STANDARDS ITS TRAINING

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U.S. Department of Transportation

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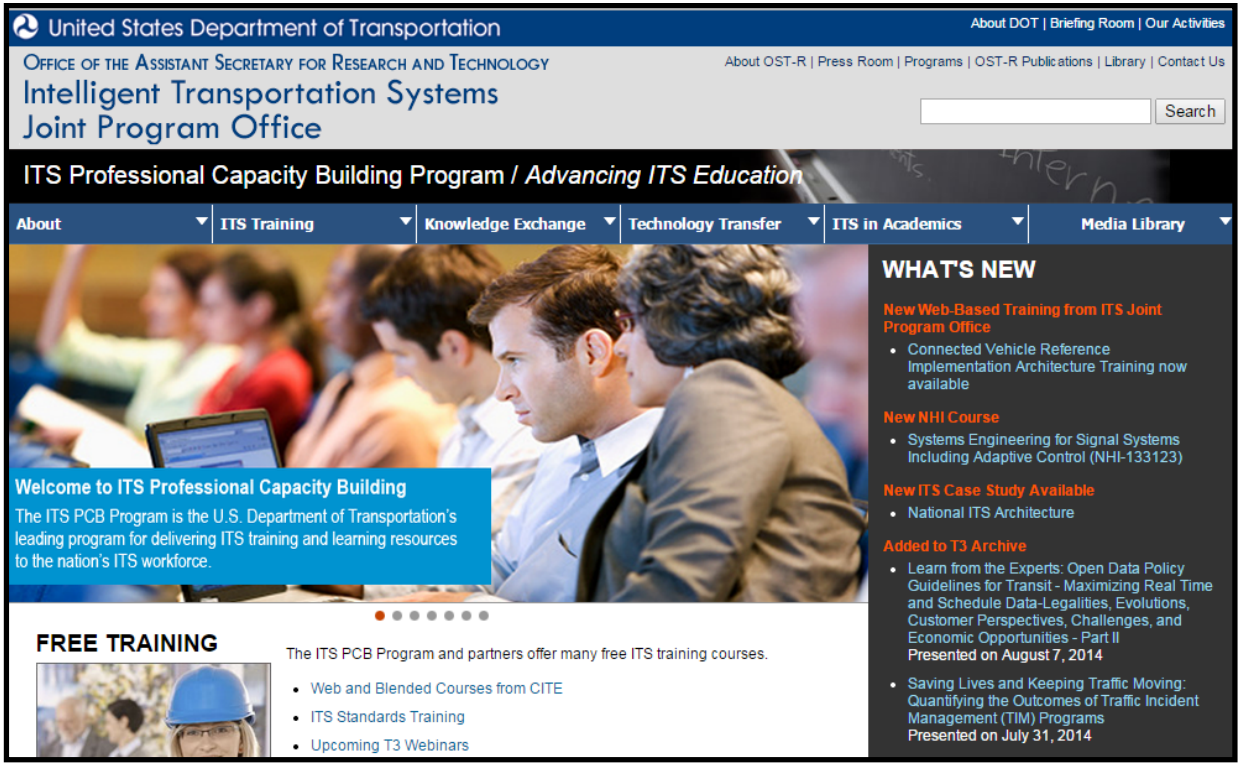

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ACTIVITY

STANDARDS ITS TRAINING

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

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

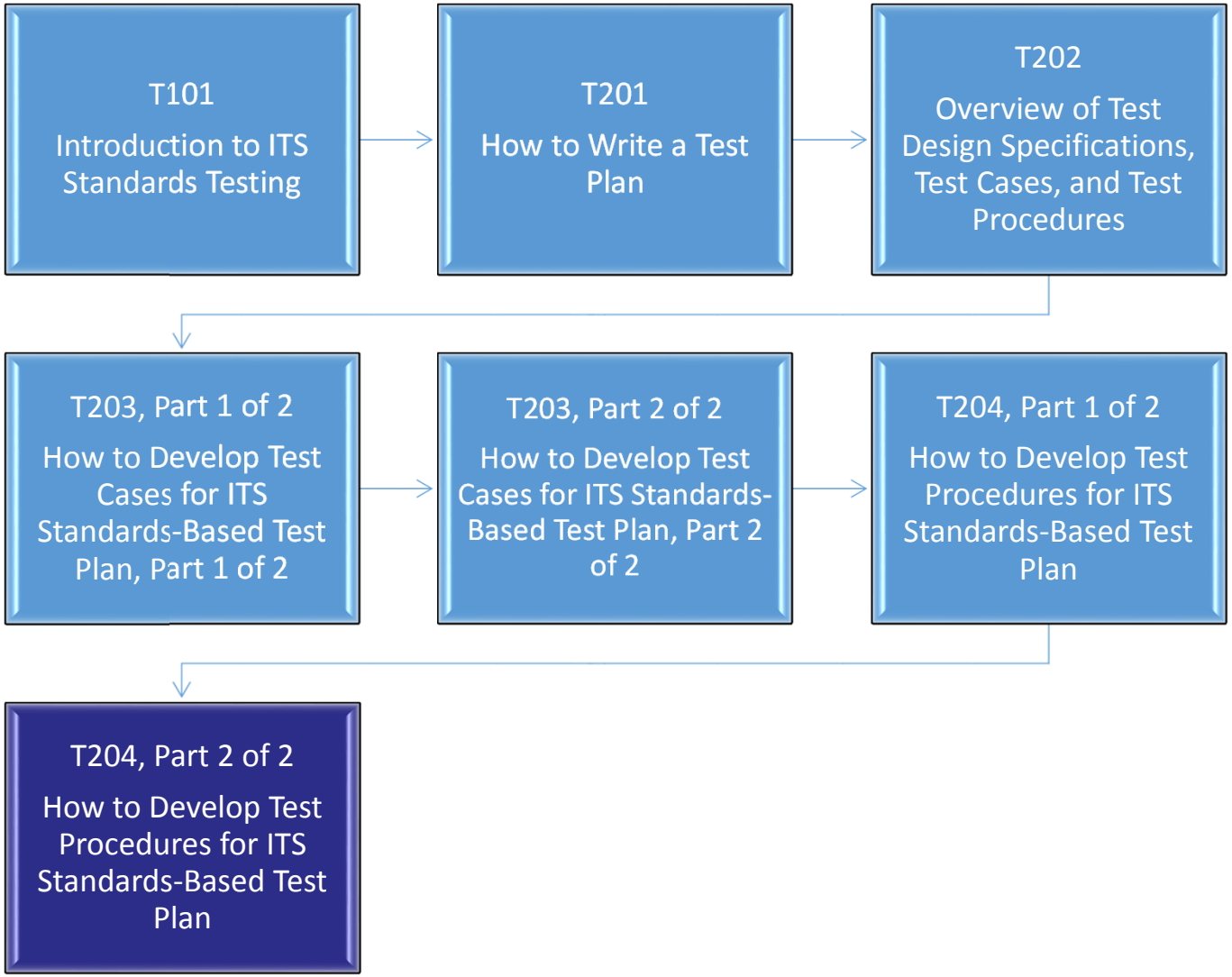
Target Audience

- 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

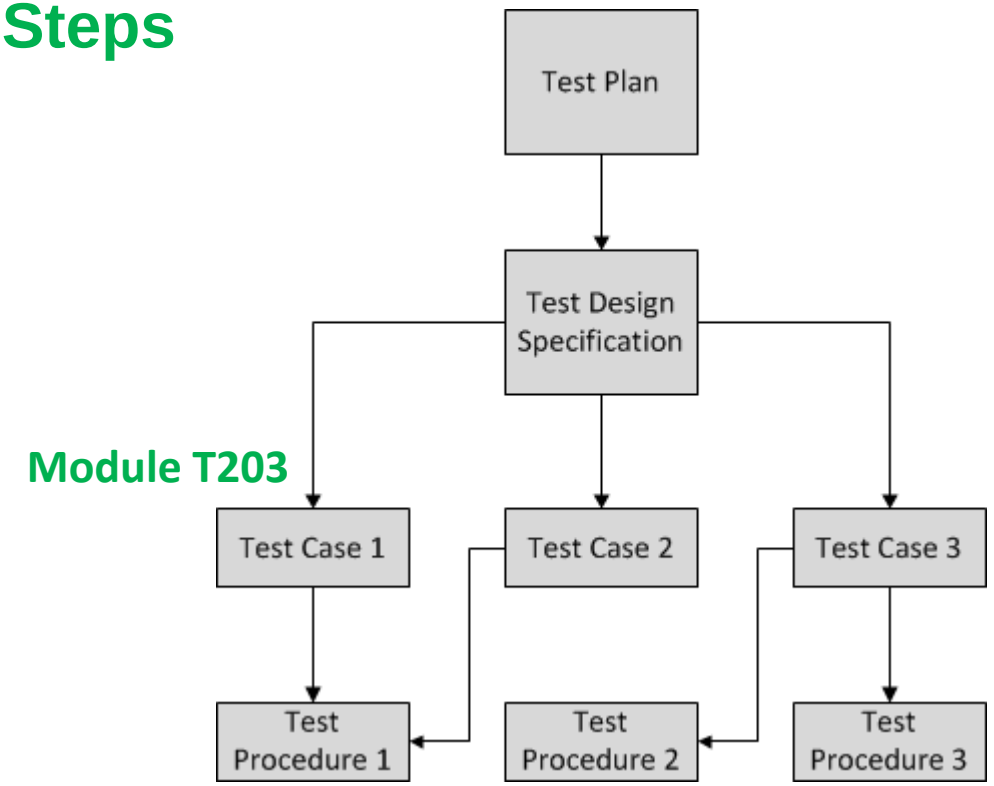
What We Have Learned in Part 1

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

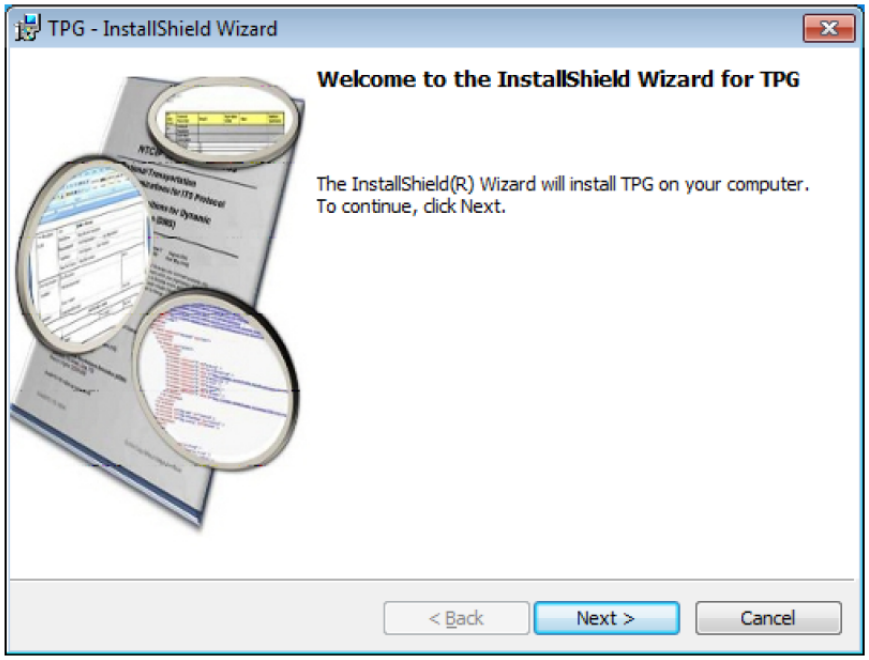
Name	Mnemonic	Specification Number	Version Number	Source
Microsoft Windows 7 Operation System	Windows 7 SP 1	Service Pack 1	2009	Microsoft Corp
Microsoft Word 2010, Professional Edition	Word 2010	14.0.7128.5000 or greater **32-bit**	Microsoft Word 2010, Professional Edition	Microsoft Corp

TPG Successful Installation

TPG Shortcut, NTCIP Standards, and Test Procedure Directories

ITS STANDARDS TPG TEST PROCEDURE GENERATOR

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

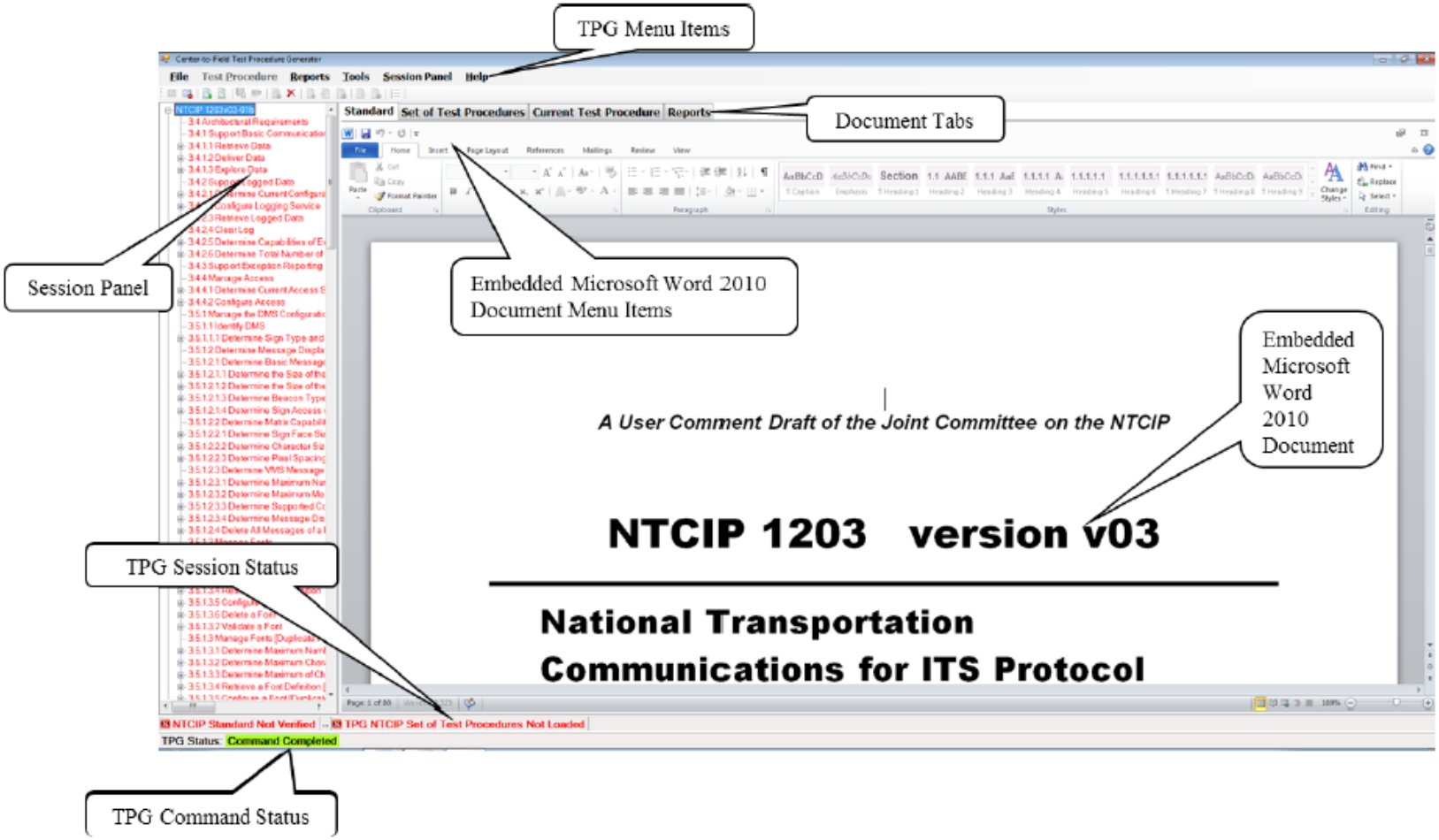


- C:\NTCIP Standards
  - Default Directory where TPG looks for the NTCIP Standards
- C:\Set of Test Procedures
  - Default directory where TPG loads and stores test procedures

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

TPG Successful Installation (cont.)

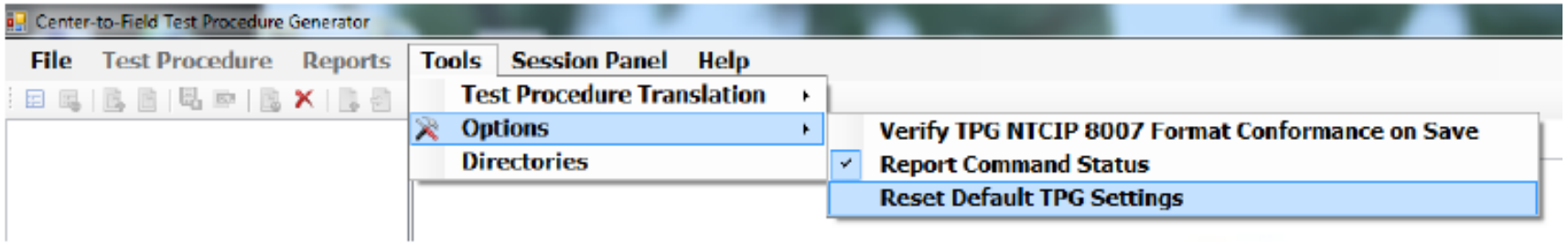
TPG Graphical User Interface (GUI)



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

Example Test Procedure

Reset the TPG Environment

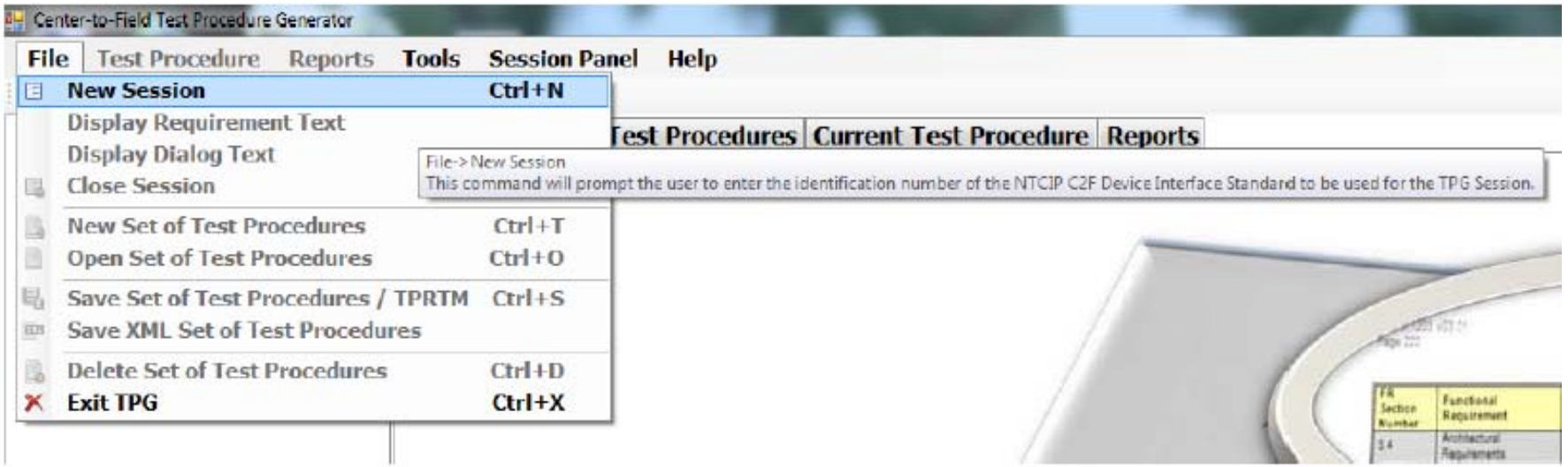


- "Tools → Options → Reset Default TPG Settings" resets:
  - Standard number used
  - Major Version
  - Minor Version
  - Revision Letter
  - NTCIP Standard Default File Path
  - Set of Test Procedures Default File Path

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

Example Test Procedure (cont.)

