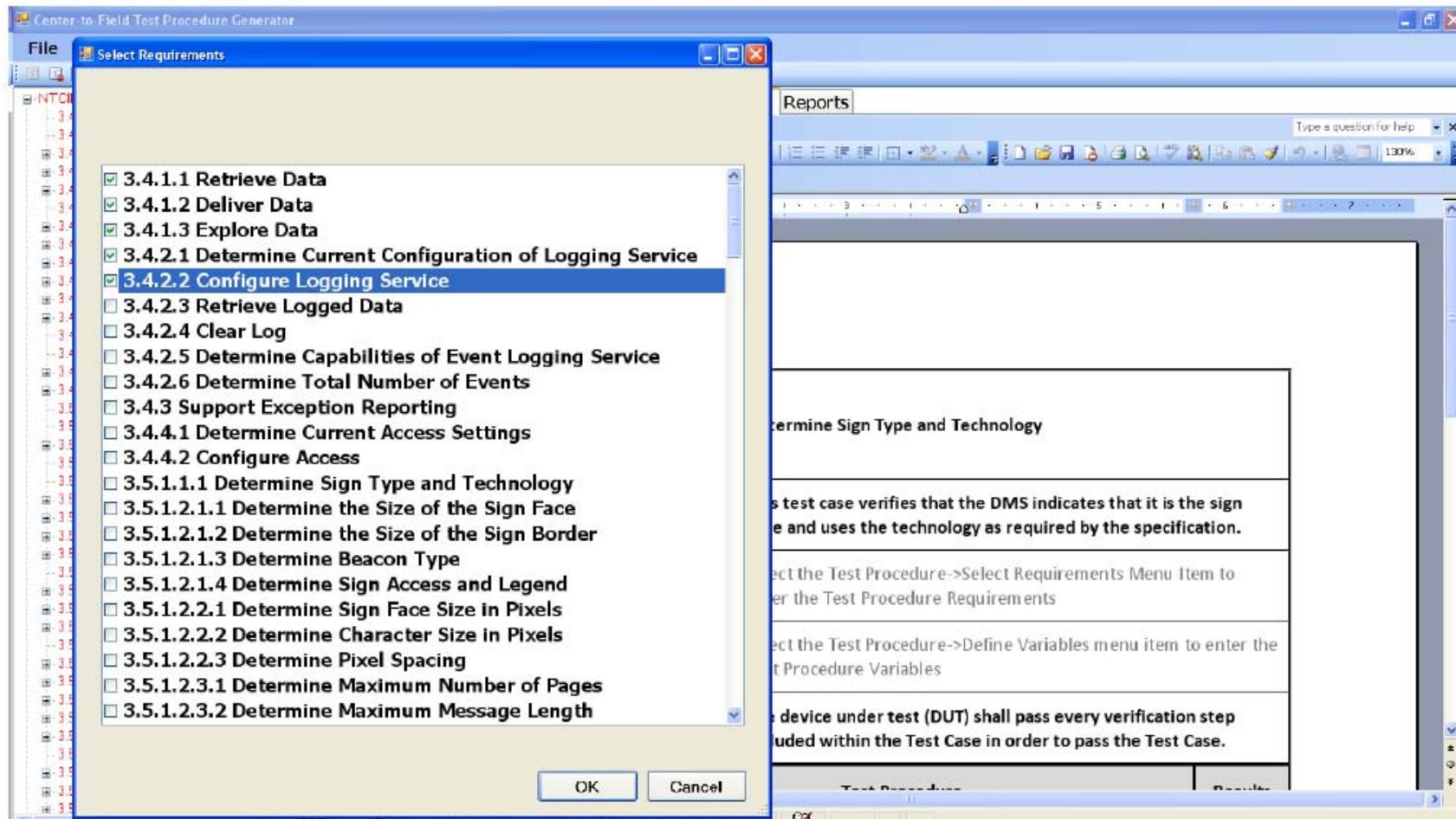
## Select the Requirements



Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# Example Test Procedure for a DMS (cont.)

## Select the Requirements



Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# Example Test Procedure for a DMS (cont.)

## Populated Test Procedure Document

The screenshot shows the 'Center-to-Field Test Procedure Generator' application window. The menu bar includes File, Test Procedure, Reports, Tools, Session Panel, and Help. The toolbar has various icons for file operations like Open, Save, Print, and Insert. The ribbon tabs are Standard, Set of Test Procedures, Current Test Procedure, and Reports. The main area displays a test procedure document with the following table:

<b>Test Procedure:</b>	01.00	<b>Determine Sign Type and Technology</b>
<b>Description:</b>	This test case verifies that the DMS indicates that it is the sign type and uses the technology as required by the specification.	
<b>Requirement(s):</b>	3.4.1.1 Retrieve Data 3.4.1.2 Deliver Data 3.4.1.3 Explore Data 3.4.2.1 Determine Current Configuration of Logging Service 3.4.2.2 Configure Logging Service	
<b>Variable(s):</b>	Select the Test Procedure->Define Variables menu item to enter the Test Procedure Variables	
<b>Pass/Fail Criteria:</b>	The device under test (DUT) shall pass every verification step included within the Test Case in order to pass the Test Case.	

The left sidebar shows a tree view of test procedures, with 'NTCIP 1203v03-01b' expanded to show sub-sections like '3.4 Architectural Requirements' and '3.4.1.1 Retrieve Data'.

Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015



# Example Test Procedure for a DMS (cont.)

## Define Variables

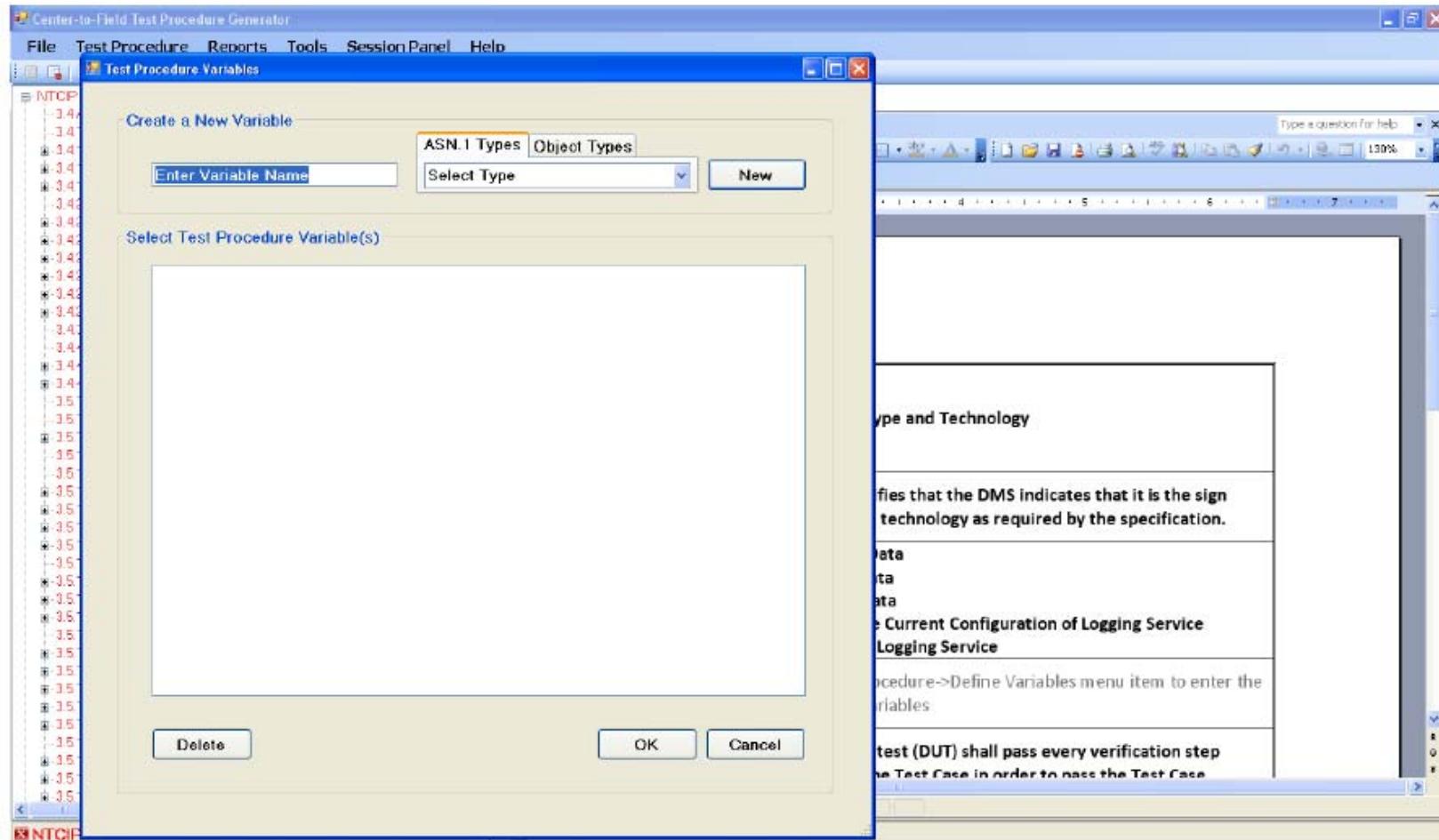
The screenshot shows the software interface for creating test procedures. The main window displays a table with a single row for a test case. The table columns are labeled 'Test Procedure:' (containing '01.00'), 'Determine Sign Type and Technology', 'Description:' (containing a detailed description), 'Requirement(s):' (containing a list of requirements), 'Variable(s):' (containing instructions to enter variables), and 'Pass/Fail Criteria:' (containing criteria for passing the test). On the left, a sidebar lists various test steps under a tree structure. A context menu is open over one of these steps, with the 'Define Variables' option highlighted.

