Welcome

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

www.pcb.its.dot.gov
T307: Applying Your Test Plan to the Advanced Transportation Controller Based on ATC 5201 Standard v06

Source: Siemens Industry Inc.
Instructor

Dave Miller

Principal Systems Engineer
Siemens Industry, Inc.
RC-US MO MM-ITS S OPS
Austin, Texas, USA
Learning Objectives

Identify key elements of ATC 5201 Standard equipment for testing documentation

Describe within the context of a systems engineering lifecycle the role of a test plan and the testing to be undertaken

Describe the application of good testing documentation for transportation controller equipment based on the ATC 5201 v06 Standard

Describe the testing of ATC using sample testing documentation
Learning Objective 1

Identify key elements of ATC 5201 Standard Equipment for Testing Documentation
Key Elements of ATC 5201 Standard v06

What Is the Purpose of This Module?

This module teaches user agencies how **to create** ATC Testing documentation based on:

- ATC 5201 v06 Standard requirements
- Agency ATC procurement configuration
- IEEE 829-2008 formats
Key Elements of ATC 5201 Standard v06

Why Do We Need ATC Testing Documentation?

Guides us in conducting the test process to establish **conformance** to the standard, **compliance** to agency ATC configuration, and **compatibility** among concerned objects-modules of ATC.
Key Elements of ATC 5201 Standard v06

What Is Advanced Traffic Controller (ATC)?

ATC is a **general purpose** field-computing platform for transportation applications (Hardware/Software)

**Examples of ATC Units**

See Modules A307a and A307b for details

Photos: Econolite, Intellitech, McCain, Peek, Siemens, and Trafficware
Key Elements of ATC 5201 Standard v06

How Is ATC Used?

- ATC 5201 standard applies to multiple transportation applications:
  - Traffic Signal Control/Traffic Management
  - Transit/Light Rail Priority
  - Emergency Management
  - Lane Use
  - Red Light Enforcement
  - Speed Monitoring/Enforcement
  - Access Control
  - Advanced Traveler Information Systems (ATIS)
  - Data Collection Systems
  - Connected Vehicle (CV) Applications

ATC testing will be affected by applications running on the ATC Units.
What Needs to Be Tested

What Is Included in the Standard: ATC Major Objects and Interfaces

- A large number of objects (approx. 73) are included in the standard from which an agency creates a **procurement configuration**:
  - **Mandatory** (Core) Objects are *always* included in procurement
  - **Optional** Objects are selected as per user needs

- **Testing Documentation** includes what is being purchased by an agency (Mandatory + Optional)
  - We will call it a **Procurement Configuration**
What Needs to Be Tested

What Is Included in the Standard: Environmental Conditions

ATC 5201 Standard, Section 8:

- **1st Article** conformance/qualification
- Minimum list of test procedures
- Normative references to NEMA TS2
- Useful for Master Test Plan (MTP)
- Can be conducted by:
  - End user agency laboratory
  - Independent laboratory
What Needs to Be Tested

What Is NOT Included in the ATC 5201 v06 Standard

- Applications Programing Interface (API) is NOT included
  (See Modules A308a and A308b and upcoming Module T308)

- Signal Control software is NOT covered by this standard

- This standard is NOT SEP-based, hence User Needs and Requirements are NOT available for testing documentation
  (see A307a and A307b Understanding User Needs/Requirements)
What Needs to Be Tested

Diagnostic Acceptance Test (DAT)

1. DAT is performed on the first article ATC unit and is part of the preproduction or pre-deployment process
2. DAT not typically performed on all units deployed
3. Production Testing is performed on all units deployed
4. ATC 5201 DAT: Environmental and Operating section
5. Manufacturers typically use automated self-test DAT
6. Agencies typically use automated self-test DAT

8.5.2 Transients, Power Service (DAT)

The ATC unit under test shall meet all requirements as defined in NEMA TS2, Section 2.1.6, Transients, Power Service.