Begin a New TPG Session

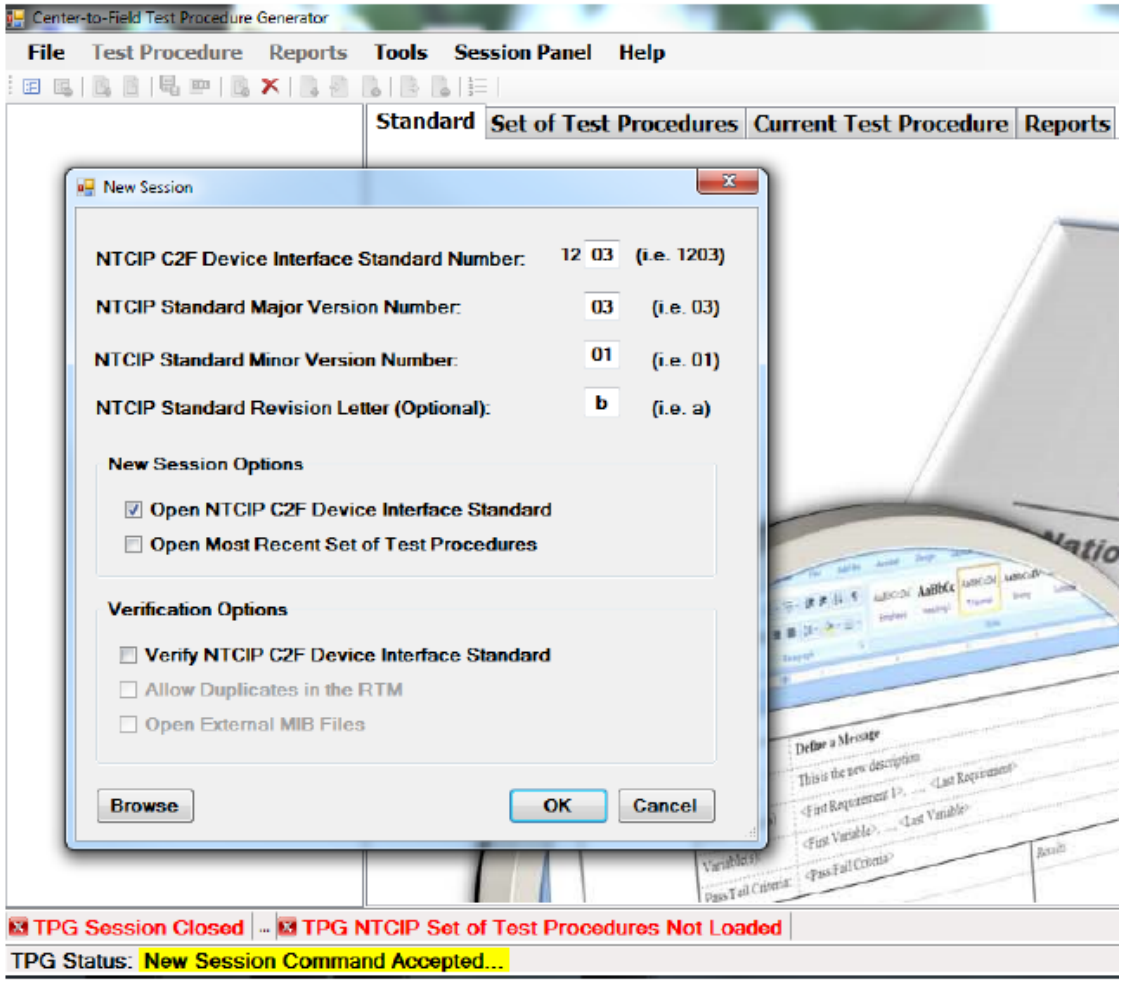


- "File → New Session":
  - Define and Open the NTCIP C2F Standard to be used

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

Example Test Procedure (cont.)

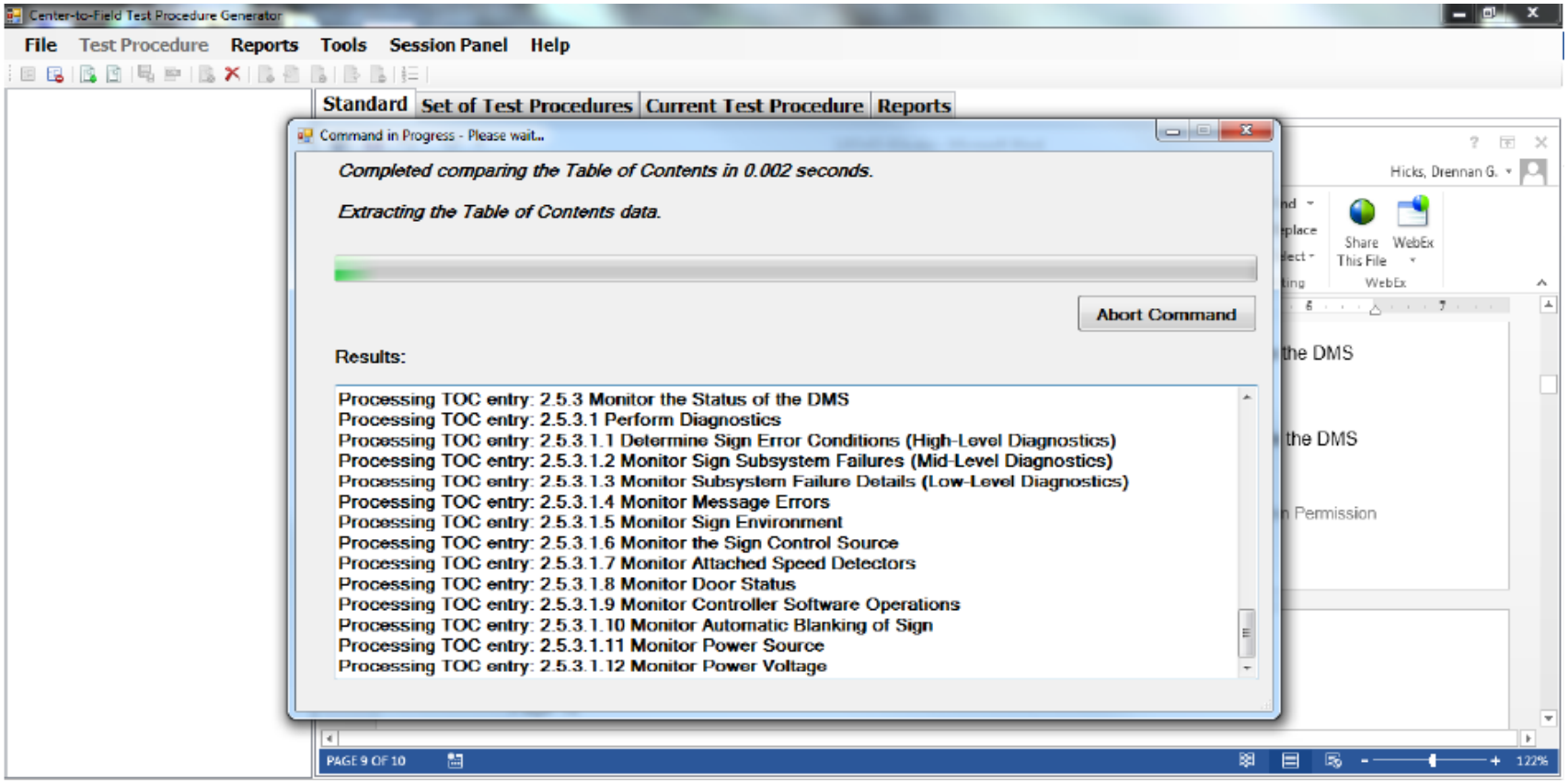
Select the C2F Standard



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

Example Test Procedure (cont.)

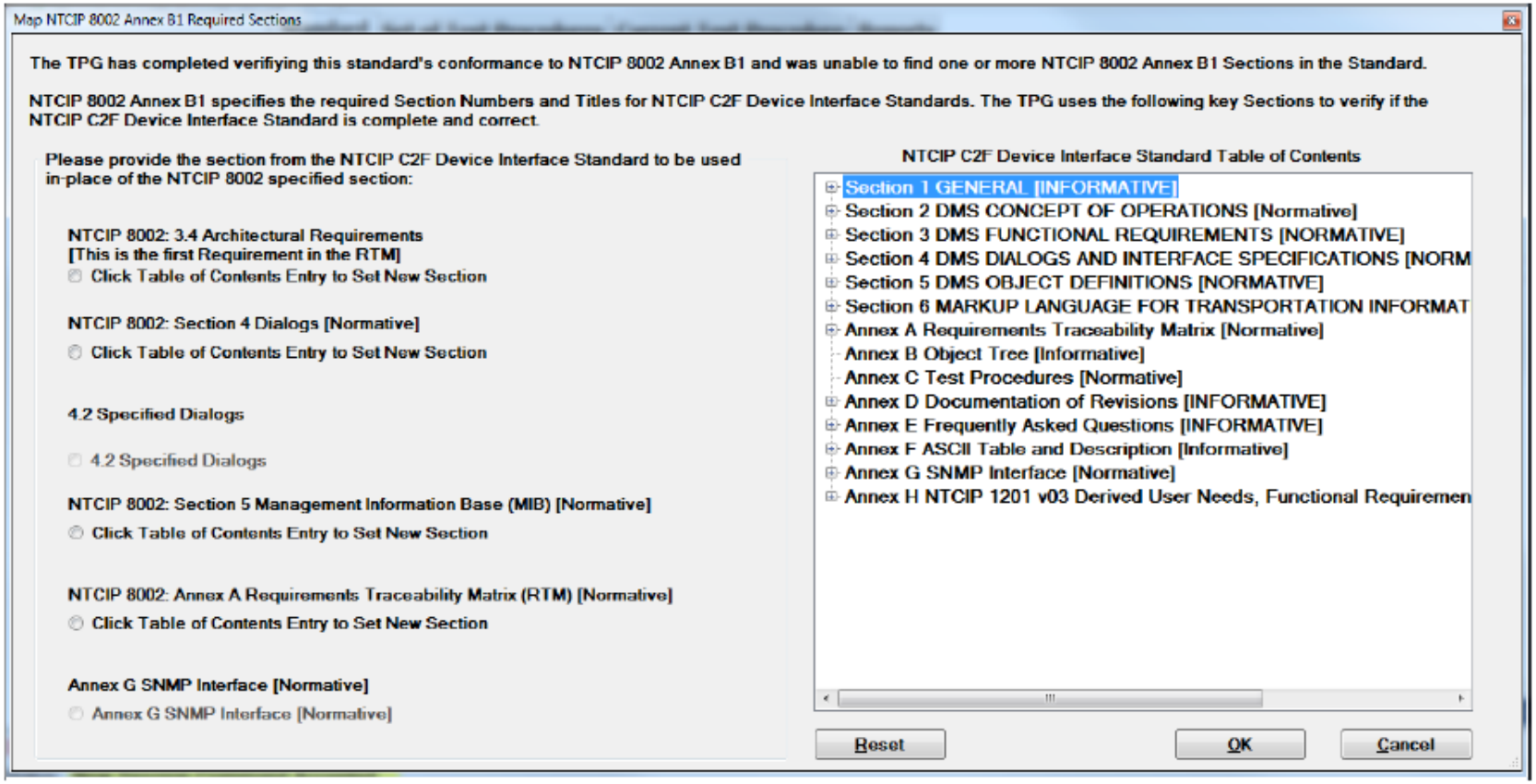
Processing the Entries



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

Example Test Procedure (cont.)

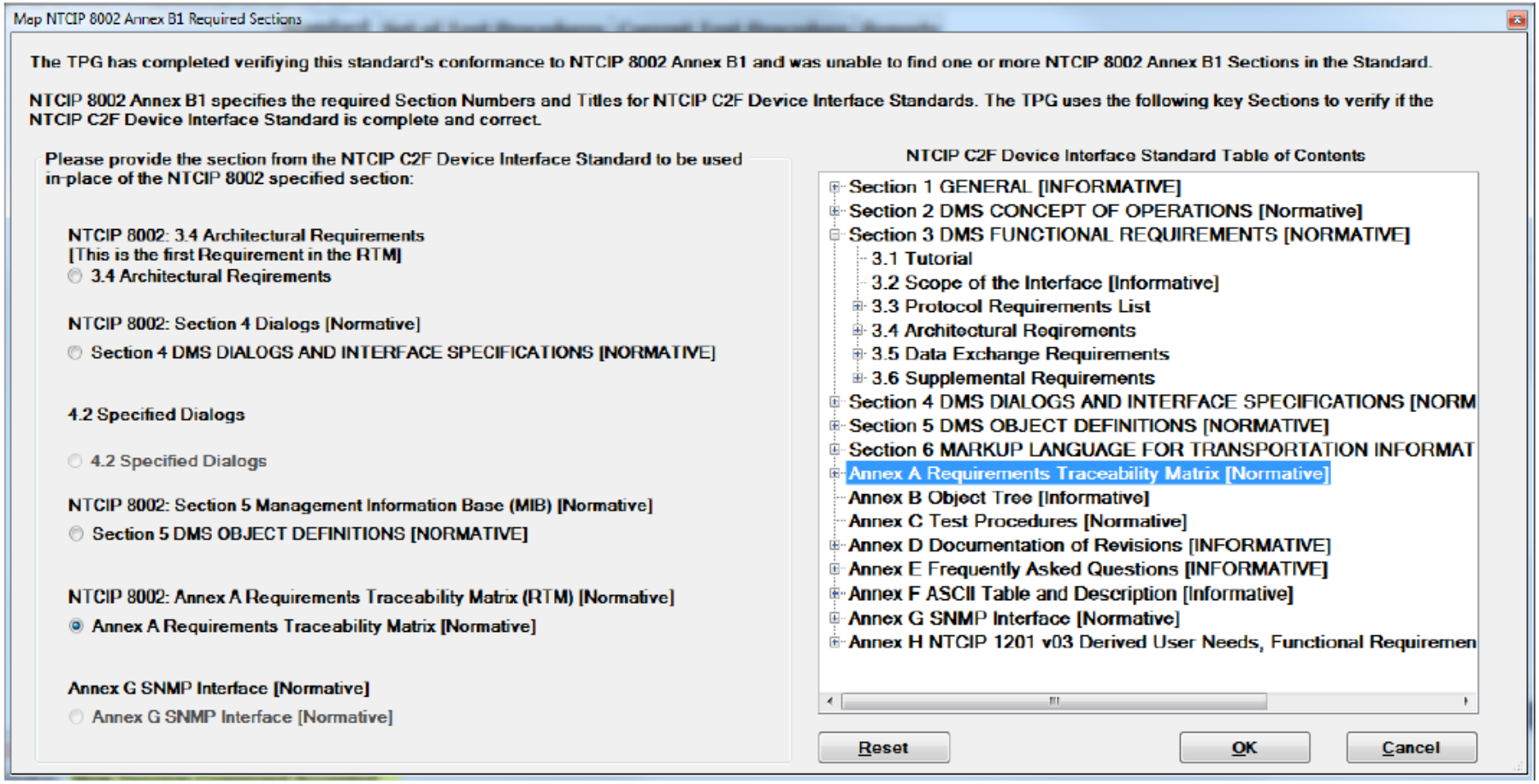
Map NTCIP 8002 Annex B1 Required Sections



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

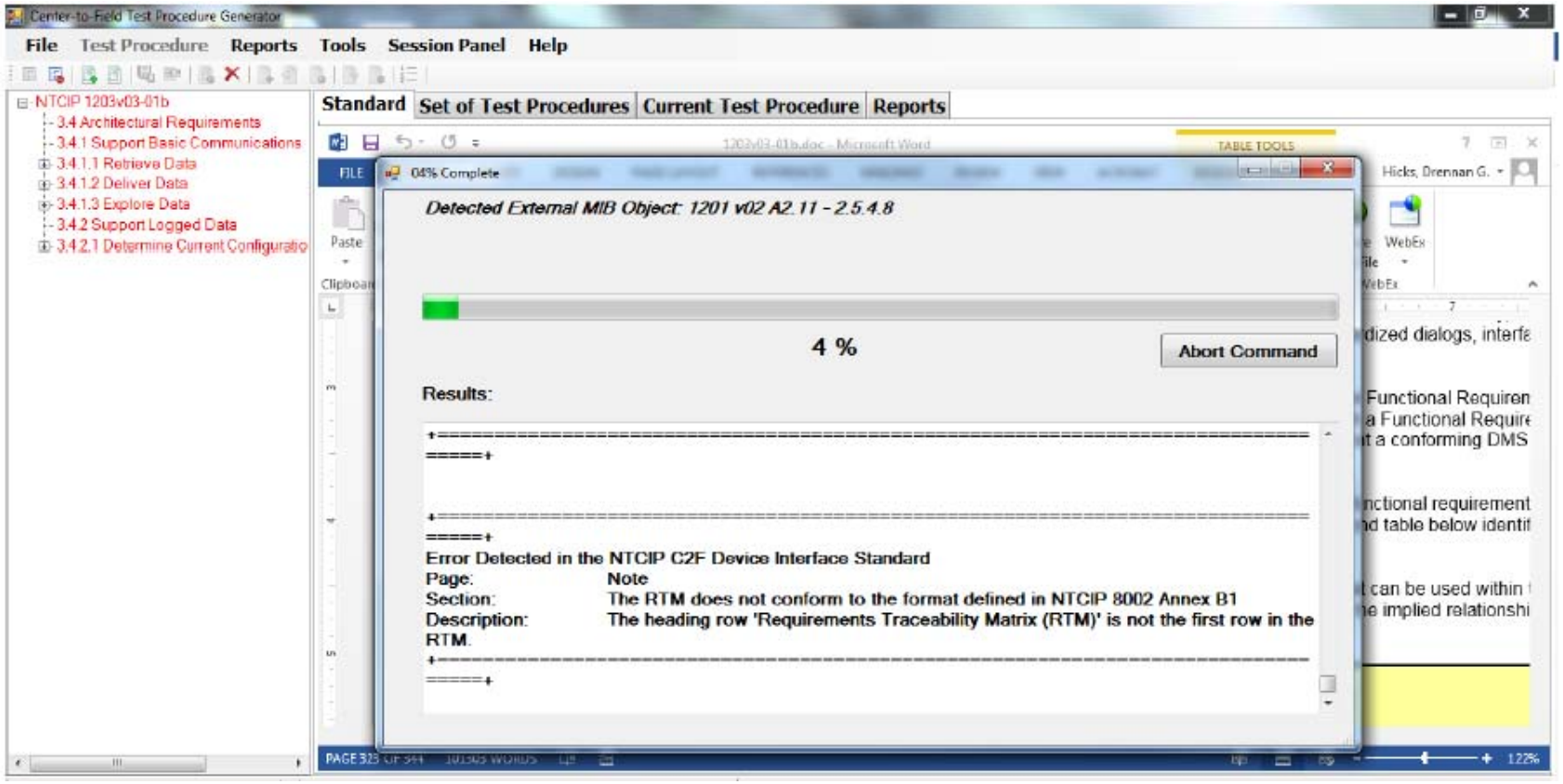


Source: Center-to-Field Test Procedure Generator User Manual, v2.0, FHWA, July 15, 2015