<b>Test Procedure:</b>	01.00	Determine Sign Type and Technology
<b>Description:</b>	This test case verifies that the DMS Indicates that it is the sign type and uses the technology as required by the specification.	
<b>Requirement(s):</b>	<ul style="list-style-type: none"> <li>3.4.1.1 Retrieve Data</li> <li>3.4.1.2 Deliver Data</li> <li>3.4.1.3 Explore Data</li> <li>3.4.2.1 Determine Current Configuration of Logging Service</li> <li>3.4.2.2 Configure Logging Service</li> </ul>	
<b>Variable(s):</b>	Select the Test Procedure->Define Variables menu item to enter the Test Procedure Variables	
<b>Pass/Fail Criteria:</b>	The device under test (DUT) shall pass every verification step included within the Test Case in order to pass the Test Case.	

Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# Example Test Procedure for a DMS (cont.)

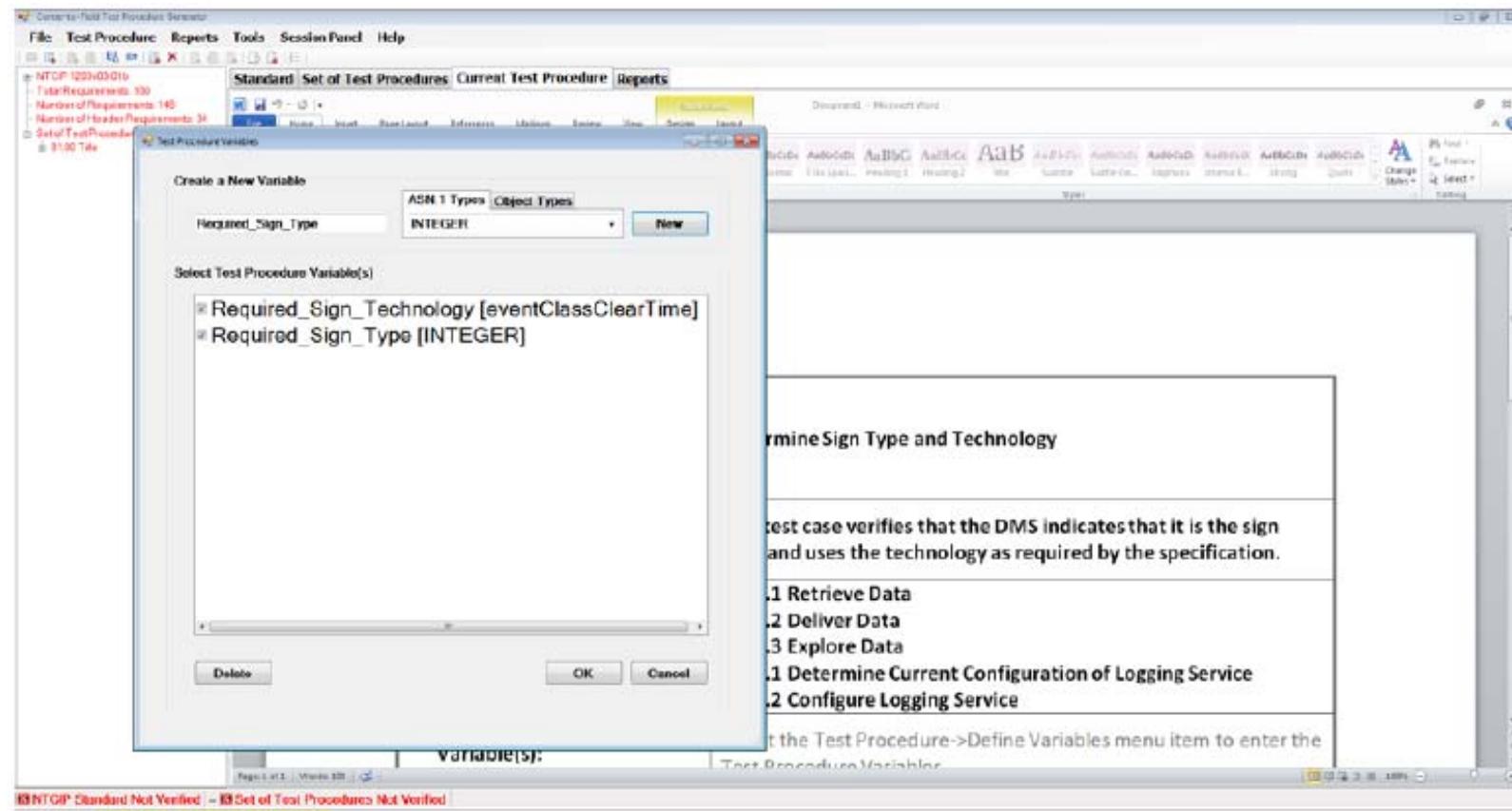
## Define Variables



Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# Example Test Procedure for a DMS (cont.)