8.5.3 Nondestructive Transient Immunity (DAT)

The ATC unit under test shall meet all requirements as defined in NEMA TS2, Section 2.1.8, Nondestruct Transient Immunity, with the following variations:

- Test voltage amplitude shall be 2000 ± 100 V, both positive and negative polarity.
What Needs to Be Tested

Suggested Approach to Preparing Testing Documentation

1. Consult Module A307b for guidance on identifying **Mandatory** and **Optional** objects and related **requirements**

2. Identify **essential** areas that must be addressed for conformance to the standard:
   - Operational Voltages
   - I/O Requirements
   - User Interface Requirements
   - CPU Performance and Memory Requirement
   - Other Requirements

3. Consider Cabinet Standards **influence**

4. Assess Agency Procurement **Configuration**

**Mandatory objects are ALWAYS included in all procurement Configuration**
What Needs to Be Tested

Review of Mandatory (Core) + Optional Objects

- Ethernet Ports (4 Mandatory)
  - NTCIP Network
  - Network Diagnostics
  - Roadside Equipment
  - ATC Diagnostics
- ATC CORE (Mandatory)
- USB Port (1 Mandatory)
  - USB 2.0
  - ASCII Characters
  - ASCII Keystrokes
- 8-Line User Interface (Optional)
- Housing (Optional)
- Serial Ports (EIA-485)
- Input States & Output States (EIA-485)
- Communications Interface(s) (Optional)
- Media
- Field I/O (Optional)
- Field Devices
What Needs to Be Tested

Mandatory Hardware Objects:
Engine Board, Memory, and Operating System (OS)
What Needs to Be Tested

Mandatory Engine Board Requirements Must be Tested

- Microprocessor
- Two Ethernet Ports
- Real Time Clock
- Memory
- Serial Inputs/Outputs
- Serial Peripheral Interface
- Standardized Connectors
What Needs to Be Tested

Mandatory Engine Board

- Microprocessor
What Needs to Be Tested

Mandatory Engine Board

- Microprocessor
- Two Ethernet Ports
What Needs to Be Tested

Mandatory Engine Board

- Microprocessor
- Two Ethernet Ports
- Real Time Clock
What Needs to Be Tested

Mandatory Engine Board

- Microprocessor
- Two Ethernet Ports
- Real Time Clock
- Memory
What Needs to Be Tested

Mandatory Engine Board

- Microprocessor
- Two Ethernet Ports
- Real Time Clock
- Memory
- Serial Inputs/Outputs
What Needs to Be Tested

Mandatory Engine Board

- Microprocessor
- Two Ethernet Ports
- Real Time Clock
- Memory
- Serial Inputs/Outputs
- Serial Peripheral Interface
What Needs to Be Tested

- Microprocessor
- Two Ethernet Ports
- Real Time Clock
- Memory
- Serial Inputs/Outputs
- Serial Peripheral Interface
- Standardized Connectors
What Needs to Be Tested

Mandatory Objects: Host Module
Ethernet Ports/Internet Protocol (IP) Communications
What Needs to Be Tested

Mandatory Host Module Requirements Must Be Tested

- (2) Ethernet Switches
- (4) RJ-45 Ports
- (1) Comm Slot 1
- (1) USB
- ID EEPROM
- Standardized Connectors
- Accepts Engine Board
Mandatory User Interface Requirements Must Be Tested

Source: Module A307b

- CPU ACTIVE LED Indicator
- Ethernet Port
- USB Port (for removable memory device only)

OR

- EIA-574, 9-pin “D” serial connector for console
- 8P8C modular jack, serial connector for console

OR

- EIA-574, 9-pin “D” connector for an external front panel
- Keyboard, Liquid Crystal Display (LCD), Bell
What Needs to Be Tested

Mandatory Hardware Objects:
Power Supply and Power Fail/Restart Operation
What Needs to Be Tested

Mandatory Power Supply Requirements Must Be Tested

- Converts service voltage to DC
- Time Base
- Power UP signal
- Power DOWN signal
- Power conditioning

Source: Siemens Industry Inc.
What Needs to Be Tested

Mandatory Operational Voltage Requirements Must Be Tested

5.6.1 Operating Voltage

The transportation controller shall meet the operating voltage requirements per Section 2.1.2 of the NEMA TS 2 Standard.

5.6.2 Operating Frequency

The transportation controller shall meet the operating frequency requirements per Section 2.1.3 of the NEMA TS 2 Standard.