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

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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

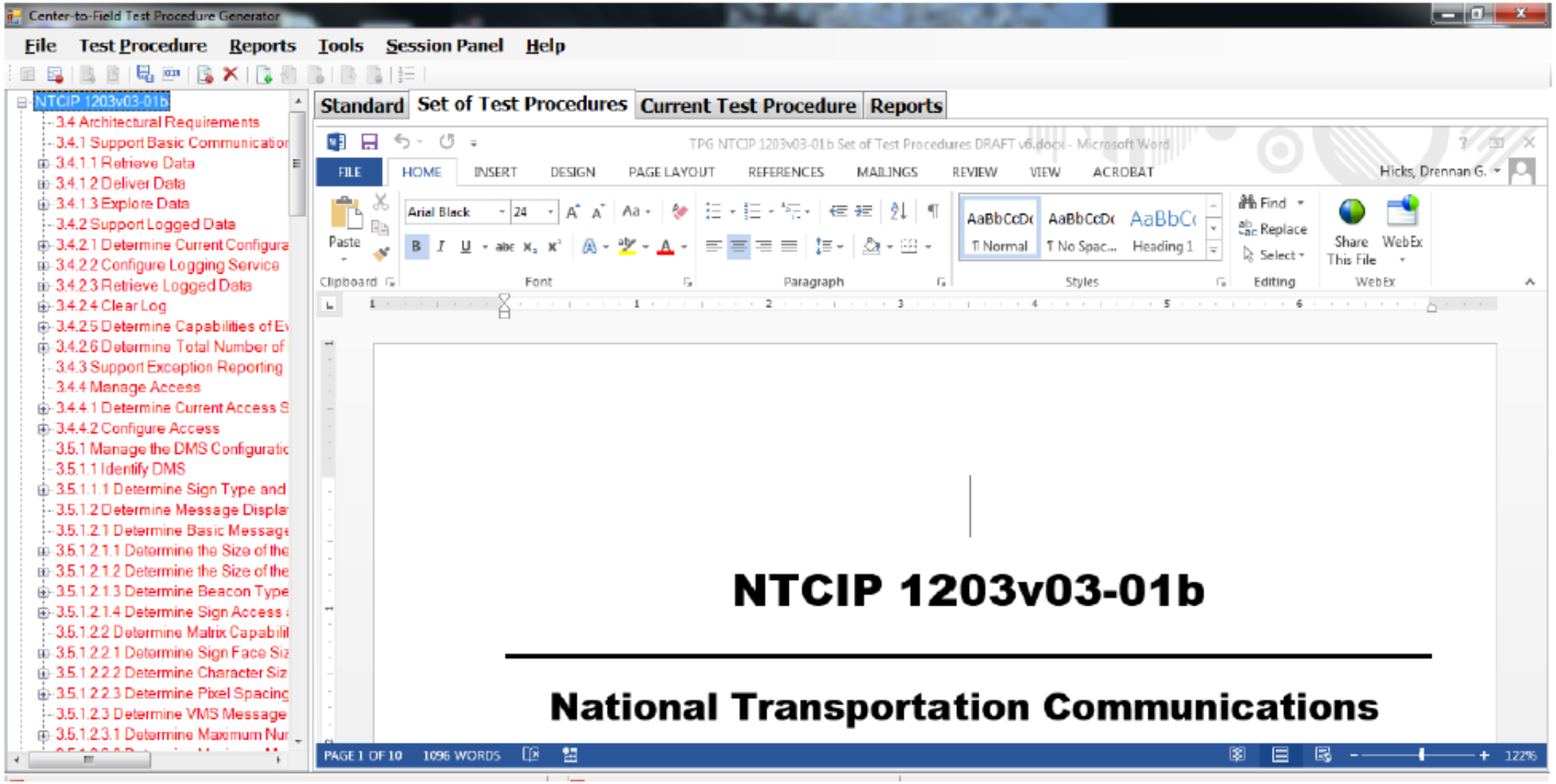
Incorrect. All are true.

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

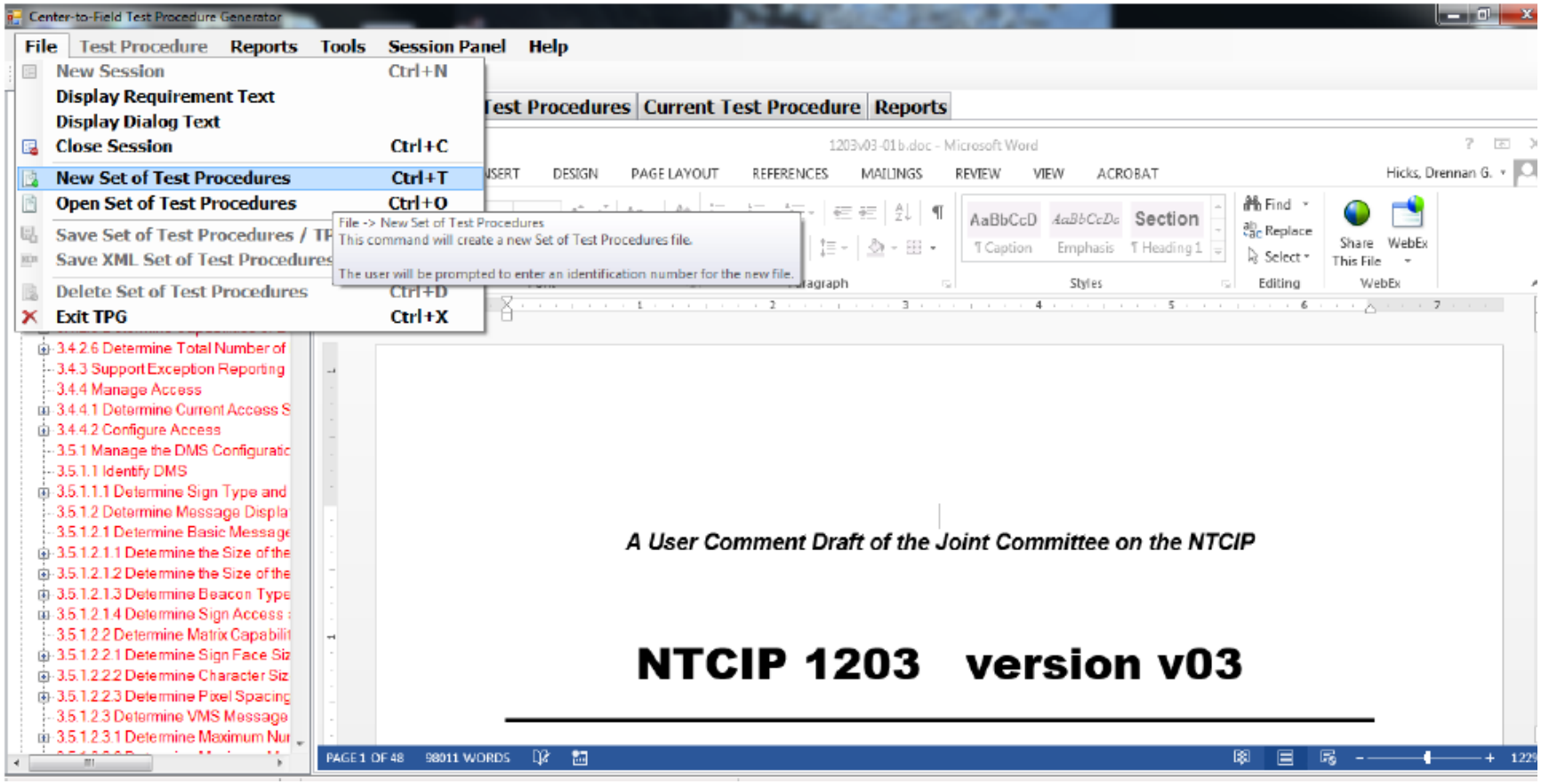
Open the NTCIP 1203 v03 DMS Standard



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

Example: Test Procedure for a DMS (cont.)

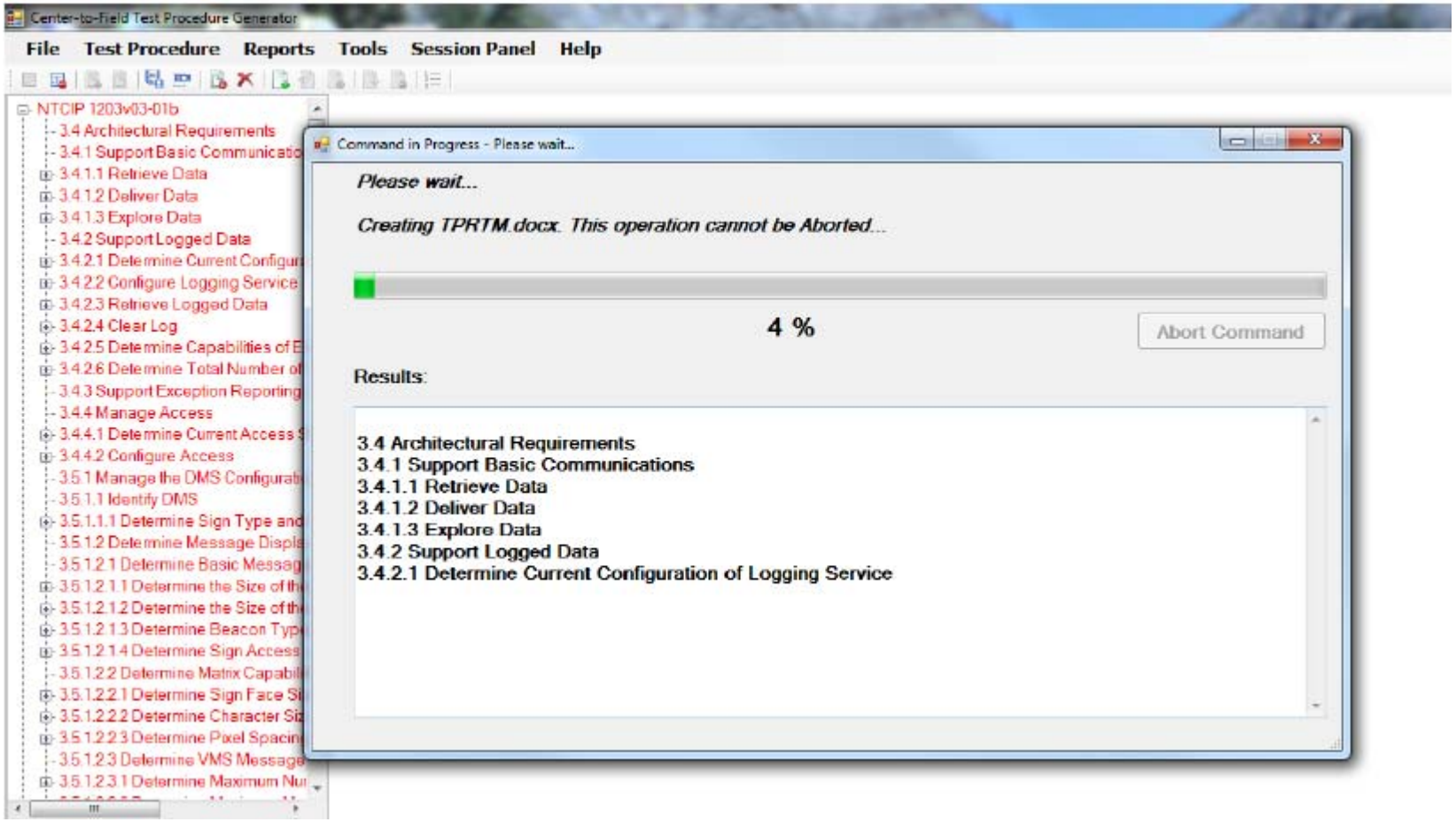
Create a New Set of Test Procedures



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

Example Test Procedure for a DMS (cont.)

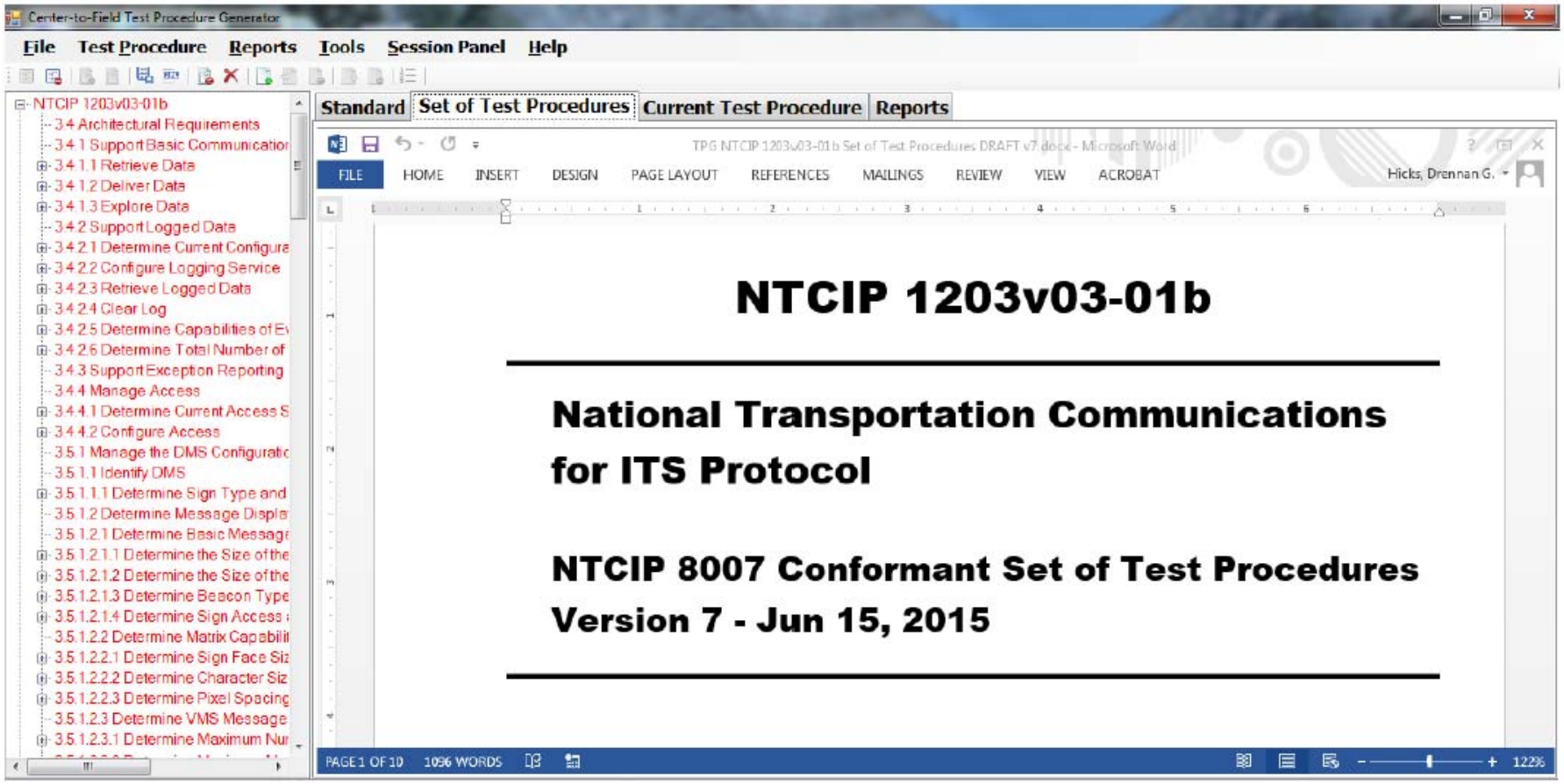
Create Test Procedure Requirements Traceability Matrix



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

Example Test Procedure for a DMS (cont.)