## Define Variables

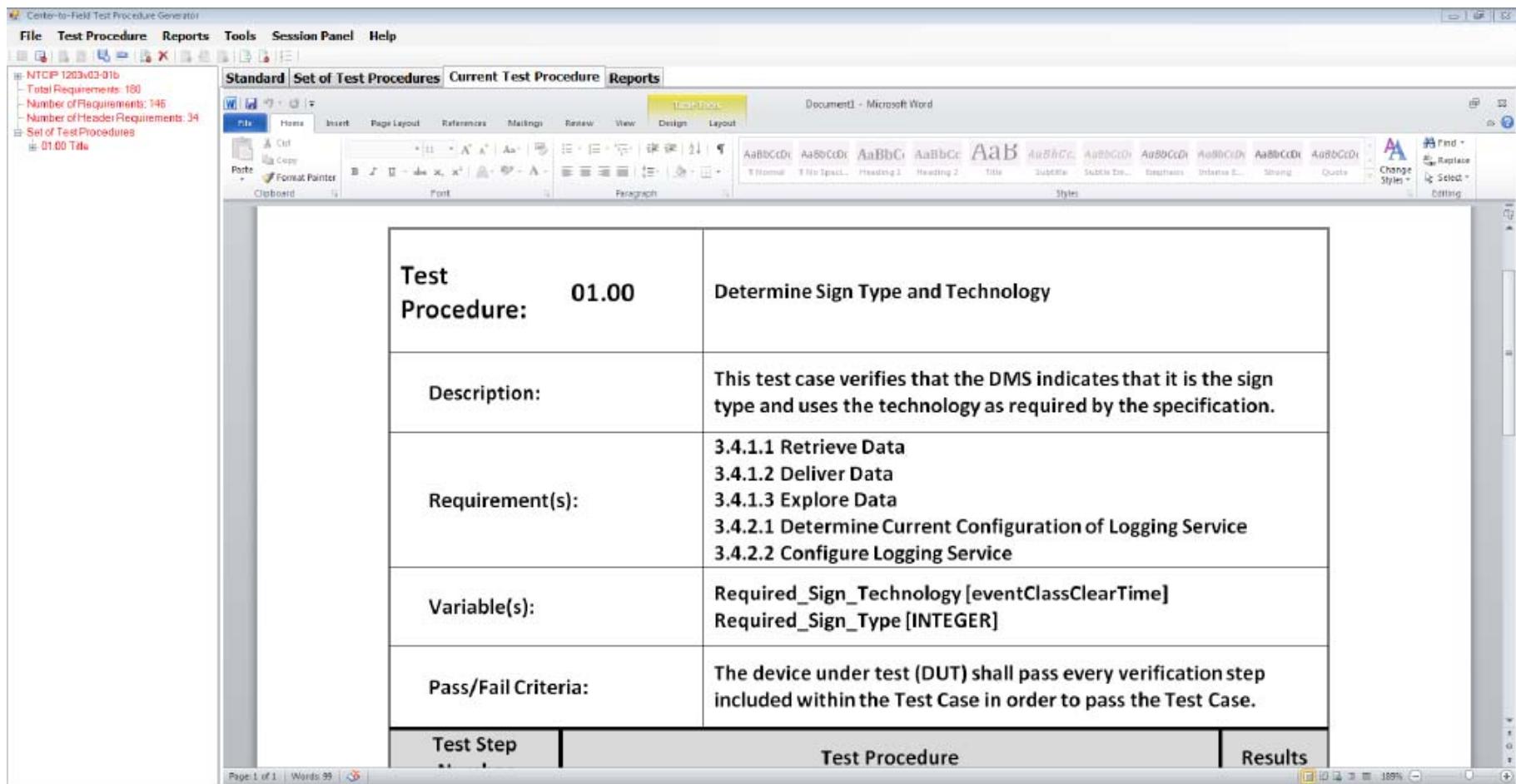


Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015



# Example Test Procedure for a DMS (cont.)

## Define Variables



The screenshot shows a Microsoft Word document titled "Document1 - Microsoft Word" generated by the "Center-to-Field Test Procedure Generator". The menu bar includes File, Test Procedure, Reports, Tools, Session Panel, and Help. The ribbon tabs are Standard, Set of Test Procedures, Current Test Procedure, and Reports, with Reports selected. On the left, a sidebar displays project statistics: NTCIP 1203v03-01b, Total Requirements: 180, Number of Requirements: 146, and Number of Header Requirements: 34, under the heading "Set of Test Procedures". A table is displayed, representing a test procedure. The table has five rows:

<b>Test Procedure:</b>	01.00	Determine Sign Type and Technology
<b>Description:</b>	This test case verifies that the DMS indicates that it is the sign type and uses the technology as required by the specification.	
<b>Requirement(s):</b>	3.4.1.1 Retrieve Data 3.4.1.2 Deliver Data 3.4.1.3 Explore Data 3.4.2.1 Determine Current Configuration of Logging Service 3.4.2.2 Configure Logging Service	
<b>Variable(s):</b>	Required_Sign_Technology [eventClassClearTime] Required_Sign_Type [INTEGER]	
<b>Pass/Fail Criteria:</b>	The device under test (DUT) shall pass every verification step included within the Test Case in order to pass the Test Case.	

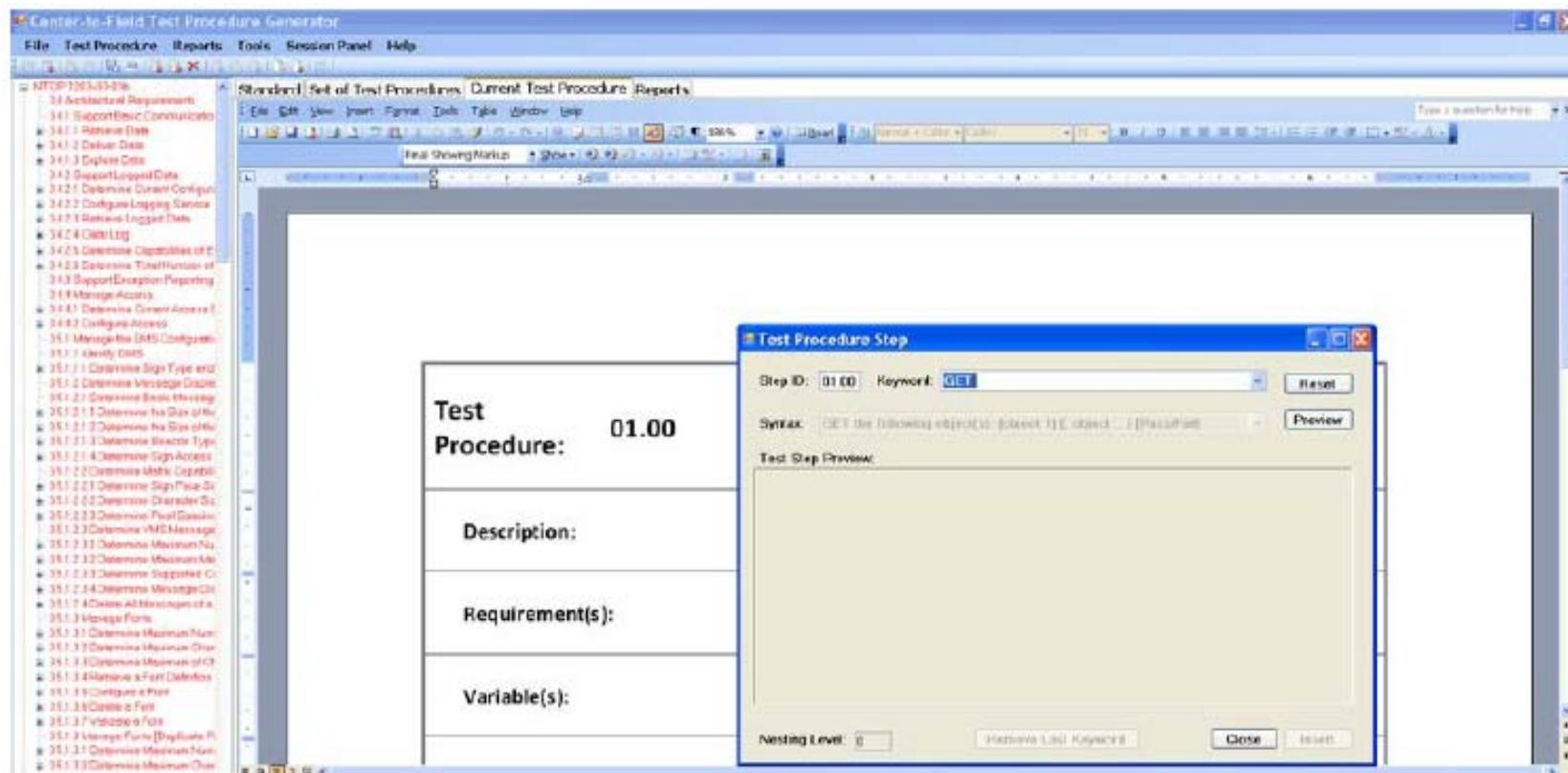
At the bottom of the table, there are three columns: Test Step, Test Procedure, and Results.

Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015



# Example Test Procedure for a DMS (cont.)

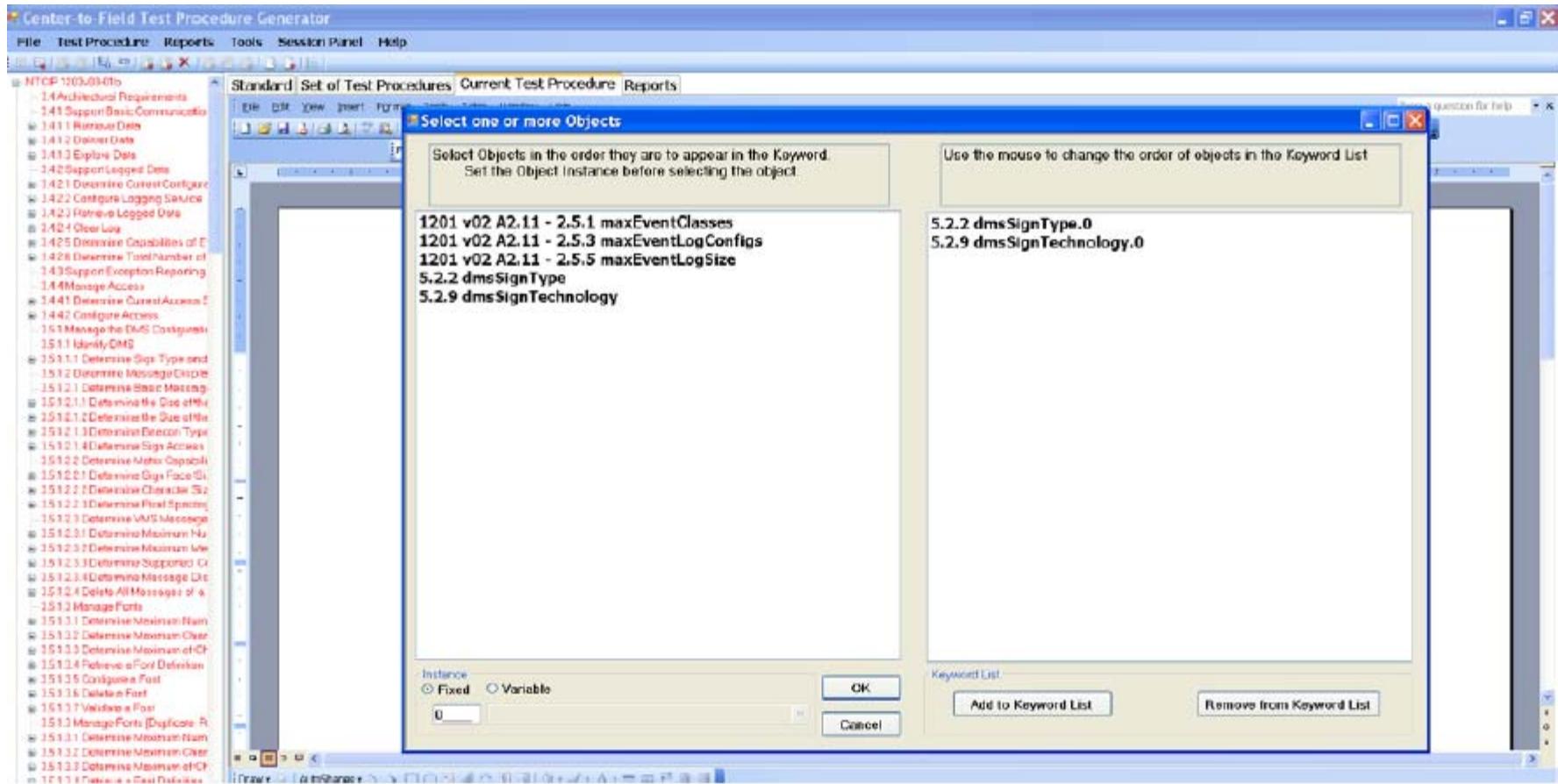
## Define a Test Procedure Step



Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# Example Test Procedure for a DMS (cont.)

## Select the Objects for the Test Step



Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# Example Test Procedure for a DMS (cont.)

## Inserting a Test Procedure Step

The screenshot shows the 'Center-to-Field Test Procedure Generator' application window. The menu bar includes File, Test Procedure, Reports, Tools, Session Panel, and Help. The toolbar has various icons for file operations like Open, Save, Print, and zoom. The main area has tabs: Standard, Set of Test Procedures, Current Test Procedure, and Reports. The 'Current Test Procedure' tab is selected. A tree view on the left shows a hierarchy of requirements under 'NTCIP 1203v03-01b'. The right side displays a table for a test case:

3.4.2.1 Determine Current Configuration of Logging Service		
3.4.2.2 Configure Logging Service		
Variable(s):	Required_Sign_Technology [eventClassClearTime] Required_Sign_Type [INTEGER]	
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.	
Test Step Number	Test Procedure	Results
01.00	GET the following object(s): » 1201 v02 A2.11 - 2.5.1.1 eventClassName.0 » 1201 v02 A2.11 - 2.5.1.2 eventClassLimit.0 » 1201 v02 A2.11 - 2.5.1.4 eventClassDescription.0 » 1201 v02 A2.11 - 2.5.1.3 eventClassClearTime.0 » 1201 v02 A2.11 - 2.5.4.1 eventConfigID.0 » 1201 v02 A2.11 - 2.5.4.2 eventConfigClass.0 » 1201 v02 A2.11 - 2.5.4.3 eventConfigMode.0 » 1201 v02 A2.11 - 2.5.4.4 eventConfigCompareValue.0 » 1201 v02 A2.11 - 2.5.4.5 eventConfigCompareValue2.0 » 1201 v02 A2.11 - 2.5.4.6 eventConfigCompareOID.0 » 1201 v02 A2.11 - 2.5.4.7 eventConfigLogOID.0 » 1201 v02 A2.11 - 2.5.4.8 eventConfigAction.0	Pass/Fail

Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015



# Example Test Procedure for a DMS (cont.)

## Saving the Test Procedure

The screenshot shows the 'Center-to-Field Test Procedure Generator' application window. The 'File' menu is open, with 'Save Test Procedure' highlighted. A tooltip for 'Save Test Procedure' states: 'This command will allow the user to save the current Test Procedure in the Set of Test Procedures file.' The main workspace contains a table for a test procedure:

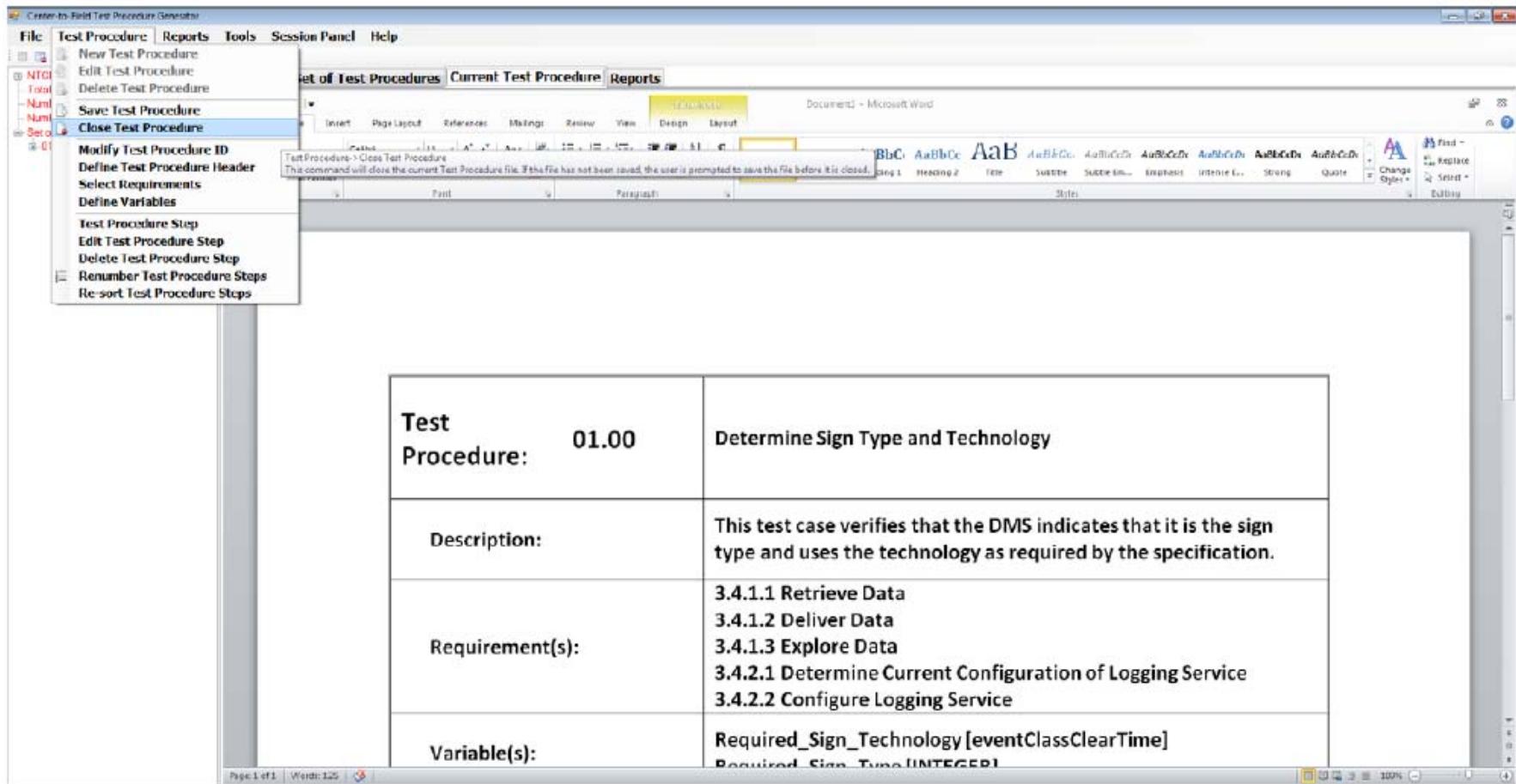
TEST Procedure:		Determine Sign Type and Technology
Description:	This test case verifies that the DMS indicates that it is the sign type and uses the technology as required by the specification.	
Requirement(s):	3.4.1.1 Retrieve Data 3.4.1.2 Deliver Data 3.4.1.3 Explore Data 3.4.2.1 Determine Current Configuration of Logging Service 3.4.2.2 Configure Logging Service	
Variable(s):	Required_Sign_Technology[eventClassClearTime] Required_Sign_Type [INTEGER]	
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.	
Test Step Number	Test Procedure	Results
01.00	ASSIGN 1201 v02 A2.11 - 2.5.1.1 eventClassNumber.0 EQUALS 1201 v02 A2.11 - 2.5.1.2 eventClassLimit.0	N/A

The status bar at the bottom left shows 'Page 1 of 1' and 'Word 129'. The status bar at the bottom right shows 'NTCIP Standard Not Verified' and 'Set of Test Procedures Not Verified'. The TPG Status is 'Command Completed'.

Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# Example Test Procedure for a DMS (cont.)

## Closing the Test Procedure



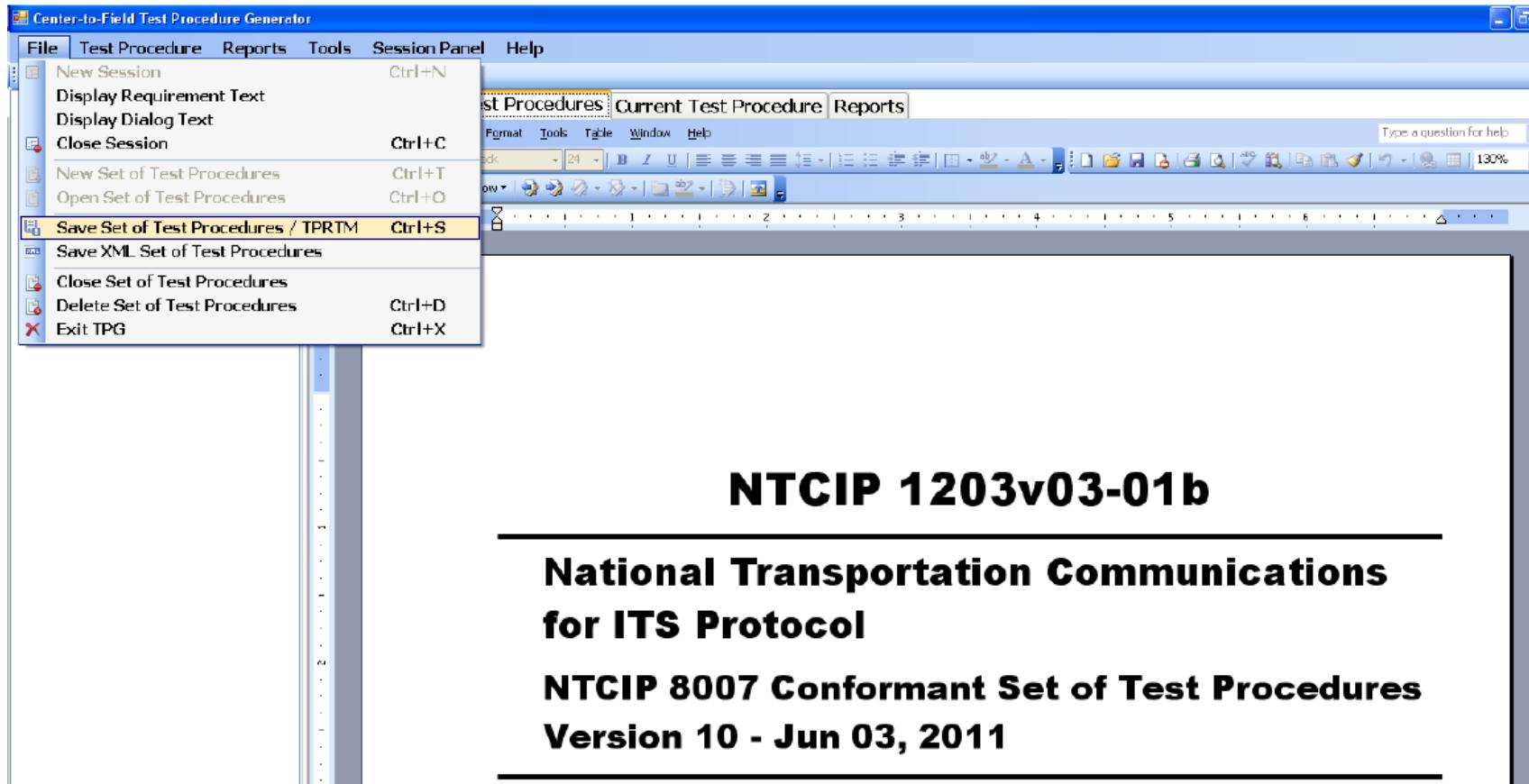
The screenshot shows the software interface for the Center-to-Field Test Procedure Generator. The menu bar at the top includes File, Test Procedure, Reports, Tools, Session Panel, and Help. The 'Test Procedure' menu is open, showing options like New Test Procedure, Edit Test Procedure, Delete Test Procedure, Save Test Procedure, Close Test Procedure (which is highlighted in blue), Modify Test Procedure ID, Define Test Procedure Header, Select Requirements, Define Variables, Test Procedure Step, Edit Test Procedure Step, Delete Test Procedure Step, Renumber Test Procedure Steps, and Re-sort Test Procedure Steps. Below the menu is a Microsoft Word document window titled 'Document1 - Microsoft Word'. The ribbon tabs at the top of the Word window are Set of Test Procedures, Current Test Procedure, and Reports. The 'Current Test Procedure' tab is selected. The main content area of the Word window displays a table with the following data:

<b>Test Procedure:</b>	01.00	Determine Sign Type and Technology
<b>Description:</b>	This test case verifies that the DMS indicates that it is the sign type and uses the technology as required by the specification.	
<b>Requirement(s):</b>	3.4.1.1 Retrieve Data 3.4.1.2 Deliver Data 3.4.1.3 Explore Data 3.4.2.1 Determine Current Configuration of Logging Service 3.4.2.2 Configure Logging Service	
<b>Variable(s):</b>	Required_Sign_Technology [eventClassClearTime] Required_Sign_Type [INTEGER]	

Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

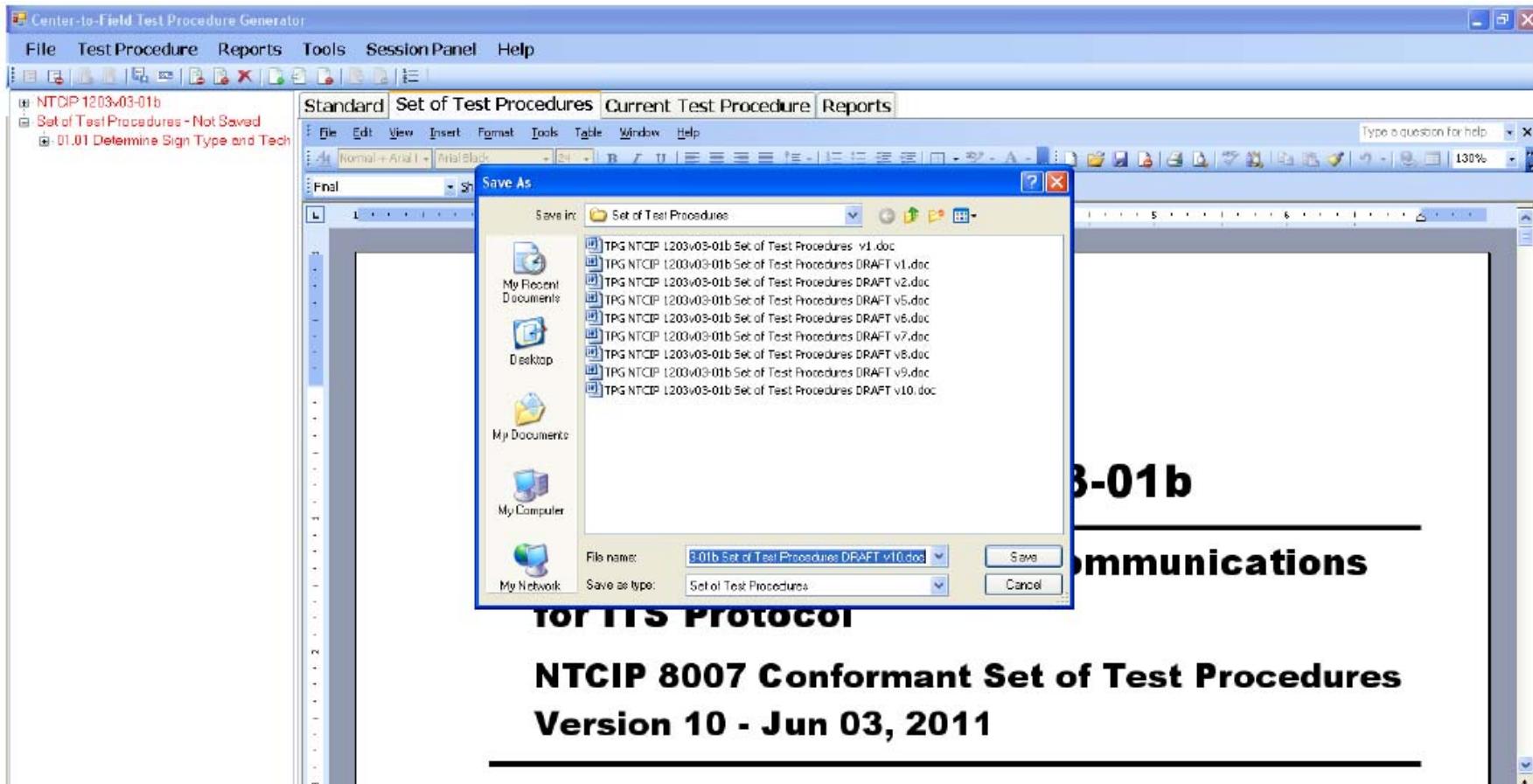
# Example Test Procedure for a DMS (cont.)