5.6.3 Power Interruptions

The transportation controller shall meet the power interruption requirements per Section 2.1.4 of the NEMA TS 2 Standard.
What Needs to Be Tested

Optional Objects Examples

Must be Tested, if Included in an Agency Procurement Configuration
CASE STUDY
Case Study: NEMA TS 2 Cabinet Compatibility Requirements

NEMA TS 2 Cabinet Compatibility Requirements

- Agency already has a TS 2 cabinet
- Agency needs ATC Installation
- Procurement Configuration requires a NEMA TS 2 cabinet interface

Testing Task:
Check for compatibility in such a configuration
Case Study: NEMA TS 2 Cabinet Compatibility Requirements

- Needs require **NEMA FIO, Shelf-Mount Housing, Display**
  - Need for TS2 cabinet compatibility is to be met by the requirement for a **mandatory** TS2 power supply calibration and an **optional** FIO with NEMA ABC connectors

How it will be verified

For procurement-testing, a Test Flow must be developed to ensure (verify) that:

- ATC is configured correctly
- Each ATC element is tested
- All ATC objects configured into an ATC will work correctly in a TS2 cabinet
**What Needs to Be Tested**

**Needs to Requirements Traceability Matrix**

See Module A307b

<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>UN001</td>
<td>Compliant to ATC 5201 v06</td>
<td>M</td>
<td>Yes</td>
<td>M</td>
<td>Yes</td>
<td>Verify to ATC 5201 Engine Board section</td>
</tr>
<tr>
<td>FR001</td>
<td>Configuration shall include Engine Board</td>
<td>M</td>
<td>Yes</td>
<td>M</td>
<td>Yes</td>
<td>Verify to ATC 5201 Host Module section</td>
</tr>
<tr>
<td>FR002</td>
<td>Configuration shall include Host Module</td>
<td>M</td>
<td>Yes</td>
<td>M</td>
<td>Yes</td>
<td>Verify to ATC 5201 Host Module section</td>
</tr>
<tr>
<td>FR003</td>
<td>Configuration shall include Power Supply</td>
<td>M</td>
<td>Yes</td>
<td>M</td>
<td>Yes</td>
<td>Verify to ATC 5201 Power Supply section</td>
</tr>
<tr>
<td>FR008</td>
<td>Configuration shall include IP communications to TMC</td>
<td>M</td>
<td>Yes</td>
<td>M</td>
<td>Yes</td>
<td>Verify to ATC 5201 network switch section</td>
</tr>
</tbody>
</table>

Entries can be extended to include Mandatory and Optional FR as per agency procurement configuration.
What Needs to Be Tested

Mandatory (Core) Software Objects Must Be Tested

Mandatory Linux OS and Drivers always require testing
What Is NOT to Be Tested

Software Objects Not Part of ATC Standard, Not Tested

API & Signal Control software applications are not included
Capture Open Source Linux IP Obligations Within the Contract Terms and Conditions

Open Source Obligations

- Establish clear and unambiguous ownership of IP and derivative works

- [https://opensource.org/osd-annotated](https://opensource.org/osd-annotated)

- ATC includes an Open Source Linux OS

ATC Manufacturer XYZ

Open Source Declaration

Version 2.3

October 8, 2016
Board Support Package (BSP)

- **Library** and **tools** to compile and load 3rd party software for that ATC
- **Required** by ATC 5201 v06
- **No BSP: Not ATC compliant**
Capture Open Source Linux IP Obligations Within the Contract Terms and Conditions

Open Source Terms and Conditions

- Ensure ATC Standard **Open Source Linux** objects are delivered
- Declaration
- Licenses
- BSP

Open Source Terms and Condition

________________________________________
________________________________________
________________________________________
________________________________________
________________________________________
________________________________________
________________________________________
What is NOT an ATC procurement deliverable?