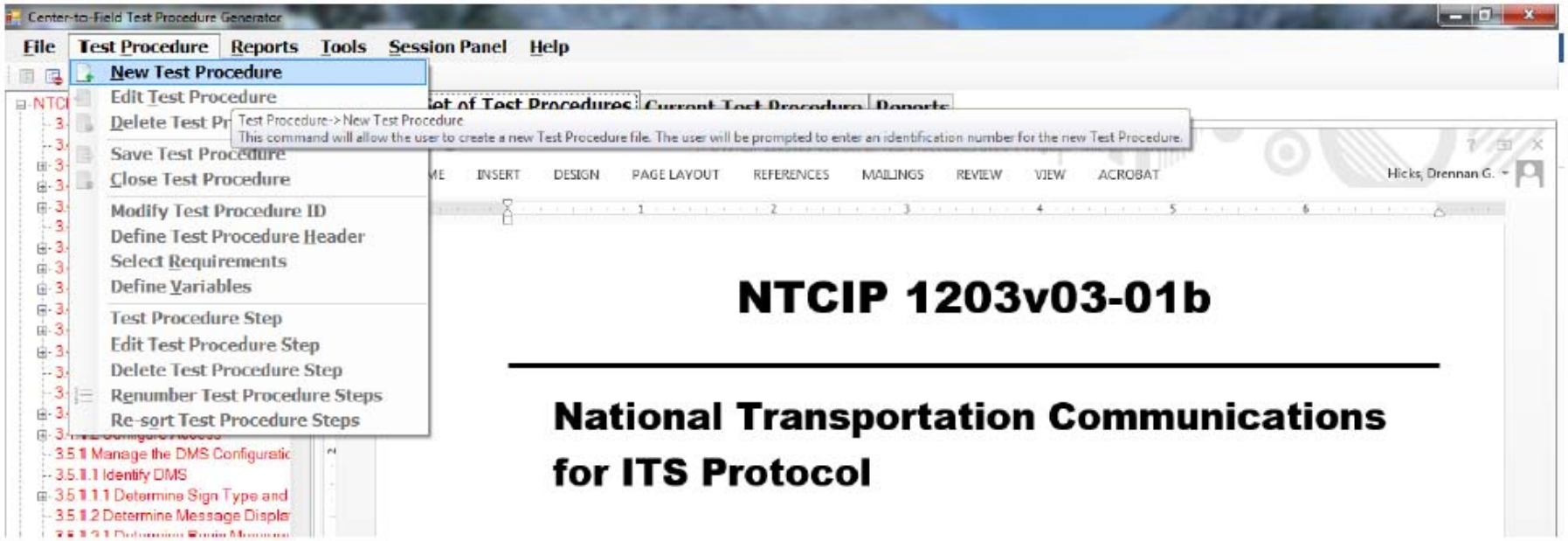
Set of Test Procedures



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

Example Test Procedure for a DMS (cont.)

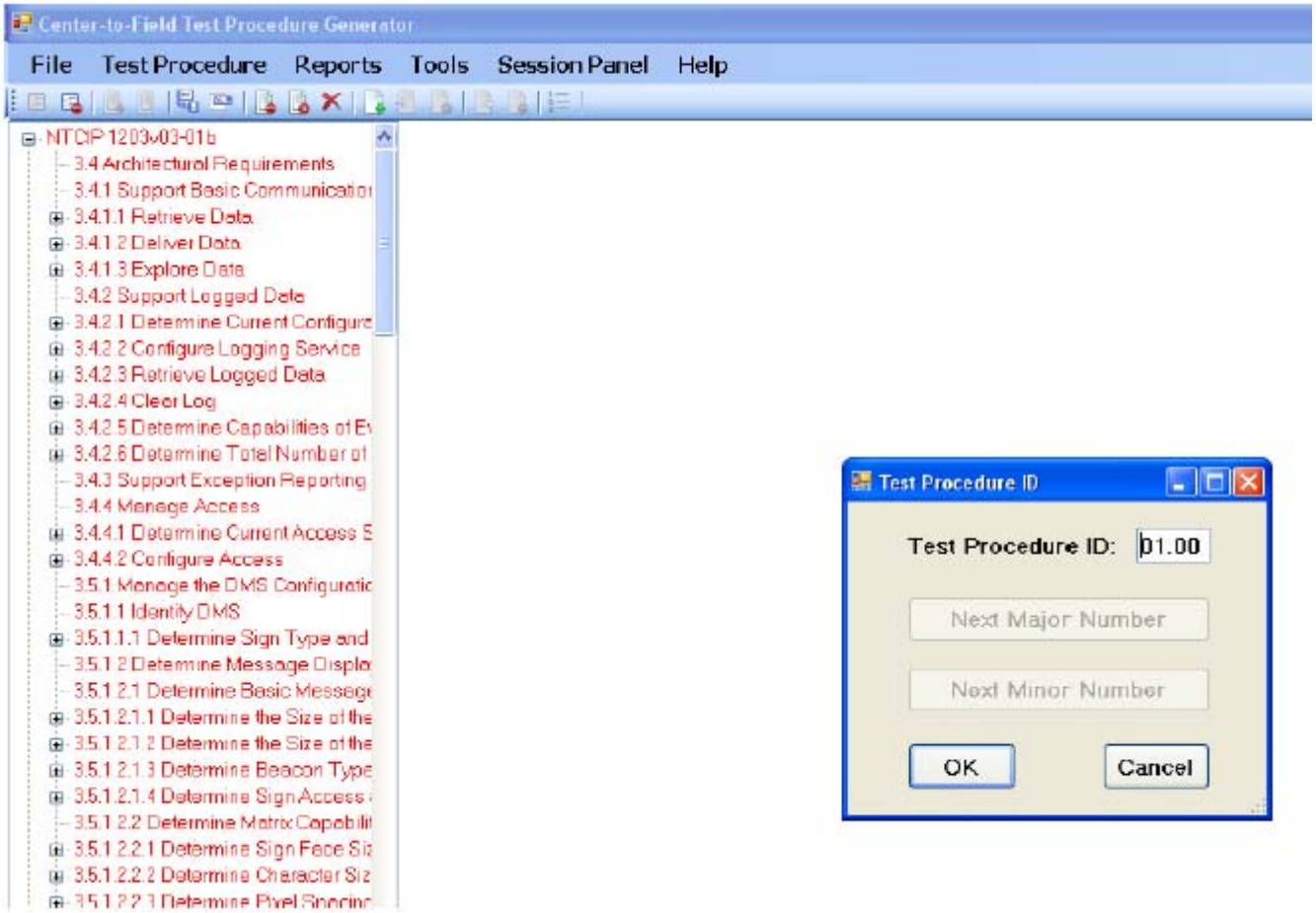
Create a New Test Procedure



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

Example Test Procedure for a DMS (cont.)

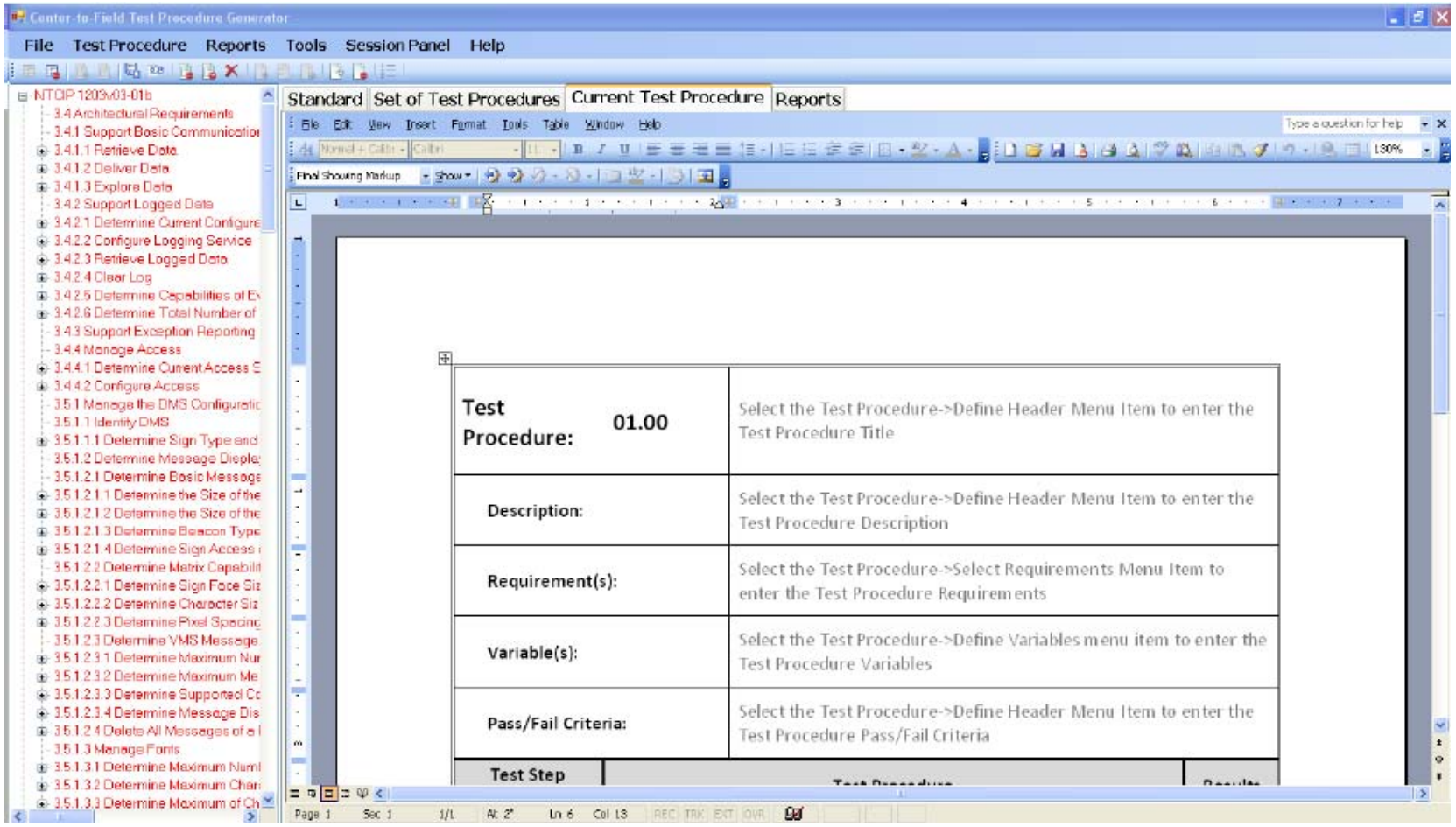
Test Procedure ID



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

Example Test Procedure for a DMS (cont.)

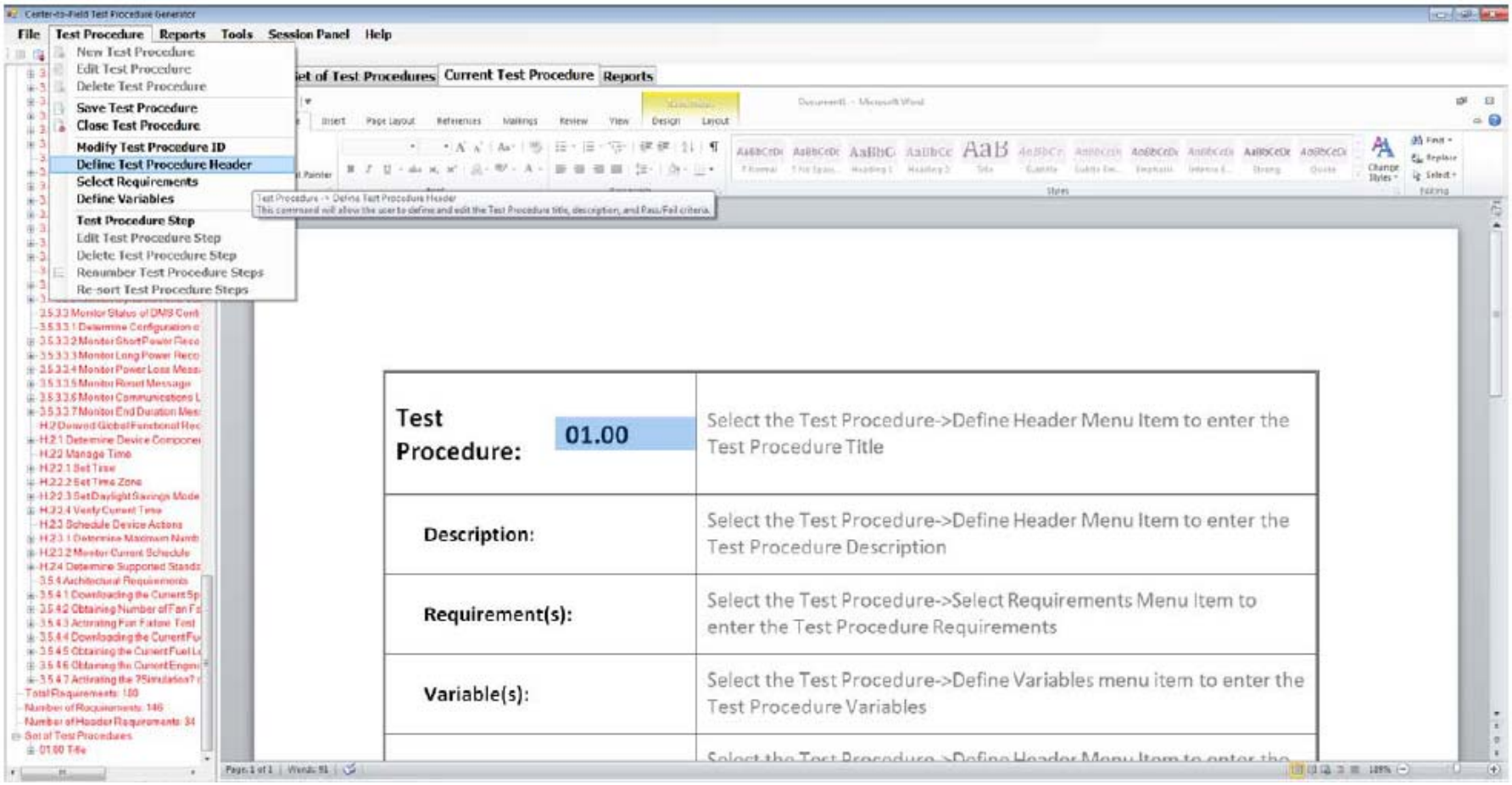
Test Procedure File



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

Example Test Procedure for a DMS (cont.)

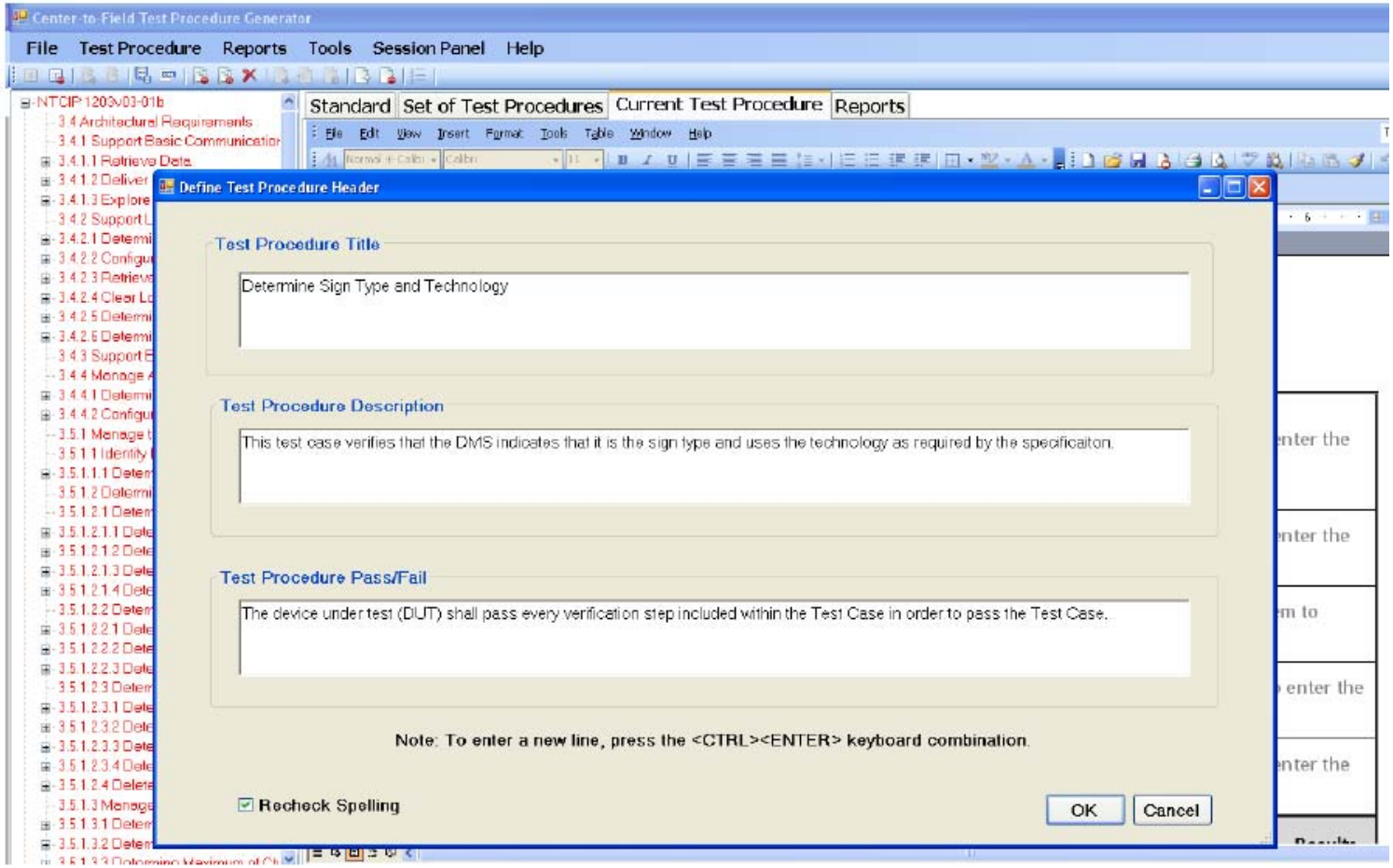
Test Procedure Header



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

Example Test Procedure for a DMS (cont.)