## Saving the Sets of Test Procedure



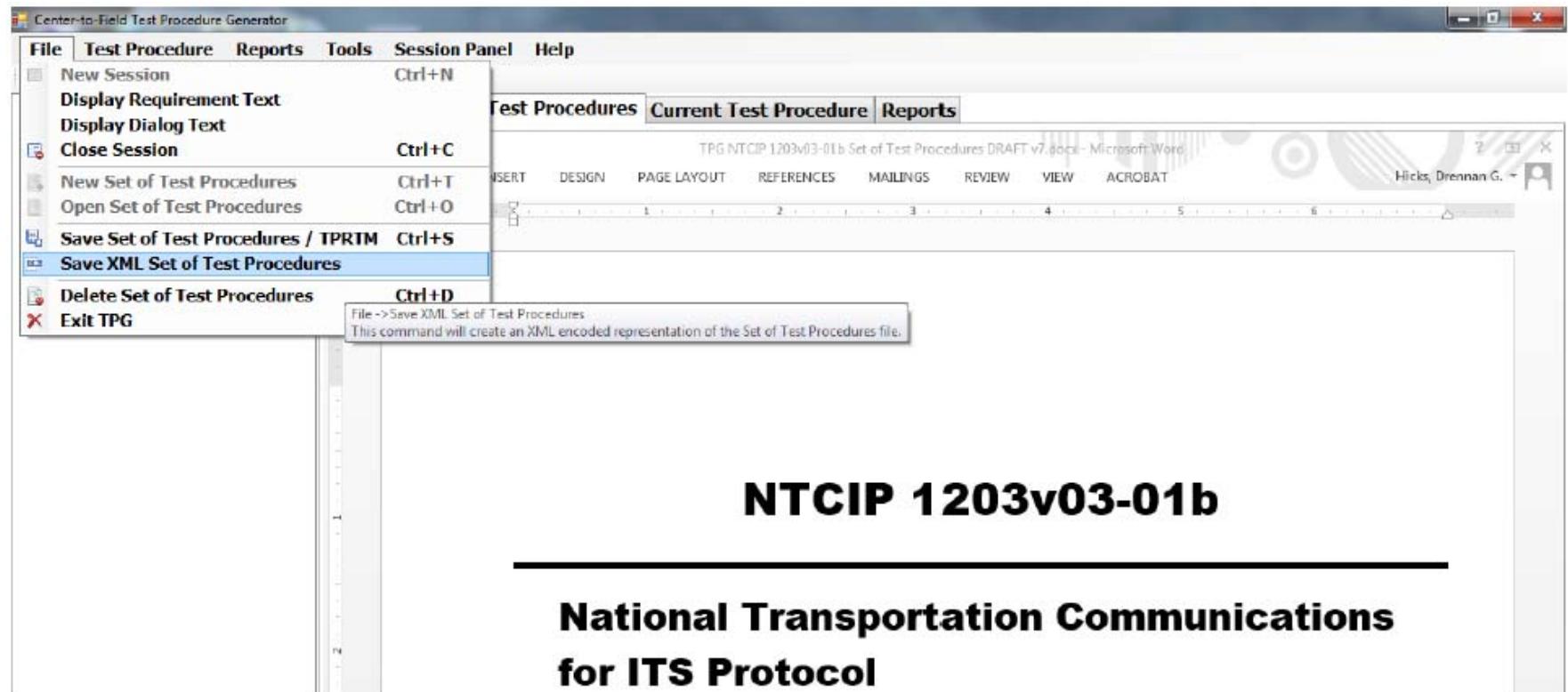
# Example Test Procedure for a DMS (cont.)

## Saving the Sets of Test Procedure



# Example Test Procedure for a DMS (cont.)

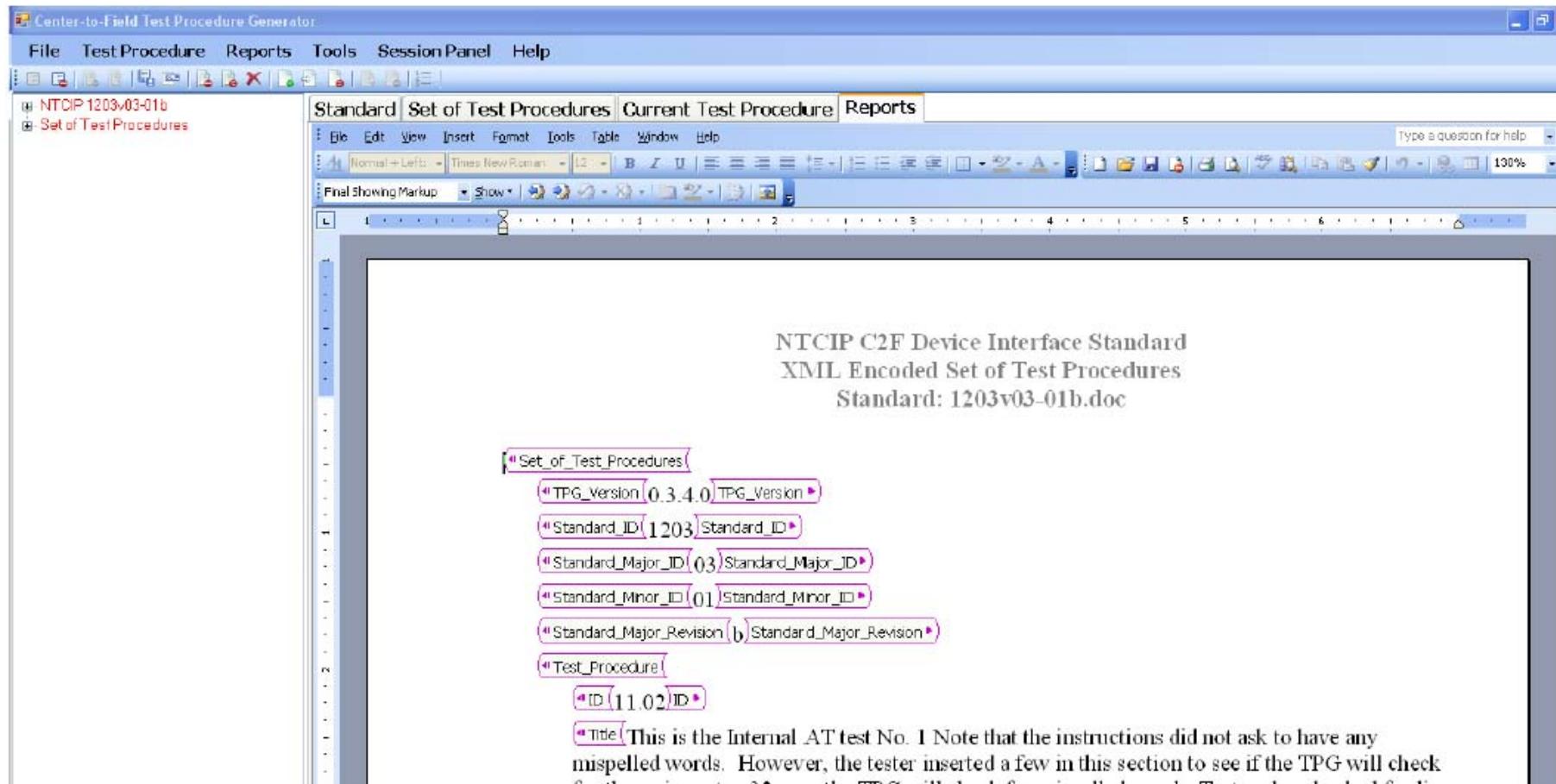
## Saving XML Test Procedure



Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# Example Test Procedure for a DMS (cont.)