**Answer Choices**

a) Open Source Declaration  
b) Board Support Package (BSP)  
c) Application Program Interface (API)  
d) Open Source Distribution Licenses
Review of Answers

a) Open Source Declaration

Incorrect. *Open Source Declaration is required in the contract terms to verify ownership and source of software included in ATC by an examination of the Open Source license terms by Legal.*

b) Board Support Package (BSP)

Incorrect. *BSP is required as part of the ATC delivery to be compliant to ATC 5201 Standard.*

c) Application Program Interface (API)

Correct! *API is controlled by a standard that is separate from ATC 5201. ATC software can be built using the BSP to run directly on the Linux operating system without the API.*

d) Open Source Distribution Licenses

Incorrect. *Open Source software is distributed under license agreements, such as Apache™, verified by license document.*
Learning Objectives

Identify key objects of ATC 5201 Standard equipment for testing documentation

Describe within the context of a systems engineering lifecycle the role of a test plan and the testing to be undertaken
Learning Objective 2

Describe within the context of a systems lifecycle the role of a test plan and the testing to be undertaken
Test Documentation Purpose

- Test documentation is a general term used to describe unambiguous and **common understanding** among all stakeholders to:
  - Outline what to test (**requirements**)
  - Describe how to test (**process**)
  - **IEEE 829-2008** formats are used to prepare documentation

- For whom and why do we need test documentation?
Key part of test documentation is ATC **Test Plan**, which identifies Test Design, Test Case, and Test Procedure documents.
Test Plan Structure Based on IEEE 829-2008

**Test Plan** describes the Overall Approach to Testing

**Test Design** specifies the details of the test approach; shown here for *unit test* – similar design exists for Integration Test and Acceptance Test

**Test Case specification** outlines a set of test inputs, execution conditions, and expected results

**Test Procedure specification** defines the steps to execute a test
ATC Test Plan is an Agency-prepared document that is used to document the following:

- Scope (technical management)
- Approach
- Resources needed
- Schedule to complete the project

Test Plan identifies

- Test items (ATC objects)
- Features to be tested (Requirements)
- Testing Tasks
- Risks requiring contingency plan

Source: FHWA ITS Lab
The main purpose of test design is to specify what is to be tested in terms of ATC units and requirements.

- Test Design traces to Test Cases and Test Procedures
- All three parts of Test Plan are used to verify ATC requirements.
Purpose, Structure, and Content of a Well-Written Documentation Based on IEEE 829-2008

Documentation for Reporting Test Results/Outcomes

Prepared During and After Testing

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

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

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

- **Summarizes the results/evaluations/recommendations**
  - Level Test Report (LTR)

Test Plan Execution (Process)
ACTIVITY
Which is part of an Agency’s ATC Testing Documentation?

Answer Choices

a) Scope
b) Approach
c) Resources and Schedule
d) All of the above
Review of Answers

a) Scope

Incorrect. Testing scope is always part of the Agency-prepared ATC testing documentation. It should include what is specifically not included in the scope, for clarity.

b) Approach

Incorrect. Test approach is always included to identify equipment needed, for example.

c) Resources and Schedule

Incorrect. Testing scope and approach without identified and agreed resources and schedule will be unsuccessful.

d) All of the above

Correct! All are part of the Agency-prepared ATC testing documentation.
Learning Objectives

Identify key objects of ATC 5201 Standard equipment for testing documentation

Describe within the context of a systems engineering lifecycle the role of a test plan and the testing to be undertaken

Describe the application of good testing documentation for transportation controller equipment based on the ATC 5201 v06 Standard
Learning Objective 3

Describe the **application** of good testing documentation for transportation controller equipment based on the ATC 5201 v06 Standard
Key Elements of ATC 5201 Standard v06 Tied to What Is Covered by a Test Plan

- Needs to Requirements Traceability Matrix (NRTM)
  - Answers “What needs to be tested”
- Requirements Traceability Matrix (RTM)
  - Answers “What section or part of the standard (design)” is affected

Note: The ATC 5201 v06 standard does NOT provide NRTM and RTM; The user must develop them for testing documentation
Summary of a Test Plan (Testing Process)

- Testing process is about verifying a requirement
  - Each (identified) requirement is to be **tested**
  - Each requirement validated by testing is **traced to a Test Case** in the Requirement Test Case Traceability Matrix (RTCTM)
  - Each Test Case lists one or more Test Procedures that end with **Pass/Fail** declaration

Note: User must develop RTCTM for testing process in the Test Design
NRTM Identifies “What Is to Be Tested”