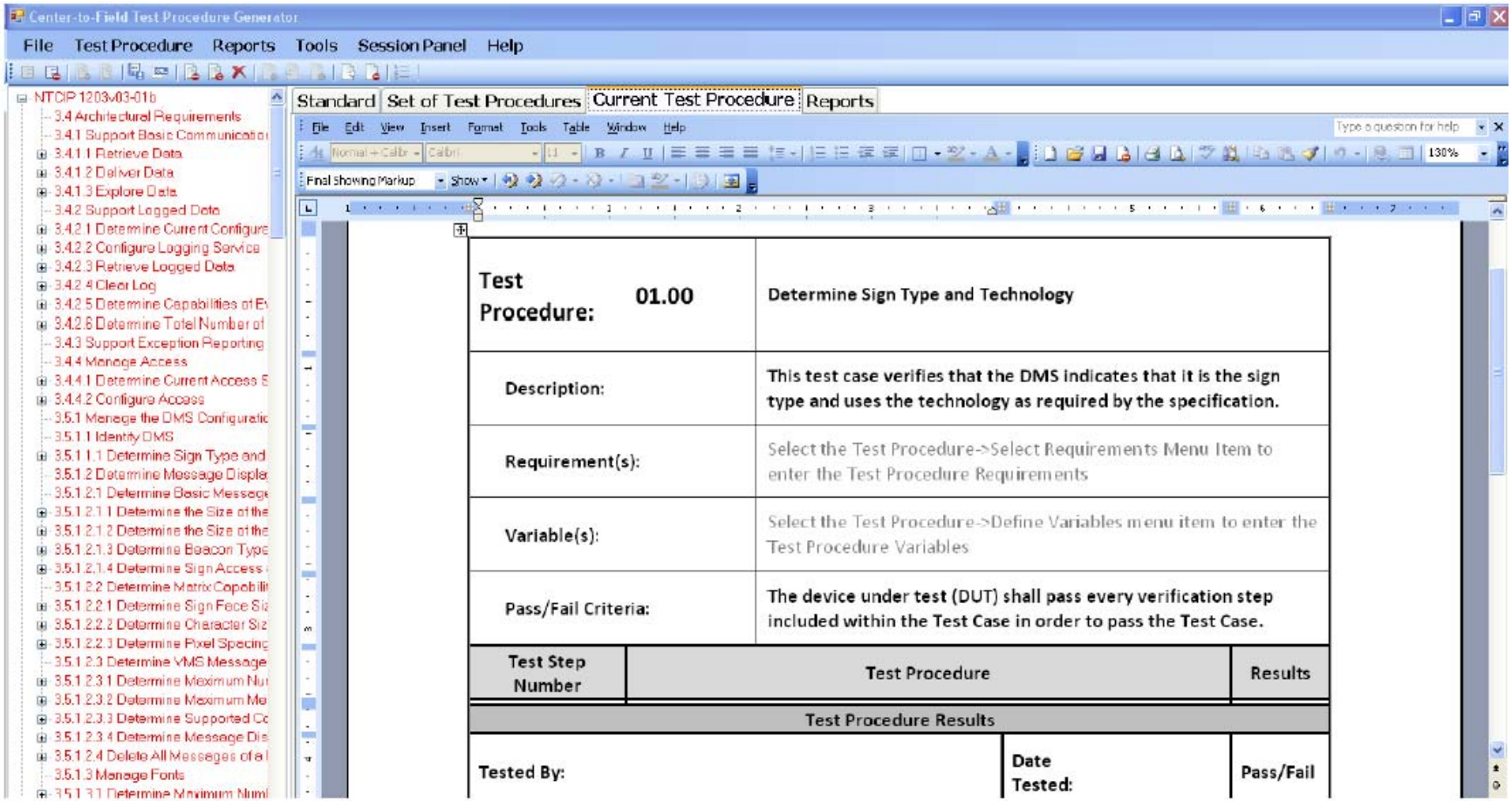
Populate the Test Procedure Header



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

Example Test Procedure for a DMS (cont.)

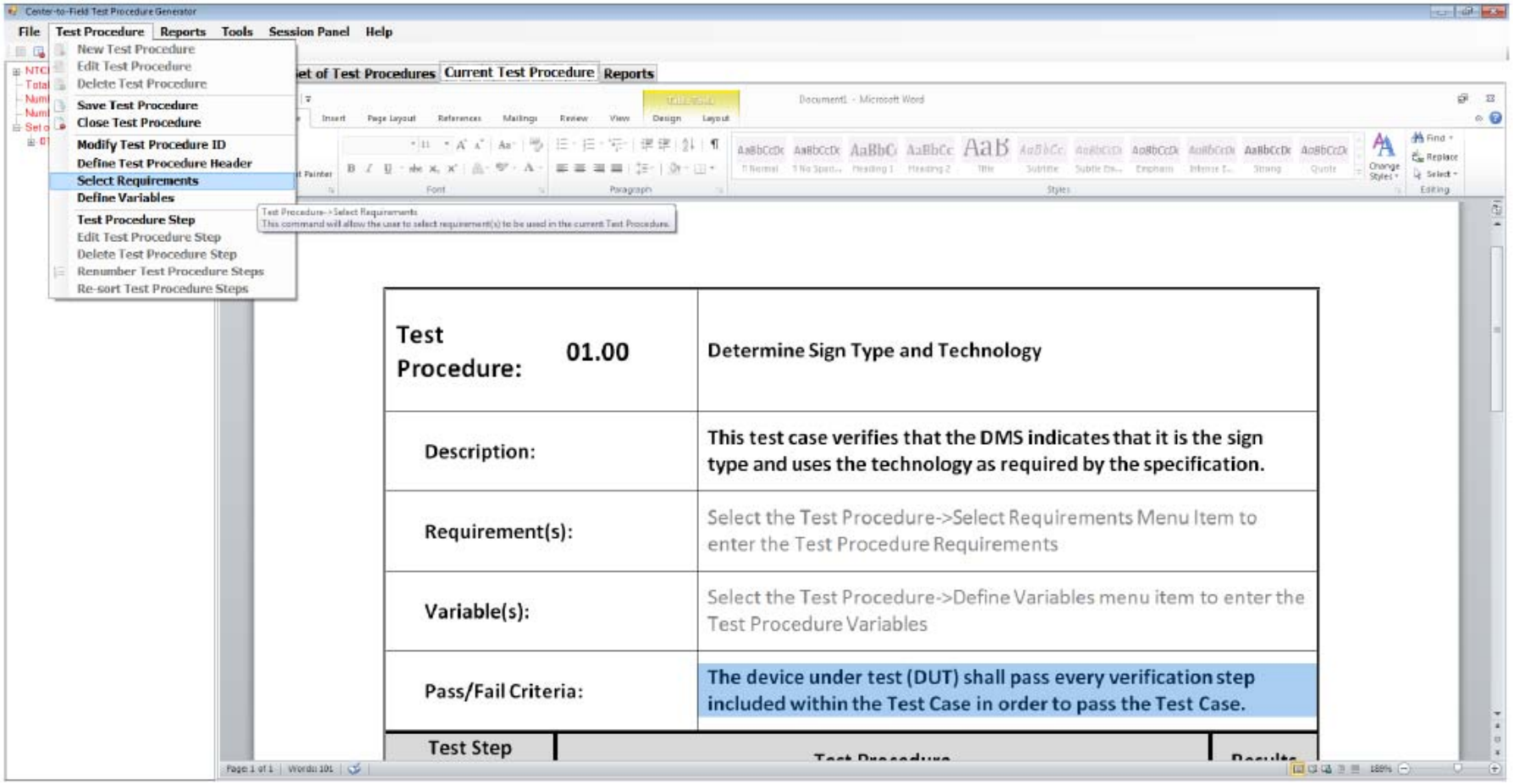
Populate the Test Procedure Header



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

Example Test Procedure for a DMS (cont.)

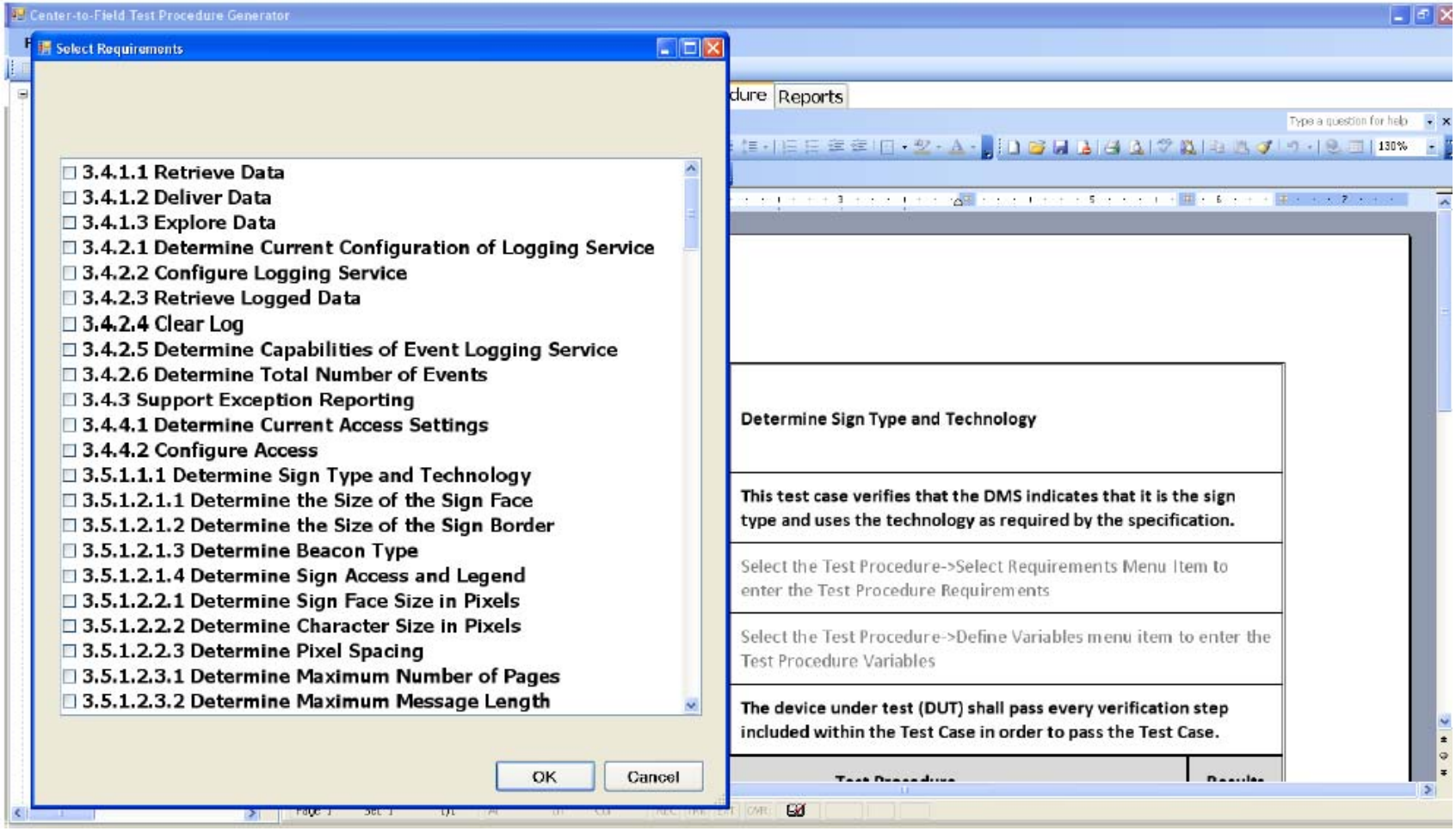
Select the Requirements



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

Example Test Procedure for a DMS (cont.)

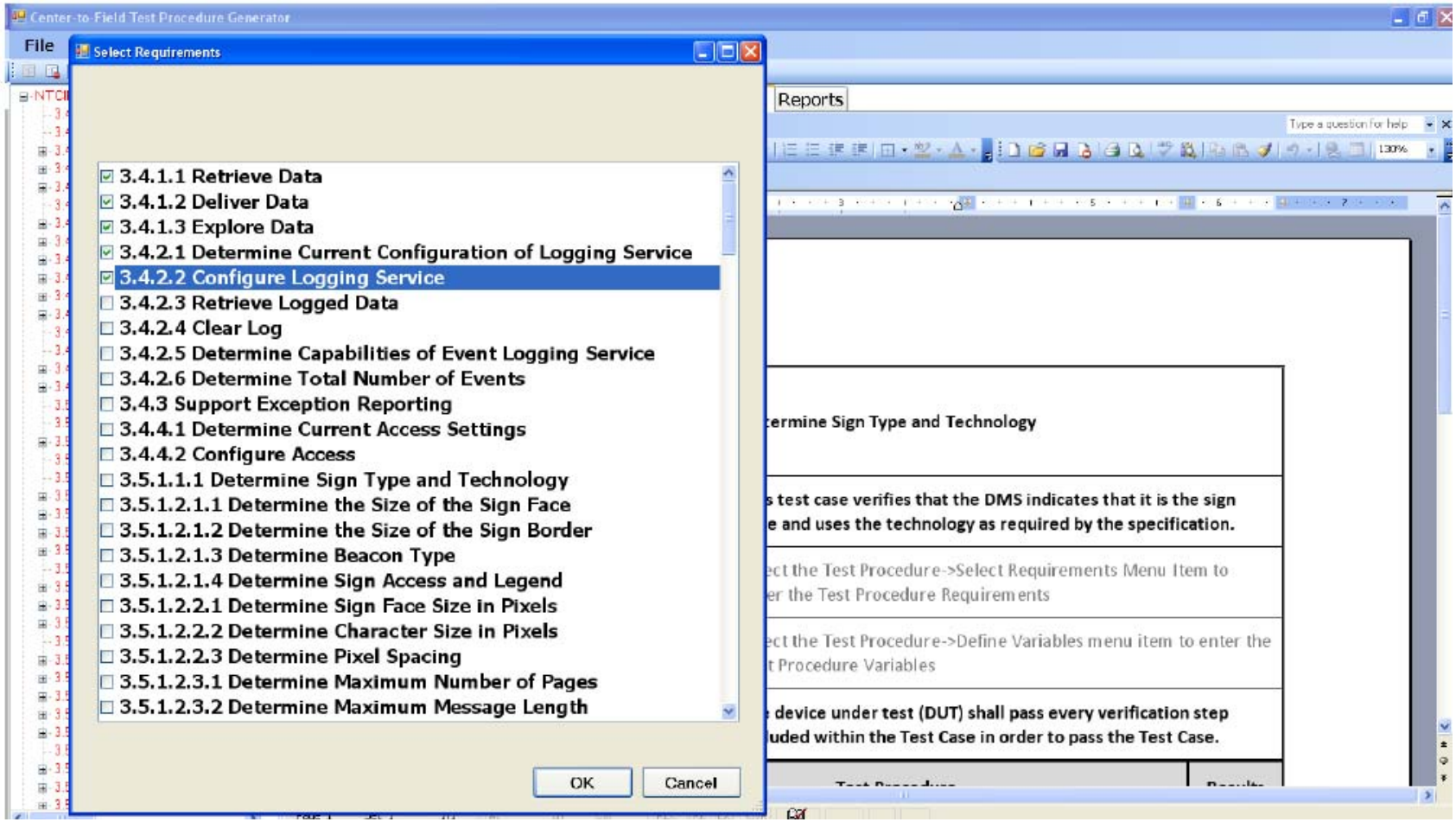
Select the Requirements



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

Example Test Procedure for a DMS (cont.)

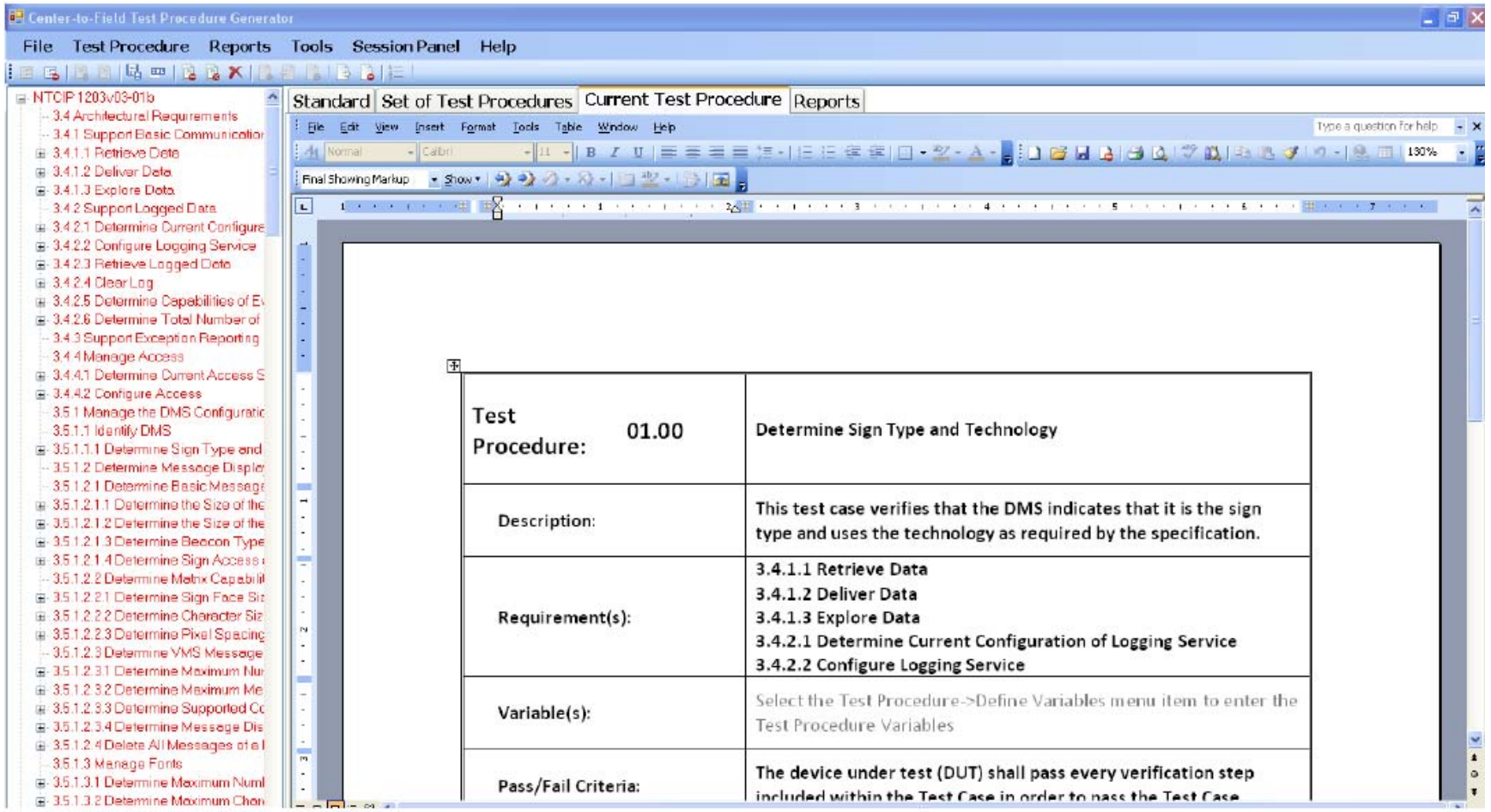
Select the Requirements



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

Example Test Procedure for a DMS (cont.)