## Displaying XML Test Procedure



Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

# A C T I V I T Y



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

## **Which is the order of the TPG example workflow?**

### **Answer Choices**

- a) XML Requirement Step Object Variable
- b) Object Variable Requirement Step XML
- c) Requirement Variable Step Object XML
- d) Object Requirement Variable Step XML

## Review of Answers



- a) XML Requirement Step Object Variable

*Incorrect. XML is an output created at end of workflow.*



- b) Object variable Requirement Step XML

*Incorrect. Objects are not known until Requirements are known.*



- c) Requirement Variable Step Object XML

**Correct! Requirements are populated with Variables that are tested in Steps of Objects that create XML output.**



- d) Object Requirement Variable Step XML

*Incorrect. Objects are not known until Requirements are known and Test Steps must be known before Objects are selected.*

## Summary of Learning Objective #6

### Use the TPG to Generate Test Procedures for a Variety of Equipment

- TPG follows NTCIP 8002 for uniform numbering system and content
- Role of TPG includes proper use of key words, test procedure in IEEE 829 format, and XML outputs for use by test equipment
- We stepped through a successful TPG installation
- We used the TPG to develop an example test procedure for an NTCIP 1203 v03 dynamic message sign



# **Learning Objective #7: Adapt the Generated Test Procedures to Procurement Contract Terms and Conditions for Successful Project Conclusion**

- Discuss lessons learned from unsuccessful ITS projects and explain how to avoid repetition
- BEGIN by planning a test procedure to be used successfully at the END of the procurement
- Demonstrate how to include clear, unambiguous contract terms and conditions
- Demonstrate how to work backwards FROM the project's successful end TO the beginning of the procurement process



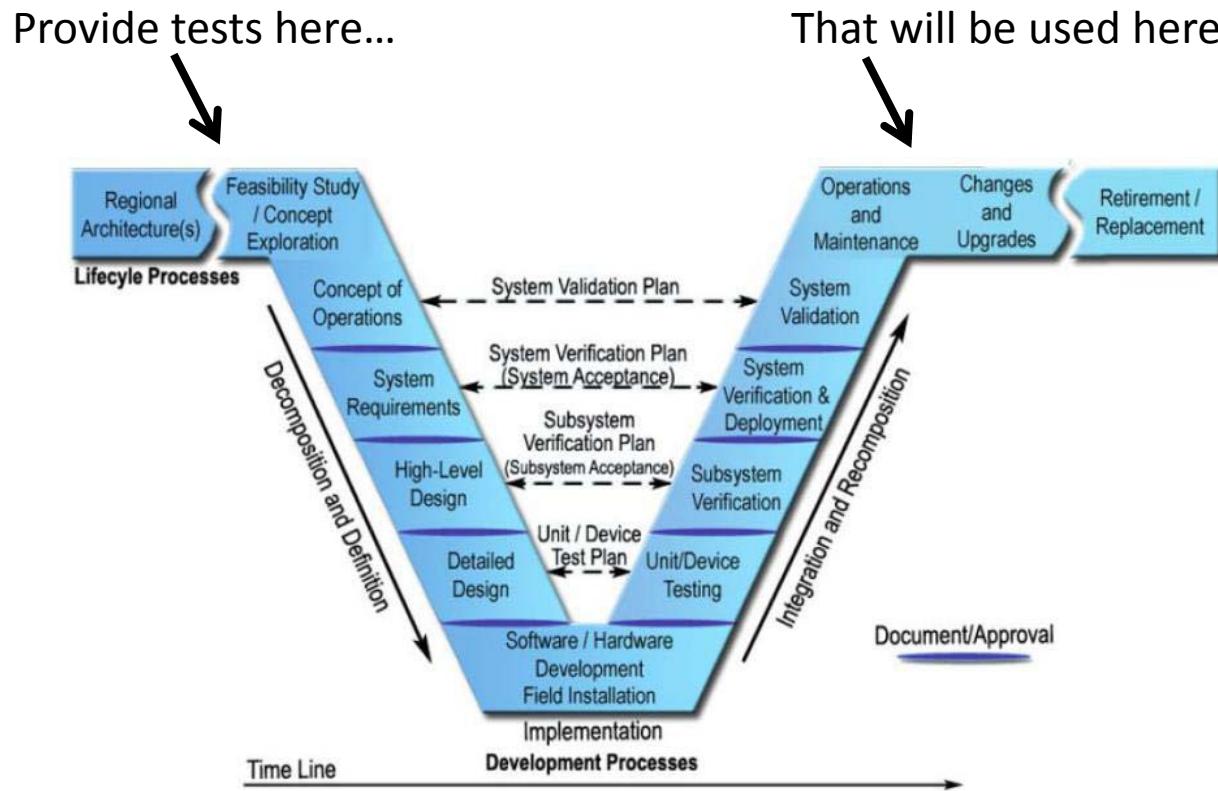
# Plan the Test Procedure from the Beginning

## BEGIN by Planning As If You Were at the END

- DO NOT approach an ITS project as a normal construction project
- DO approach the beginning of an ITS project as if ending an IT project
  - Cost to correct at the end is 100X more expensive than the cost to correct at the point where the defect is created
  - Begin at the end
- In the beginning, the contract should provide the ending:
  - Test case inputs
  - Test procedures, the TPG variables
  - Expected TPG outputs
- Manufacturers can use the TPG for testing throughout the project
- Eliminates the unexpected results that are expensive to fix later

# Plan the Test Procedure from the Beginning

Plan the Level Tests As If the Project Is Ending



Source: Systems Engineering for Intelligent Transportation Systems, USDOT, January 2007

# Lessons Learned from Unsuccessful ITS Projects

## From T204 Part 1, Learning Objective #3

- The odds are slim that ITS projects will be successful:
  - On time
  - Within budget
  - Include all of the agreed features
- Roads projects are designed by consultants and built by contractors
  - Does not work well for ITS projects
  - ITS has large IT content