NRTM Contains NEMA TS2 ATC Configuration with Requirements

<table>
<thead>
<tr>
<th>UN ID</th>
<th>User需</th>
<th>FR ID</th>
<th>Functional要求</th>
<th>Conformance</th>
<th>Support</th>
<th>Additional Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.5.1</td>
<td>NEMA TS 2 Equipment</td>
<td>5.2.1</td>
<td>NEMA TS 2 Type 2 Interfaces</td>
<td>M</td>
<td>Yes</td>
<td>ATC 5201 v06 used with NEMA TS 2 Cabinet Configuration</td>
</tr>
<tr>
<td>5.6.1</td>
<td>NEMA Operating Voltages</td>
<td>M</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.6.2</td>
<td>NEMA Operating Frequencies</td>
<td>M</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.6.3</td>
<td>NEMA Power Interruptions</td>
<td>M</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.3.1</td>
<td>Minimum Display Size</td>
<td>5.3.3</td>
<td>Text-Based Display Size</td>
<td>O</td>
<td>Yes/NO</td>
<td></td>
</tr>
</tbody>
</table>
### Key Elements of ATC 5201 Standard v06 Tied to What Is Covered by a Test Plan

#### RTM Traces to HW & SW Objects from Standard for Testing

#### Requirements to ATC 5201 v06 Standard Cross-Reference

<table>
<thead>
<tr>
<th>Req ID</th>
<th>Requirement</th>
<th>Standard Ref</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.2.1.1</td>
<td>NEMA TS2 Type 2 Interfaces</td>
<td>7.2.2</td>
<td>Parallel Connected to NEMA TS-1 or TS2 Type 2 Cabinets</td>
</tr>
<tr>
<td>5.2.1.2</td>
<td>NEMA TS2 Operating Voltage</td>
<td>6.2.6.1</td>
<td>Line and Load Regulation</td>
</tr>
<tr>
<td>5.2.1.3</td>
<td>NEMA Operating Frequencies</td>
<td>8.5.1.2</td>
<td>Operating Frequency</td>
</tr>
<tr>
<td>5.2.1.4</td>
<td>NEMA Power Interruption</td>
<td>6.2.5.1</td>
<td>Power Up and Power Down</td>
</tr>
<tr>
<td>5.3.3</td>
<td>Text-Based Display Size</td>
<td>6.1.4.1</td>
<td>Keyboard LCD and Bell Operation</td>
</tr>
</tbody>
</table>

ID numbers are user-assigned
Elements of ATC 5201 Standard v06 Tied to What Is Covered by a Test Plan

NRTM + RTM Specify Procurement Configuration, Which Answers What an Agency Desires in ATC Units

Both NRTM and RTM are used in the development of an RTCTM, which actually states what will be tested.
RTCTM Traces Each Requirement to Test Cases, Which Are Used in the Testing Process

<table>
<thead>
<tr>
<th>Rq. ID</th>
<th>Requirement</th>
<th>TC ID</th>
<th>ATC 5201 Reference and Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR010</td>
<td>ATC configuration shall include TS2 Type 2 FIO</td>
<td>TC010</td>
<td>7.2.2 Parallel Connections to NEMA TS-1 or TS2 Type 2 Cabinets</td>
</tr>
<tr>
<td>FR020</td>
<td>Signal control source code shall compile and load using Board Support Package tool</td>
<td>TC020</td>
<td>3.3.1 Board Support Package</td>
</tr>
<tr>
<td>FR030</td>
<td>ATC configuration shall include Front Panel</td>
<td>TC030</td>
<td>6.1.1 Minimum User Interface</td>
</tr>
<tr>
<td>FR040</td>
<td>ATC Front Panel shall include 8 lines for data entry plus 8 lines for status</td>
<td>TC040</td>
<td>6.1.4.1 Keyboard, LCD and Bell Operation</td>
</tr>
<tr>
<td>FR050</td>
<td>ATC Front panel data entry keys shall conform to the ATC 5201 key codes</td>
<td>TC050</td>
<td>Table 6-4 Configuration Command Codes</td>
</tr>
</tbody>
</table>
### Key Elements of the Conformance Statement