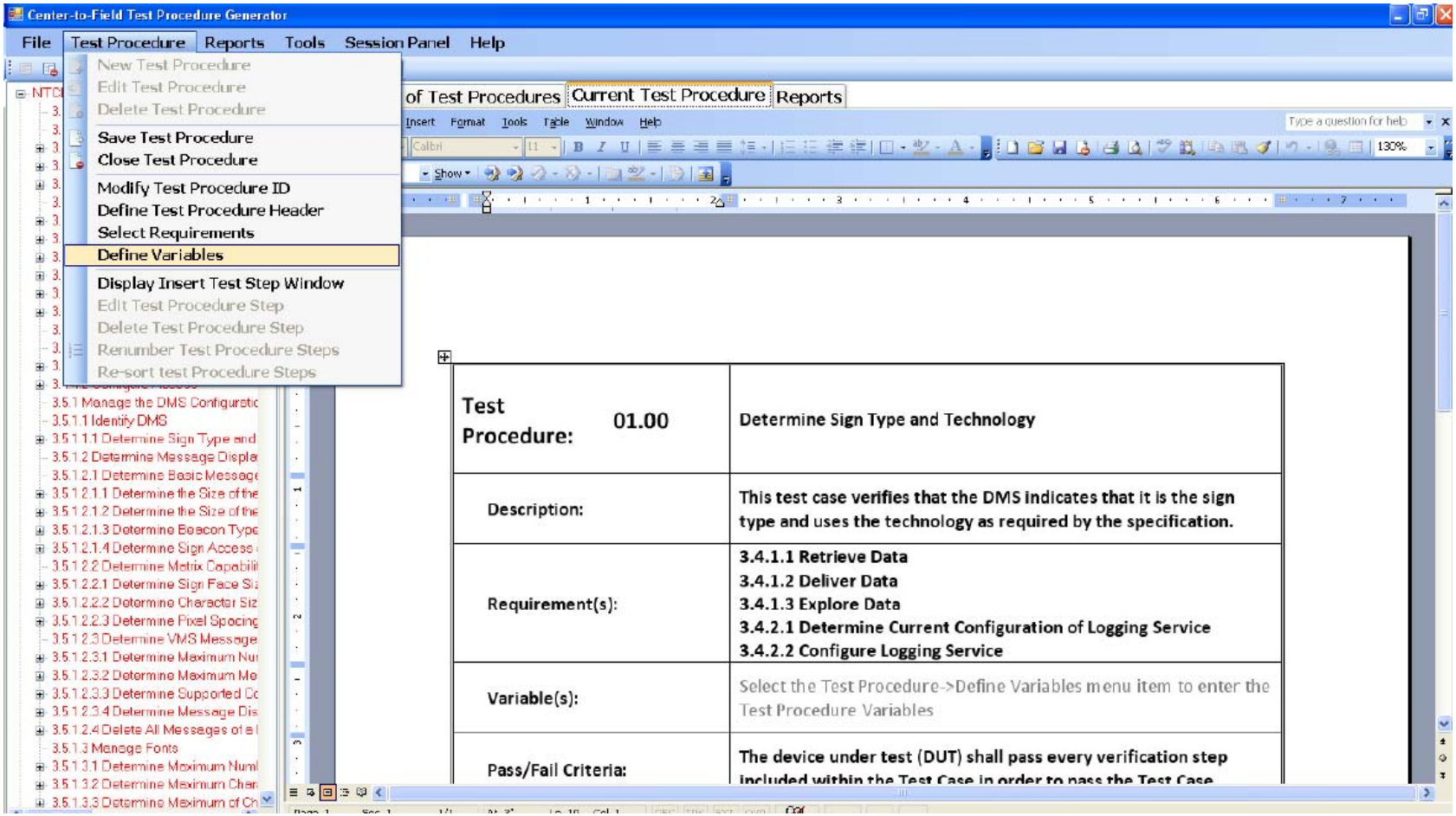
Populated Test Procedure Document



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

Example Test Procedure for a DMS (cont.)

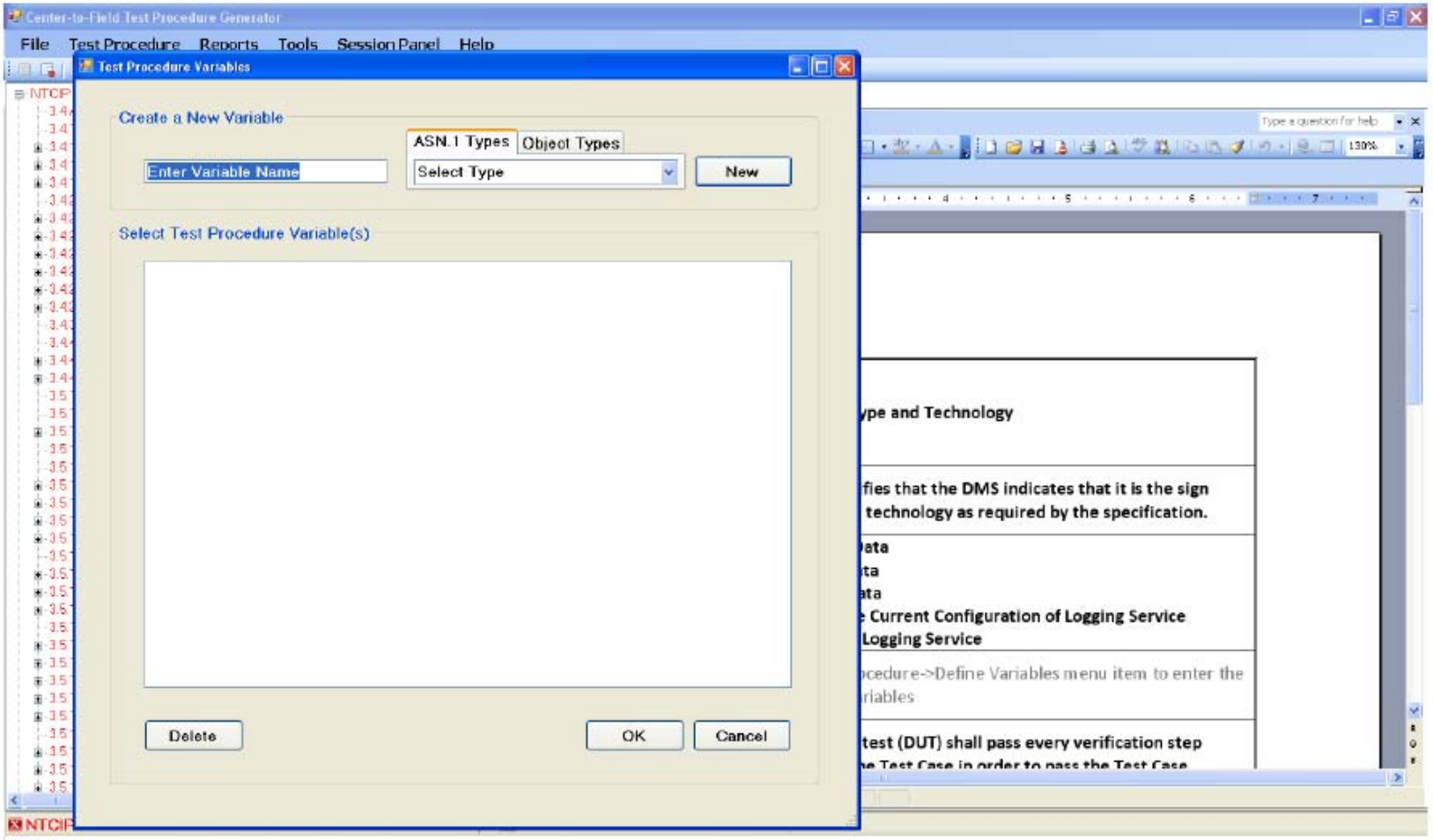
Define Variables



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

Example Test Procedure for a DMS (cont.)

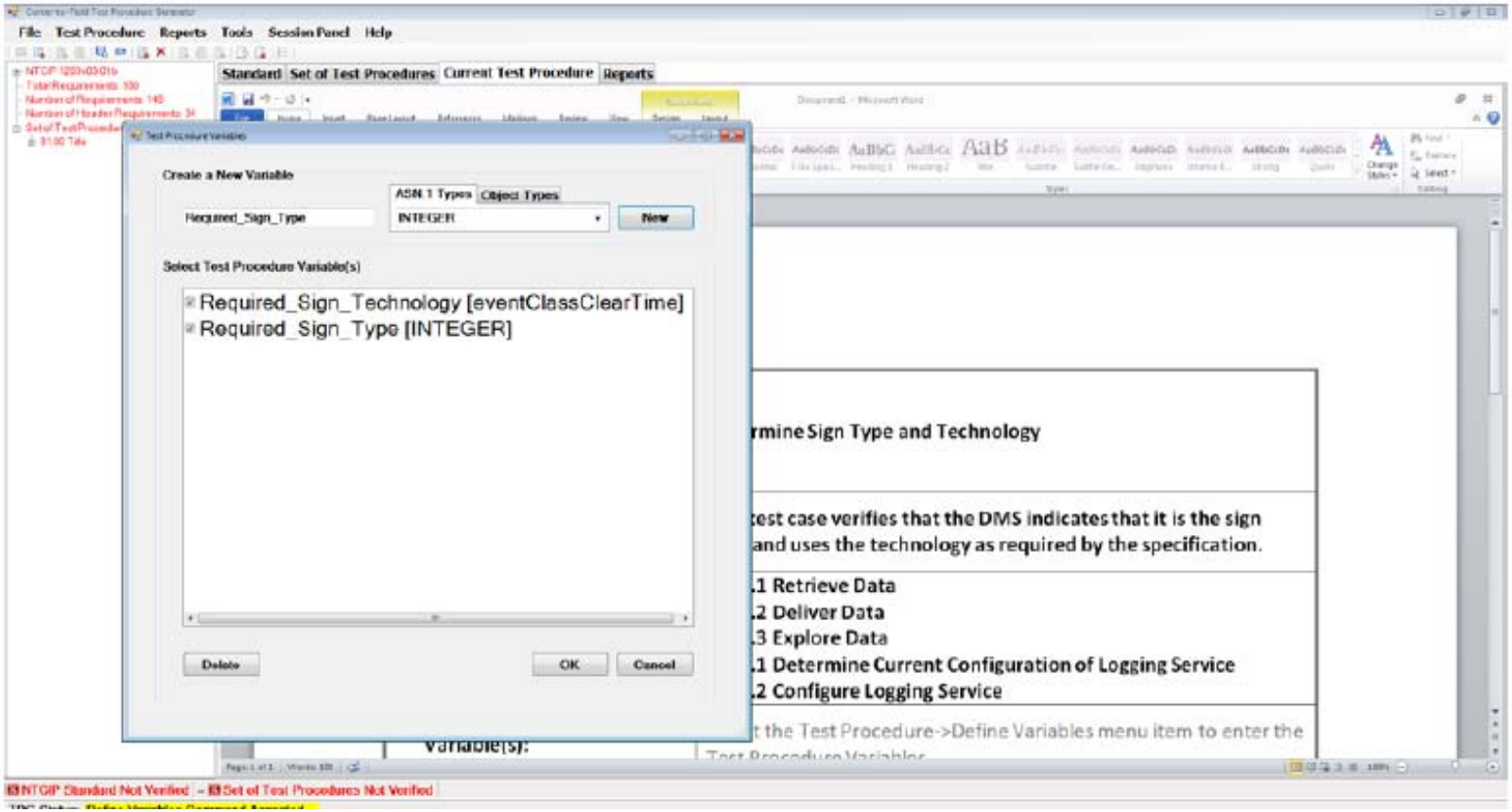
Define Variables



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

Example Test Procedure for a DMS (cont.)

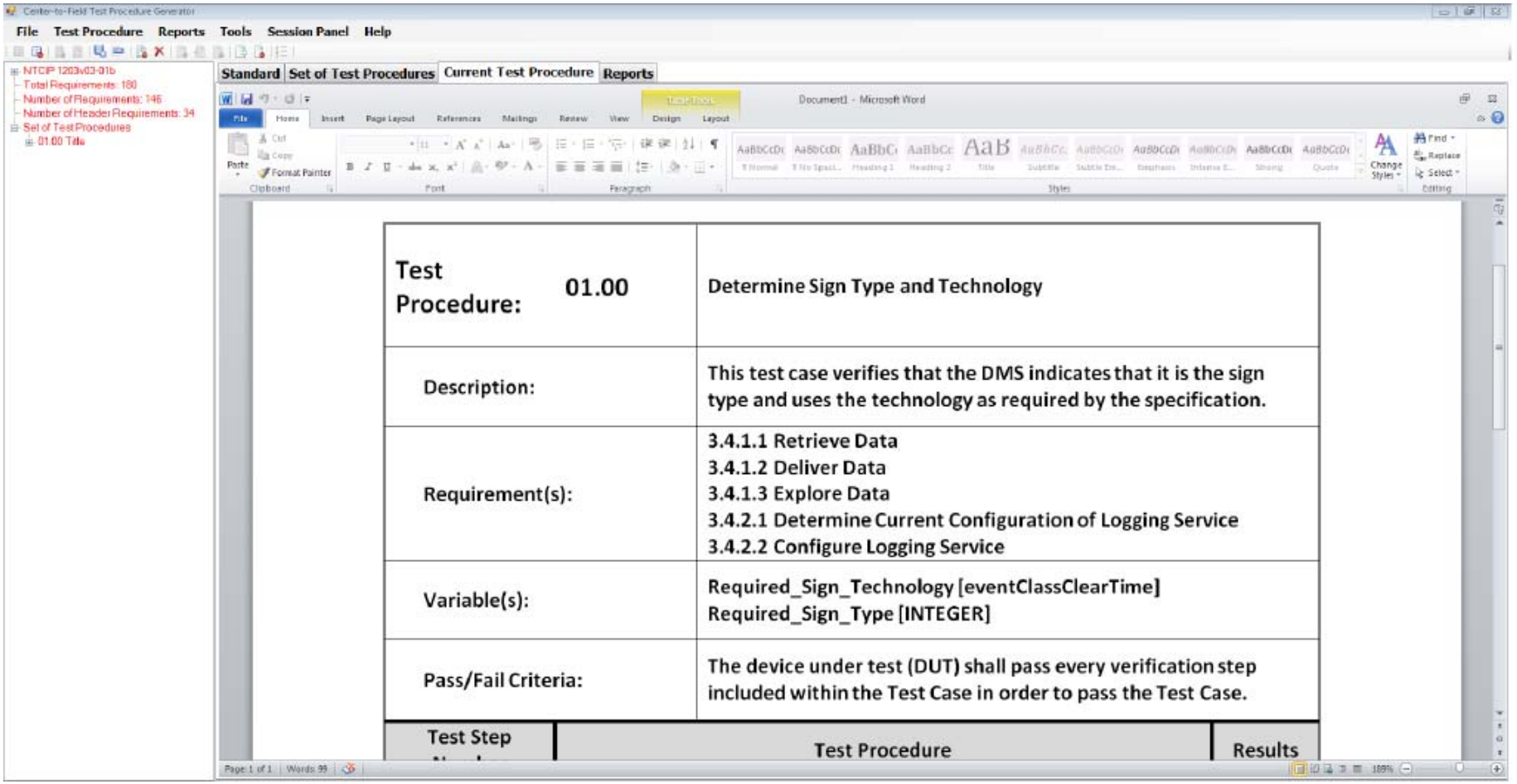
Define Variables



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

Example Test Procedure for a DMS (cont.)

Define Variables



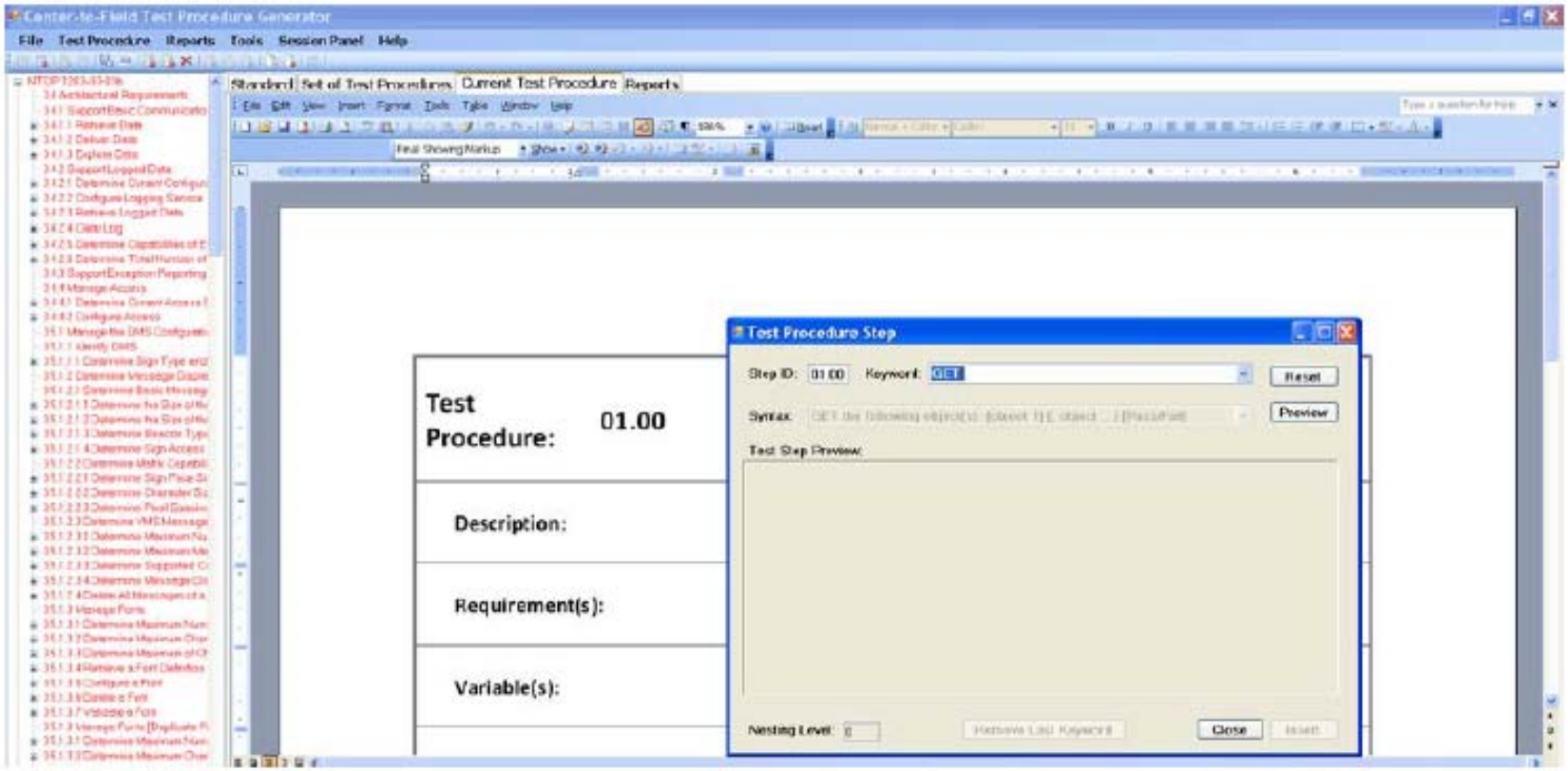
Test Procedure: 01.00	Determine Sign Type and Technology
Description:	This test case verifies that the DMS indicates that it is the sign type and uses the technology as required by the specification.
Requirement(s):	3.4.1.1 Retrieve Data 3.4.1.2 Deliver Data 3.4.1.3 Explore Data 3.4.2.1 Determine Current 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	Test Procedure	Results

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

Example Test Procedure for a DMS (cont.)