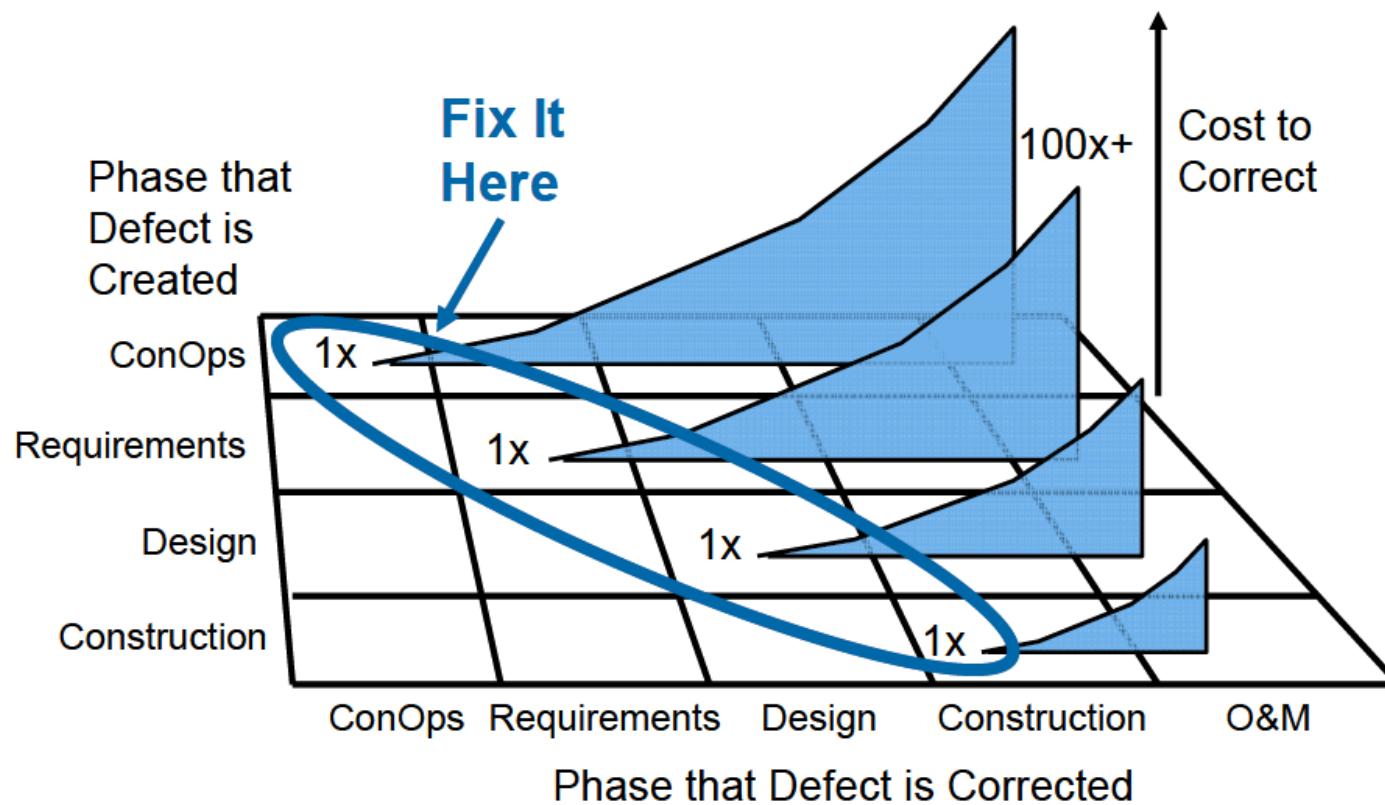
# How to Avoid Repetition of Failure

## Find and Correct Defects Early in the Project

- Projects should require level testing at:
  - Unit / device level
  - Subsystem level
  - System integration level
  - System validation level
  - Deployment and operation level (commissioning)
- Each step of the system design has a test for that level
  - Test procedure
  - Expected outcomes

## How to Avoid Repetition of Failure (cont.)

### Find and Correct Defects Early in the Project



Source: Systems Engineering for Intelligent Transportation Systems, USDOT, January 2007

# Use Clear and Unambiguous Contract Terms

## Contract Provisions Should Provide:

- Varieties of equipment needed
- Standards for each variety
- Conformance Group (CG) within each standard
- Test cases for each CG
- The expected test outputs



# Use Clear and Unambiguous Contract Terms (cont.)

## Contract Requirements

- Contracts should require:
  - The use of TPG
  - Use of IEEE 829 format for records
  - Present Test Outputs in XML format
  - Use of standardized objects
  - Use Block object formats and dialogs
  - Use ONLY XML format for Manufacturer Specific Object (MSO) and dialogs for special needs

# Use Clear and Unambiguous Contract Terms (cont.)

## Contract Prohibitions

- Contracts should prohibit:
  - MSOs in place of standardized conformance groups
  - MSOs that are not documented for interoperability



# A C T I V I T Y



## **ITS project cost and schedule should be developed in which of the following orders?**

### **Answer Choices**

- a) From the test procedures back through the project workflow
- b) From the requirements only
- c) To enforce the contract terms at the end of the project
- d) To minimize the planning costs up front

## Review of Answers



- a) From the test procedures back through the project workflow

***Correct! Providing the test procedures in the contract terms allows the manufacturers to use the TPG throughout the design phase to eliminate defects early.***



- b) From requirements only

*Incorrect. Providing only the requirements allows multiple interpretations that will be costly to correct at installation.*



- c) To enforce contract terms at the end of the project

*Incorrect. Contract terms should enforce continuous verification throughout the project, not enforcement at the end.*



- d) To minimize planning costs up front

*Incorrect. Additional up-front planning reduces overall costs.*

## **Summary of Learning Objective #7**

### **Adapt the Generated Test Procedures to Procurement Contract Terms and Conditions for Successful Project Conclusion**

- Lesson learned from successful ITS projects: Testing insures success
- Plan the test procedure used at project end in the beginning
- Clear, unambiguous contract terms include test procedures with expected results and ban the use of poor design practices
- A good procurement process documents the successful project end, then works backwards through the procurement process to the contract terms



## Learning Objective #8: Develop Complex Test Procedures That Pull Together NTCIP Elements Using the TPG

- Analyze pre-existing central station from Vendor A
- Plan upcoming procurement contract to add variety of equipment
- Specify, create, and test MSOs for special needs
- Use of TPG as acceptance test throughout the project
- Explain how terms and conditions are based on the test procedure
- Use TPG outputs as pass/fail criteria for project end and example of reports for project end



## Analyze Pre-Existing Central Station from Vendor A

### Requirements Currently Supported

- Identify requirements currently supported
- Identify new requirements (if any)
- Those objects associated with the selected requirements will automatically show up as part of the TPG operations
- Requirements “left over” from TPG operations might require a manufacturer-specific design to realize the requirements
- Determine existing communications media and performance

## **Plan Upcoming Procurement Contract to Add Variety of Equipment**

### **Add Equipment and Identify the Gap:**

- Dynamic message signs
- Additional actuated signal controllers
- Adaptive control equipment
- Identify the gap of additional functionality to meet requirements

# Specify, Create, and Test MSOs for Special Needs

## Special Needs Might Include:

- Control of normal traffic flow based on known vehicle counts
- Control of abnormal traffic flow from nearby events center
- Automatic adaptation of signal timing to abnormal traffic flow
- Update of signal timing every three seconds
- Elimination of the need for manual control of traffic by police



## **Use of TPG As Acceptance Test Throughout the Project**

### **Use the TPG to Guide Each Level Test**

- Create test procedure header
- Select requirement to fulfill user needs
- Define the variables
- Define the steps of the test procedure
- Select objects
- Create XML outputs



# Explain How Terms and Conditions Are Based on the Test Procedure

## Include Test Procedure and Expected Results

- Include the test procedure for each level of the system in the contract
- Include the expected outputs from the TPG in the contract terms
- Remaining requirement, such as Adaptive, become MSOs
- Include MSO documentation in contract for interoperability
- Require test reports at each level before proceeding to the next level



## Use TPG Outputs As Pass/Fail Criteria for Project End and Example of Reports for Project End

### Compare TPG XML Outputs to Expected XML Outputs

- The expected outputs of each level test are known in the beginning
- The TPG produces script files (in an XML format) for use by test equipment.
- Differences between the expected TPG outputs and the level test procedure outputs are not “failures” but rather anomalies
- Each anomaly report is addressed and disposed by the stakeholders



## **NTCIP 8007**

### **Relationship between NTCIP 8007 and IEEE 829**

- NTCIP 8007 sets the format for all testing documentation including Test Procedures
- TPG uses the 8007 format that was modified to meet the requirements of 829



## **Standards Supported by TPG**

### **TPG Supports NTCIP 12XX Standards with SE Content**

- NTCIP 1203 v03 Dynamic Message Signs
- NTCIP 1204 v03 Environmental Sensor Station Interface
- NTCIP 1209 v02 Data Element Definitions, Transportation Sensors
- NTCIP 1210 v01 Field Management Station, Part 1
- NTCIP 1211 v02 Objects for Signal Control and Prioritization
- NTCIP 1213 v02.20 Object Definition, Electrical Management Systems

## TPG Distribution

**Copies of the TPG can be obtained:**

- Kingsley Azubike, USDOT, Kingsley.Azubike@dot.gov
- <https://www.standards.its.dot.gov/DeploymentResources/Tools>



# What We Have Learned

- 1) NTCIP 8002 will define uniform numbering and content for NTCIP 12XX series center-to-field standards.
- 2) Using TPG to enter inputs insures the proper use of key words and creates test procedures in IEEE 829 steps.
- 3) TPG outputs in XML format provides test documentation and can be used as inputs to automated test equipment.
- 4) Begin by planning test procedures to be used at the end.
- 5) Contracts should provide test procedures and expected outputs in order to verify requirements throughout the entire project.
- 6) Contract should require objects and dialogs for special needs.
- 7) Contracts ban poor practice of undocumented MSOs for interoperability.



# Resources

- T204 Part 1 of 2: How to Develop Test Procedures for an ITS Standards-Based Test Plan, Part 1 of 2
- Student Supplement: T204 Part 2 of 2: How to Develop Test Procedures for an ITS Standards-Based Test Plan, Part 2 of 2
- IEEE 829: IEEE Standard for Software and System Test Documentation  
<http://standards.ieee.org/findstds/standard/829-2008.html>
- NTCIP 1204 v03 DMS, [www.ntcip.org](http://www.ntcip.org)
- PCB Website: Module T201, T202 Available  
[http://wwwpcb.its.dot.gov/stds\\_training.aspx](http://wwwpcb.its.dot.gov/stds_training.aspx)
- Systems Engineering for Intelligent Transportation Systems, USDOT, January 2007  
<http://ops.fhwa.dot.gov/publications/seitsguide/seguide.pdf>
- Center to Field Test Procedure Generator User Manual, v2.0, Federal Highway Administration, July 15, 2015
- TPG User Manual: Contact Kingsley Azubike, FHWA at  
<https://www.standards.its.dot.gov/DeploymentResources/tools>



# QUESTIONS?