**How Does Test Case Perform Conformance to the ATC Standard?**

<table>
<thead>
<tr>
<th>ID: TC001</th>
<th>Title: Power Fail / Restart</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective:</strong></td>
<td></td>
</tr>
</tbody>
</table>
| **This is a Mandatory Requirement Test Case** | 1. To verify power fail and restart conformance to ATC 5201  
2. The test case verifies that the ATC is unaffected by service power interruptions between zero and 475 ms  
3. The Test Case verifies that the ATC restarts when service power is interrupted for a period of time greater than 550 ms |
| **Inputs:** | Service Voltage |
| **Outcome(s):** | Test will ascertain expected outcomes |
| **Environmental Needs:** | |
| **Special Procedural Requirements:** | Repeat at 100 VAC and 135 VAC |
| **Intercase Dependencies:** | None |
A Test Procedure Is the Last Step in Testing Process; It “Brings Out” Results

Results will confirm expectations (PASS) or NOT confirm (FAIL)

<table>
<thead>
<tr>
<th>Step</th>
<th>Test Procedure</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Set input voltage to 120 VAC</td>
<td>DUT restarts and runs the FIT test</td>
</tr>
<tr>
<td>2</td>
<td>Set input frequency to 60 Hz</td>
<td>DUT runs the FIT test continually</td>
</tr>
<tr>
<td>3</td>
<td>Interrupt the power for 500 ms</td>
<td>DUT issues Power Down, does not restart</td>
</tr>
<tr>
<td>4</td>
<td>Interrupt power for 1,000 ms</td>
<td>DUT issues Power Down and restarts</td>
</tr>
</tbody>
</table>
Key Elements of the Conformance Statement

Issues Affecting ATC 5201 v06 Conformance

- ATC 5201 v5.2b was published on 9/25/2006
- After five years, standards are reaffirmed or maintained
- During maintenance, ATC 5201 v5.2b remained in effect
- Once published, ATC 5201 v06 takes effect
- Cannot conform to both v5.2b and v06
### Key Elements of the Conformance Statement

**ATC 5201 Standards Conformance Statement from a Manufacturer**

**Conformance Statement** includes the level of conformance and to which version of the 5201 Standard.

**Example of a Conformance Statement**

<table>
<thead>
<tr>
<th>ver</th>
<th>Section</th>
<th>Wording</th>
<th>Implemented</th>
</tr>
</thead>
<tbody>
<tr>
<td>v5.2b</td>
<td>4.4.3</td>
<td>Operates as 4 Serial Peripheral Interface (SPI) device selects</td>
<td>4-bit binary Per v6.0</td>
</tr>
<tr>
<td>v6.0</td>
<td></td>
<td>Operates as 4-bit binary, 16 SPI devices</td>
<td></td>
</tr>
<tr>
<td>v5.2b</td>
<td>8.3</td>
<td>Two internal 100BASE-TX Hub</td>
<td>Two internal switches</td>
</tr>
<tr>
<td>v6.0</td>
<td>7.3</td>
<td>Two internal switches or two VLANS</td>
<td></td>
</tr>
</tbody>
</table>
What is the primary purpose of RTCTM?

**Answer Choices**

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

a) Sets the testing workflow sequences

Incorrect. Testing workflow is part of the ATC Unit Test Plan.

b) Correlates User Needs to Requirements

Incorrect. User Needs to Requirements are part of the NRTM, not RTCTM.

c) Contains only test cases

Incorrect. RTCTM contains test cases with inputs and expected outcomes.

d) Traces Requirement to Test Case

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

Identify key elements of ATC 5201 Standard equipment for testing documentation

Describe within the context of a systems engineering lifecycle the role of a test plan and the testing to be undertaken

Describe the application of good testing documentation for transportation controller equipment based on the ATC 5201 v06 Standard

Describe the testing of ATC using sample testing documentation
Learning Objective 4

Describe the testing of ATC using sample testing documentation
Testing Documentation

- Testing documentation for a given project is driven by **procurement configuration**
- Documentation is based on **IEEE Standard 829** formats
- Test Cases are carried out with one or more Test Procedures

![Diagram showing the relationship between Unit Test Plan (LTP), Unit Test Design, and Unit Test Cases and Procedures](Diagram.png)
Let’s Review What Should Be in an ATC TEST Plan