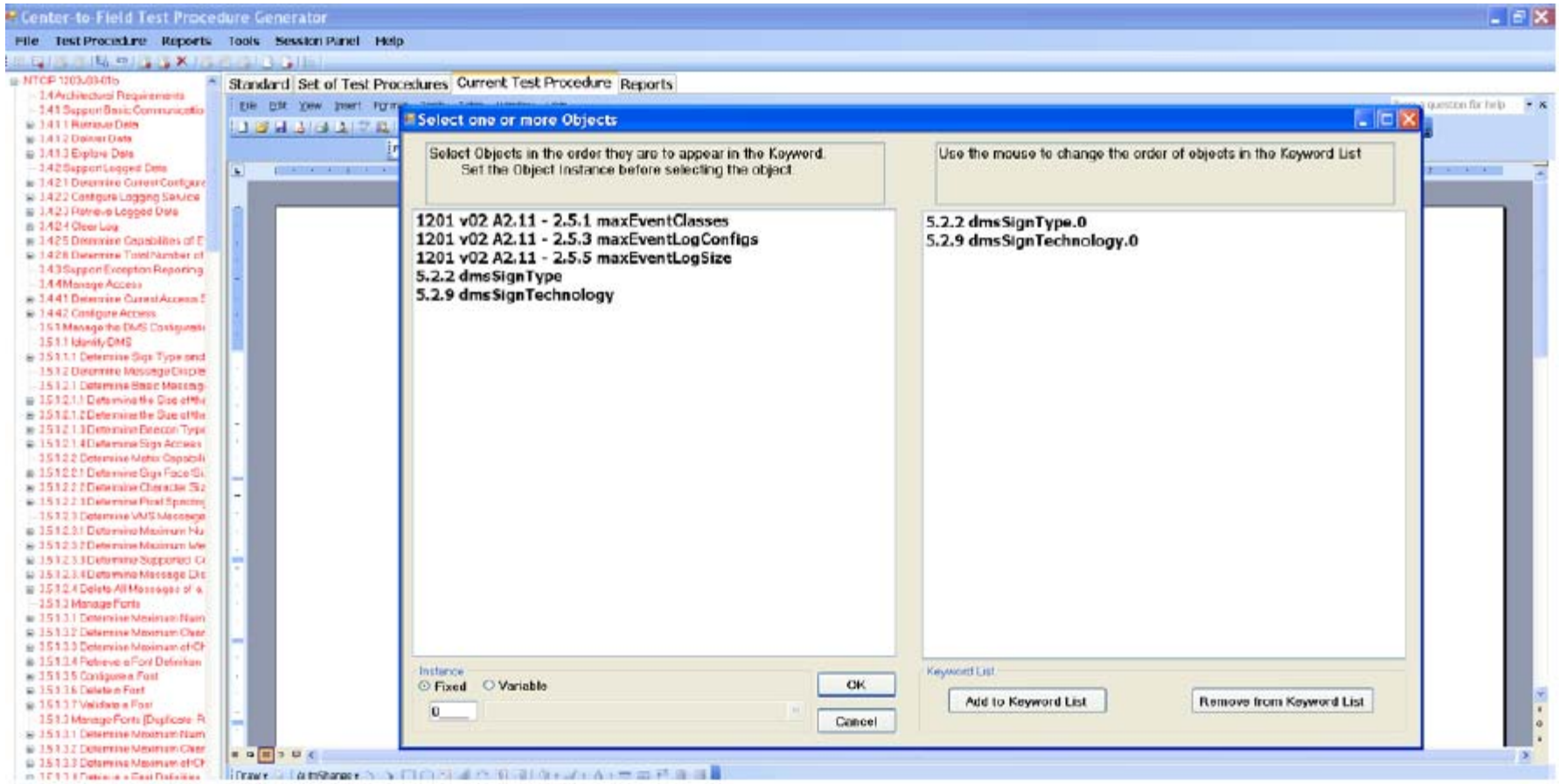
Define a Test Procedure Step



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

Example Test Procedure for a DMS (cont.)

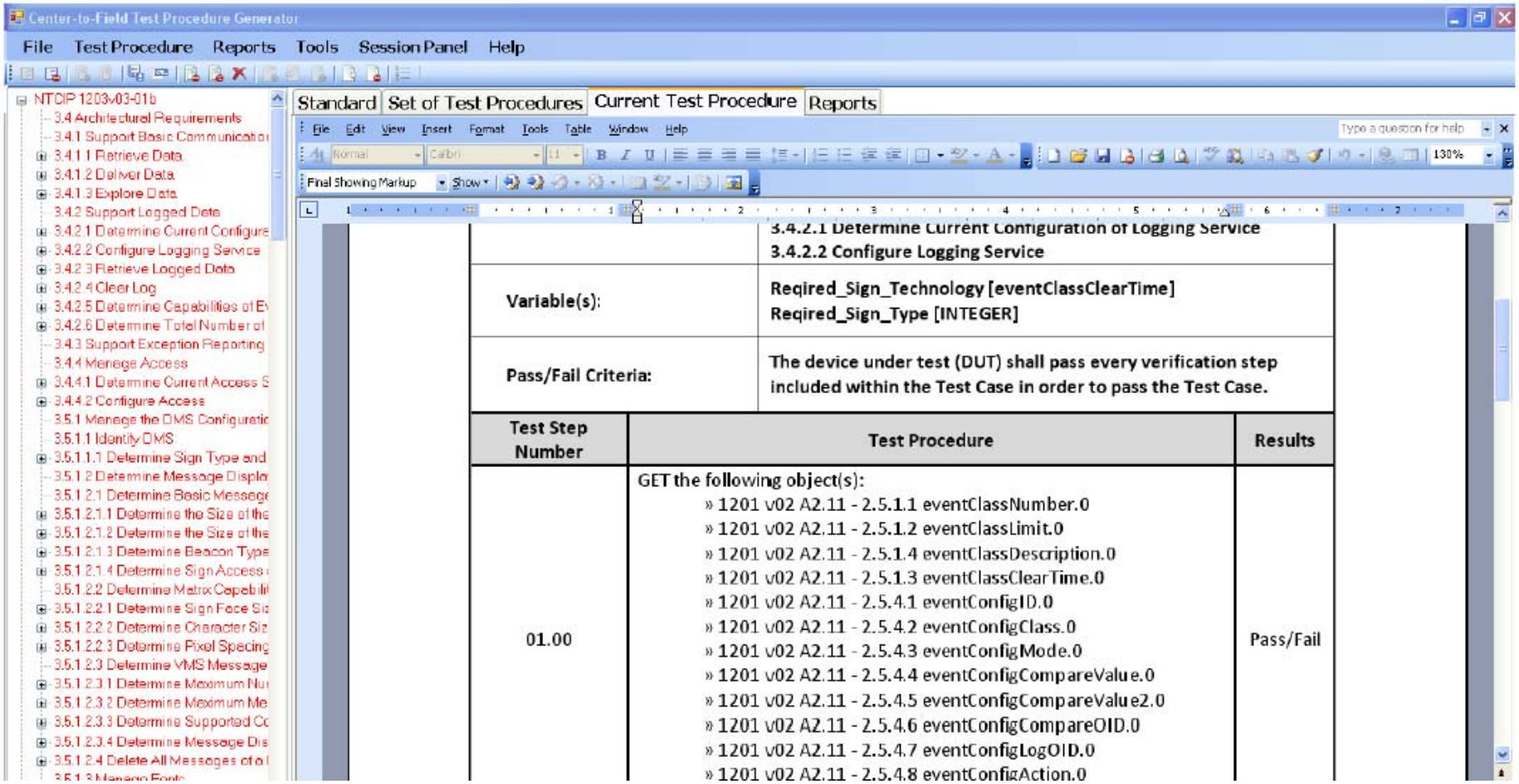
Select the Objects for the Test Step



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

Example Test Procedure for a DMS (cont.)

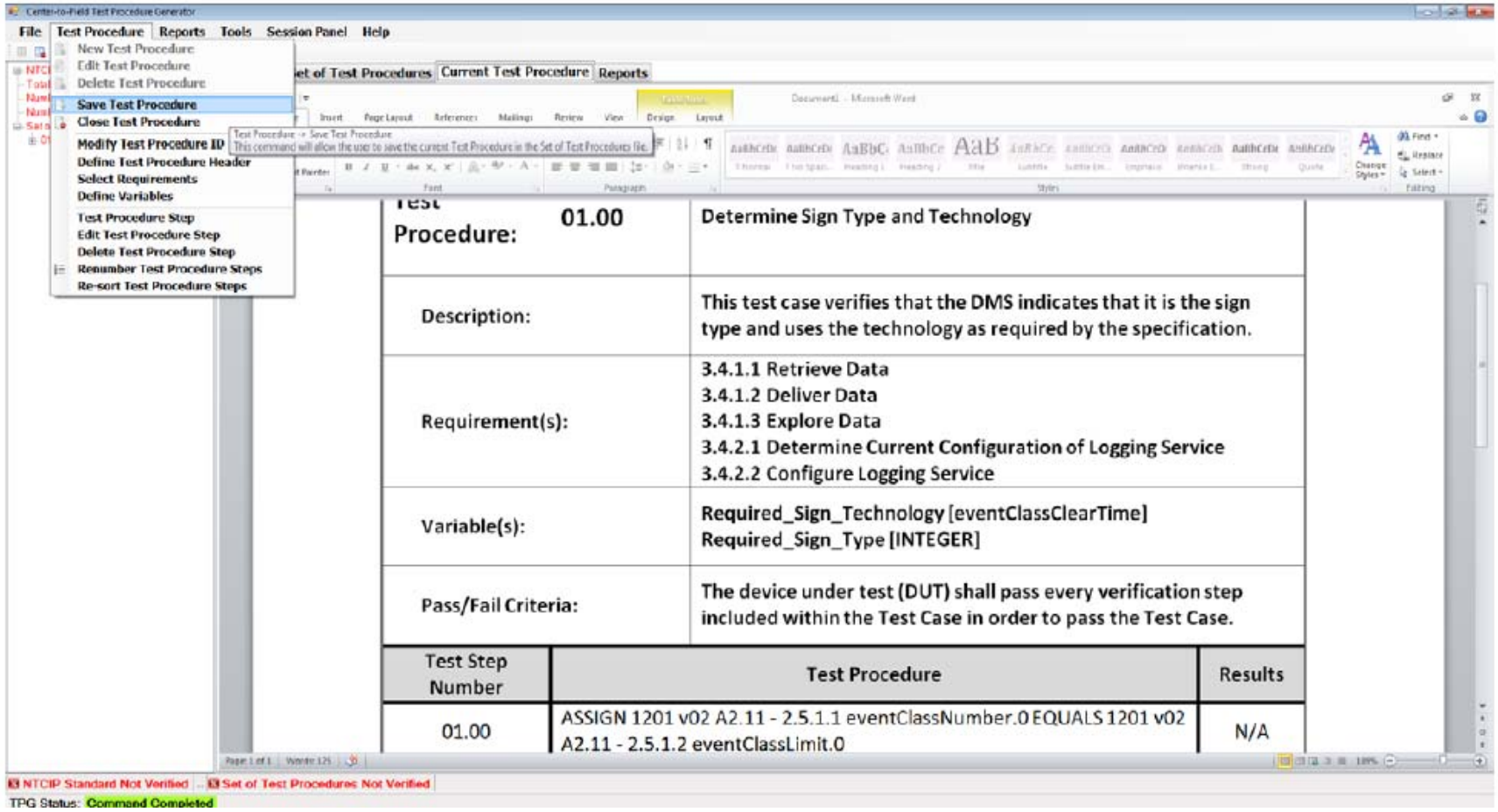
Inserting a Test Procedure Step



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

Example Test Procedure for a DMS (cont.)

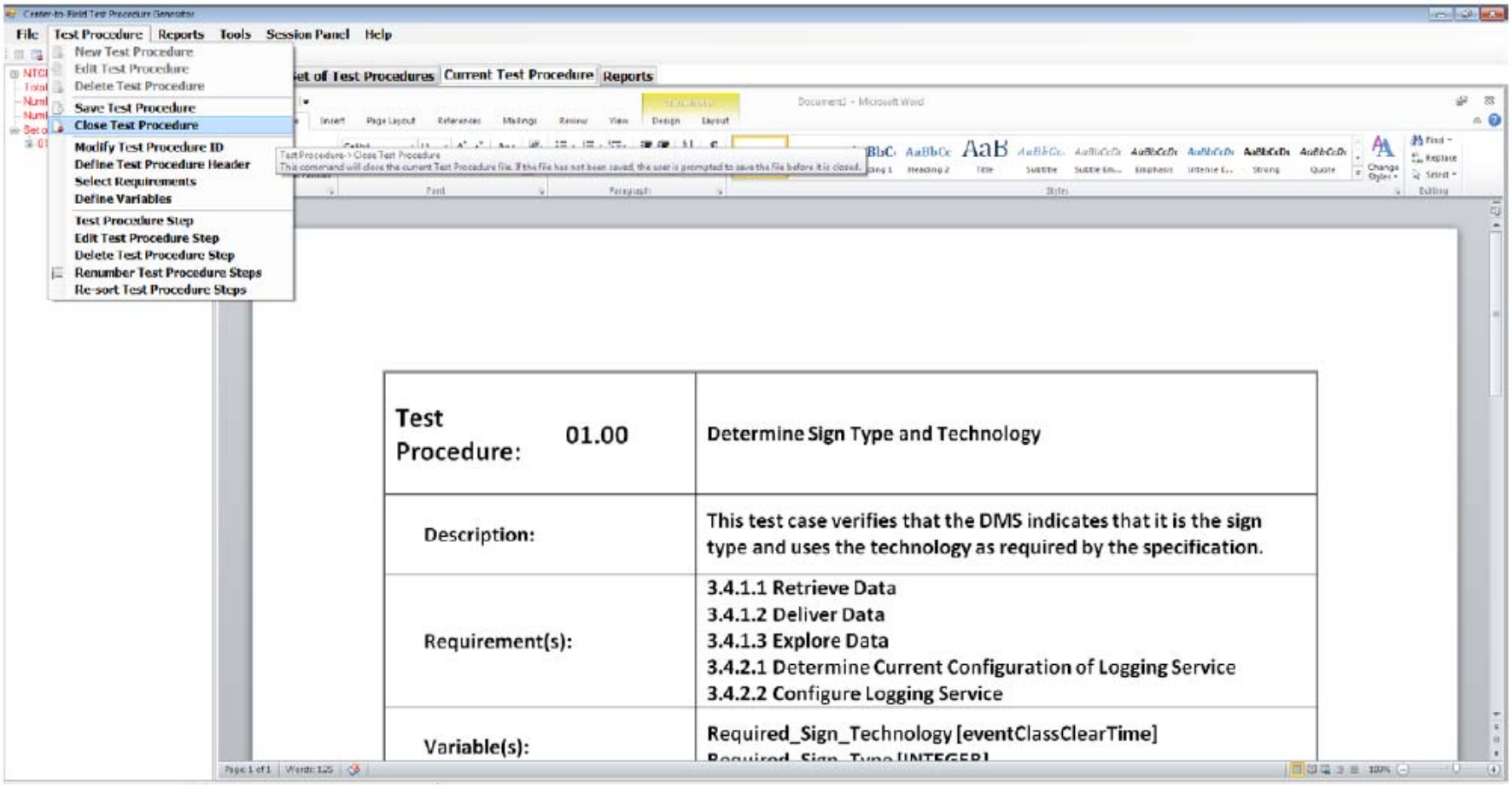
Saving the Test Procedure



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

Example Test Procedure for a DMS (cont.)

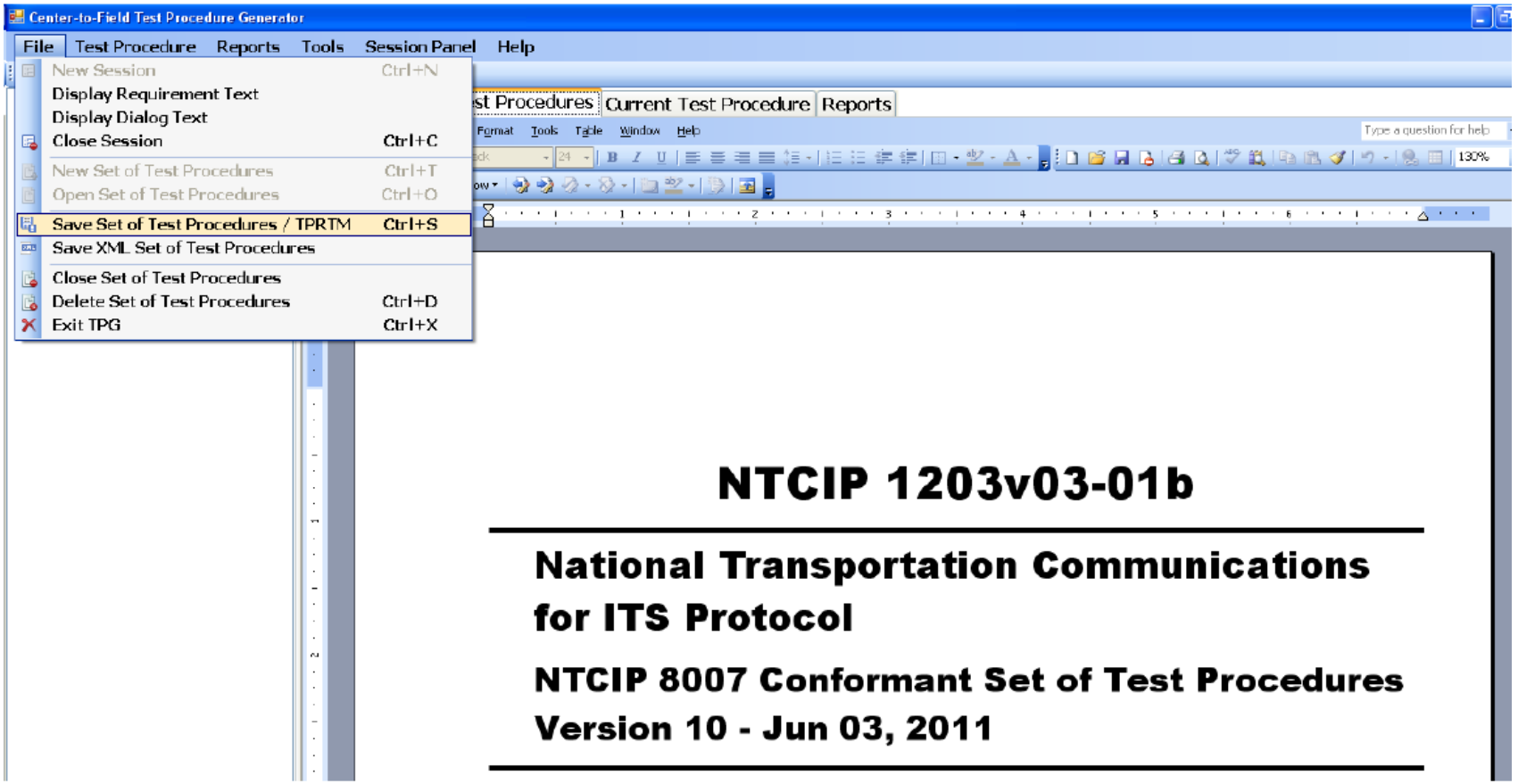
Closing the Test Procedure



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

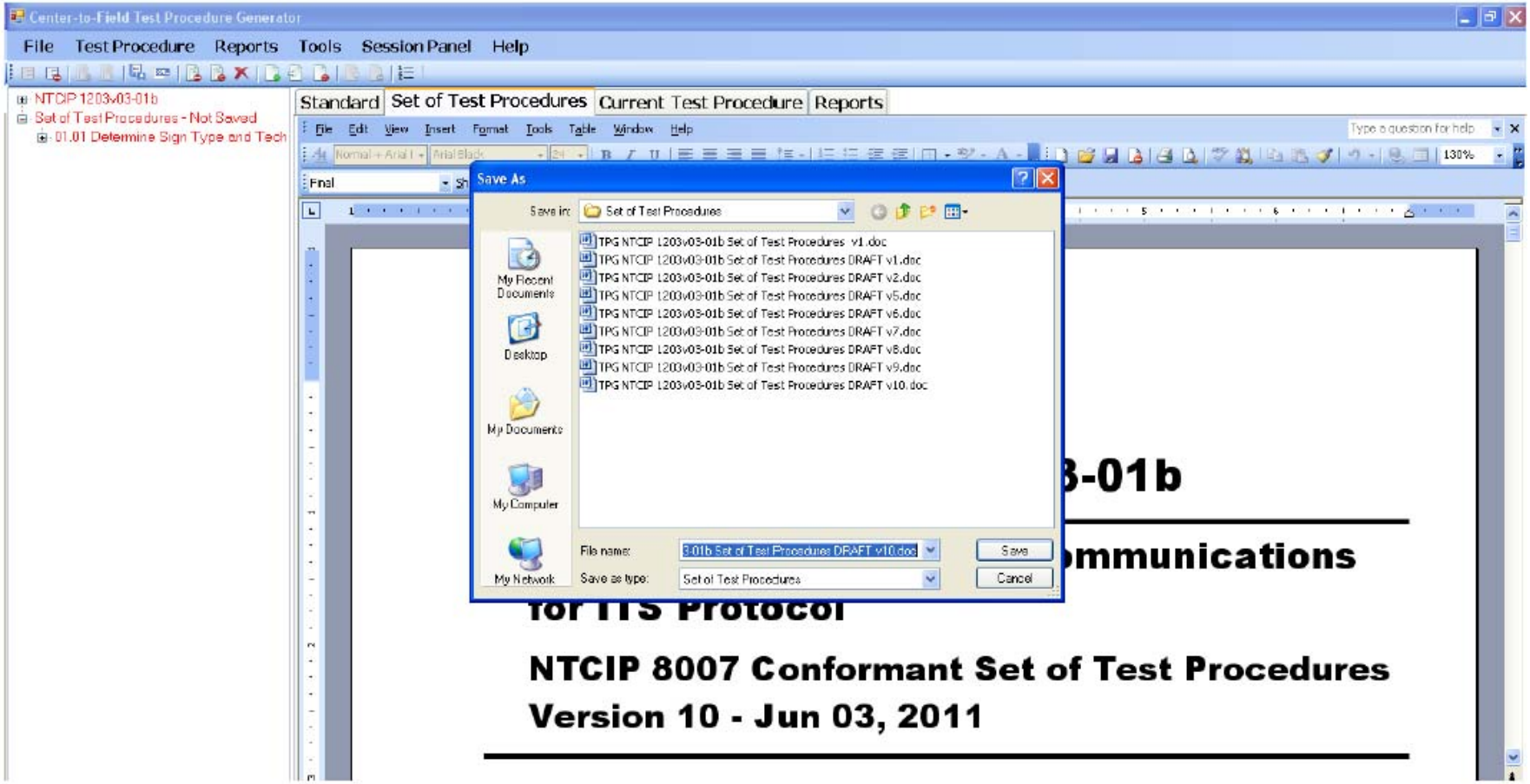
Example Test Procedure for a DMS (cont.)

Saving the Sets of Test Procedure



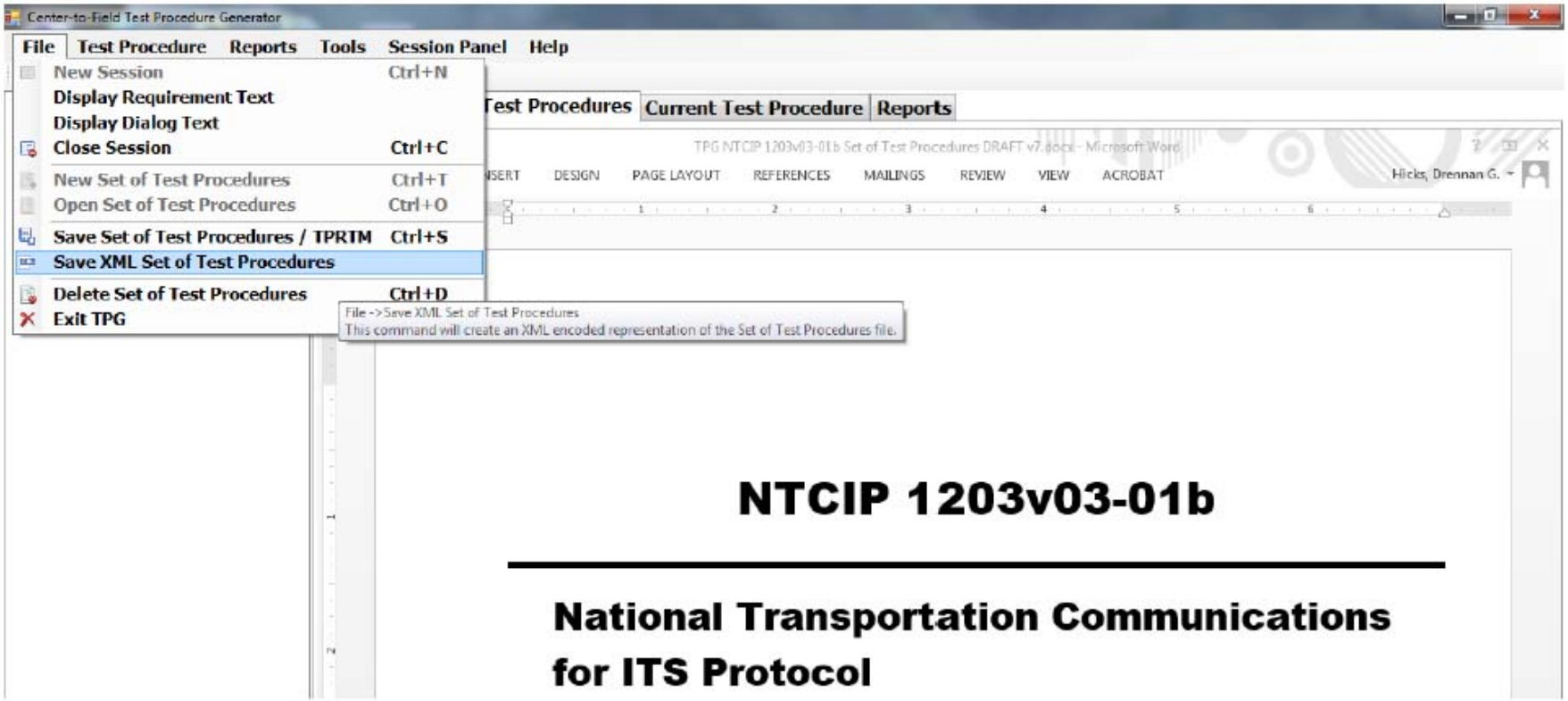
Example Test Procedure for a DMS (cont.)

Saving the Sets of Test Procedure



Example Test Procedure for a DMS (cont.)

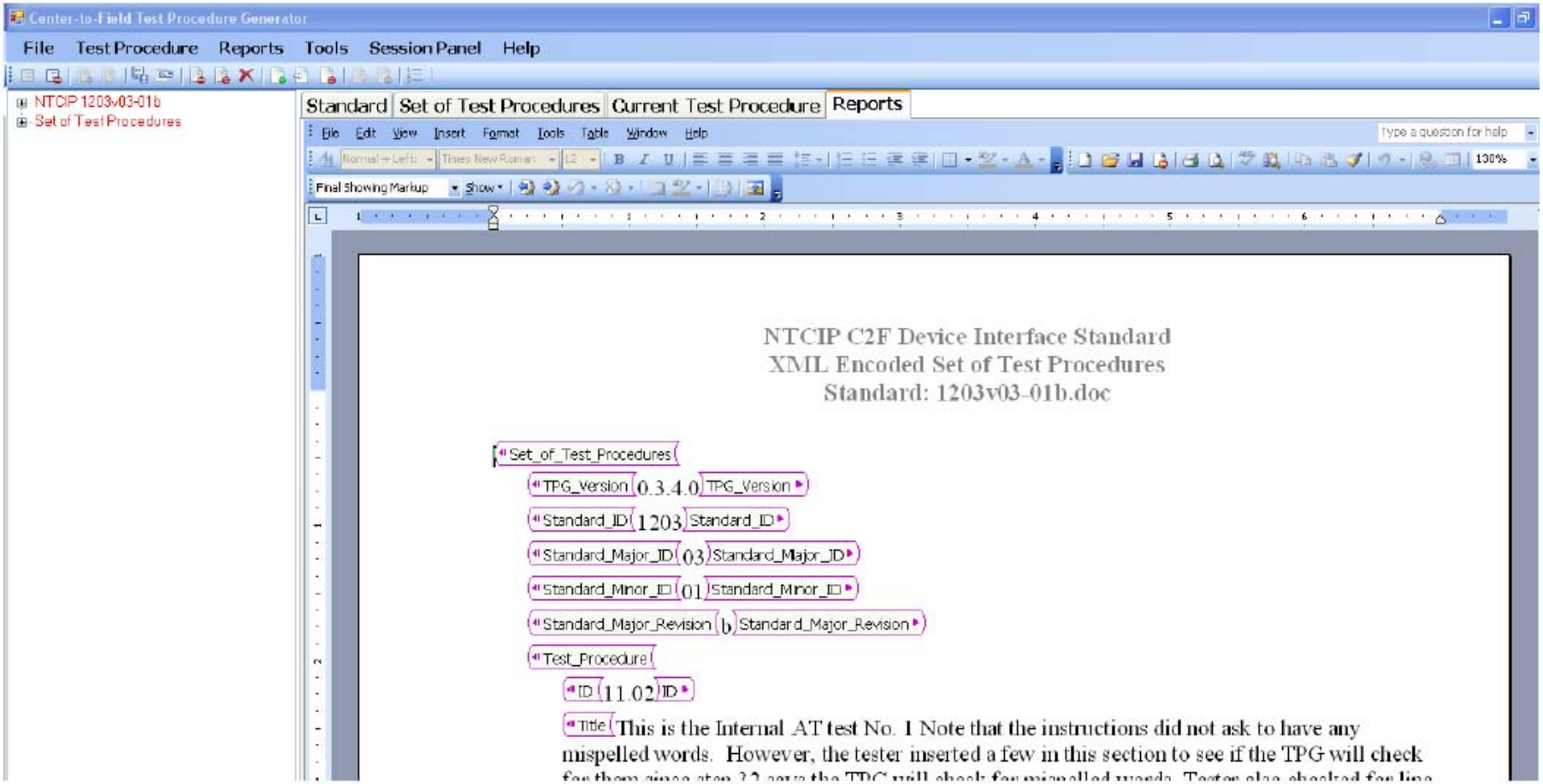
Saving XML Test Procedure



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

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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

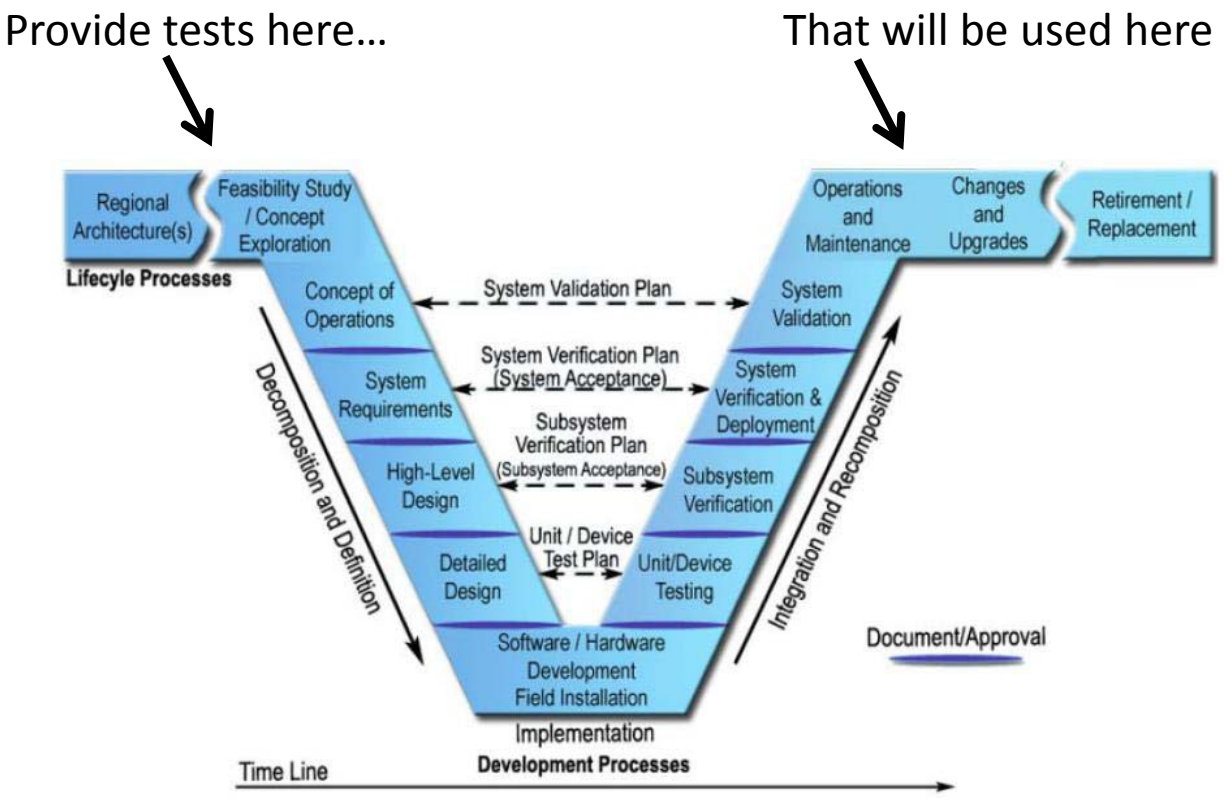
Plan the Test Procedure from the Beginning

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

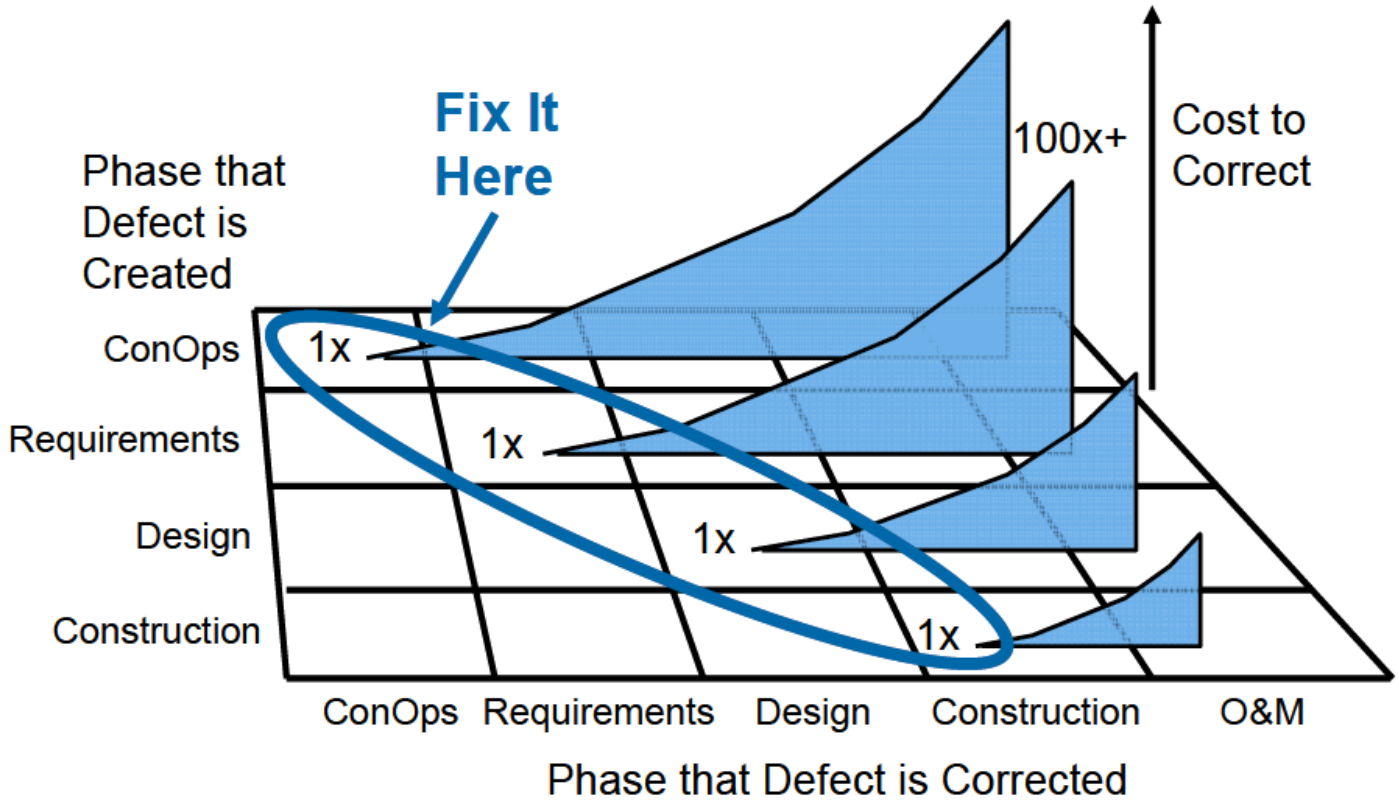
How to Avoid Repetition of Failure

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

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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
- PCB Website: Module T201, T202 Available http://www.pcb.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?

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