- Test Plan identifies
- Test items (ATC Elements)
- Features to be tested (Requirements)
- Testing Tasks
- Risks requiring contingency plan

1.0 Introduction
1.1 Testing Documentation Identifier, for example ATCCommTP v01.01
1.2 Scope
1.3 References
1.4 Level Test Plan Testing to be Covered

2.0 Details of LTP: Unit/Bench Testing
2.1 Test items and their identifiers
2.2 RCTM (Test Design/Test Procedures)
2.3 List of ATC Features to be tested
2.4 Objects to be tested (RTM)
2.5 Approach
2.6 Item Pass/Fail criteria
2.7 Suspension Criteria/ Resumption Requirements
Applying Testing Documentation to ATC Testing Process

Let’s Review What Should Be in an ATC TEST Plan (cont.)

Developing an ATC 5201 Test Design

- Specifies the details of the test approach
- Identifies features to be tested
- Identifies the requirements to be tested

Verify ATC mandatory elements are included and functional
Verify optional ATC elements are included & operational to meet User Needs
Verify ATC software elements are included as required by Appendix “A” & “B”
Verify BSP is included to compile and load software applications

SUPPLEMENT
Applying Testing Documentation to ATC Testing Process

Let’s Review What Should Be in an ATC TEST Plan (cont.)

- Verify ATC mandatory elements are included and functional
- Verify optional ATC elements are included & operational to meet User Needs
- Verify ATC software elements are included as required by Appendix “A” & “B”
- Verify BSP is included to compile and load software applications

Developing an ATC 5201 Test Design
- Specifies the details of the test approach
- Identifies features to be tested
- Identifies the requirements to be tested

- Verify fitness test source code is included
- Verify that BSP can compile and load fitness test into ATC
- Verify that BSP can compile and load signal control or other applications
- Verify environmental compliance, either
  - Create Test Plan and conduct environmental tests per ATC 5201 v06 Section 8, or
  - Require copy of independent laboratory tests per ATC 5201 v06 Section 8
Applying Testing Documentation to ATC Testing Process

ATC Testing Process

Device Under Test (DUT)

- ATC Test Plan
- Test Design
- Test Cases
- Test Procedures
- Test Results
- Test Logs
- Anomaly Reports
Apply the Process and Write a Test Plan to Verify ATC 5201 v06 Requirements

Case Study for TS2 Type 2 Cabinet Retrofit

Our Approach to the ATC Test Plan

1. Configure ATC from Core & Options
2. Prepare testing plan
3. Include it in ATC Procurement Specification

City of Midsize ATC Procurement Specification
Case Study for TS2 Type 2 Cabinet Retrofit

City of Midsize ATC
Procurement Specification

- Retrofit of ATC into NEMA TS2 Type 2 electrical cabinets
- Compatible with existing Traffic Signal Control software application
- Front panel text display of controller status and keys for data entry
- Ethernet IP communications, no serial modems
- Project User Needs of each stakeholder and RTM are included
Case Study for TS2 Type 2 Cabinet Retrofit

Our Approach to the ATC Test Plan

- First examine and determine: configure ATC from Core and Options
- Second, prepare testing plan; test design that includes configuration
- Test Plan itself is made part of ATC contact documentation

Given:

<table>
<thead>
<tr>
<th>TS2 Type 1 Wiring</th>
<th>Existing Signal Control App</th>
<th>Text Data Entry</th>
<th>IP Comm</th>
</tr>
</thead>
</table>

Apply the Process and Write a Test Plan to Verify ATC 5201 v06 Requirements
Apply the Process and Write a Test Plan to Verify ATC 5201 v06 Requirements

Let’s Determine What Needs to Be Tested
Let’s List What Needs to Be Tested in This Use Case

- Mandatory Core
- Ethernet Ports
- User Interface front panel
- TS2 Type 2 Parallel I/O
- Shelf-mount housing
Verify Mandatory Objects of ATC 5201 v06 for Compliance

Mandatory Objects to Be Tested

1. Engine Board interchangeable among manufacturers
2. Host Module that accepts the Engine Board
3. Power Supply that converts service power to voltages and control signals
4. Linux Operating System and drivers per ATC 5201 v06 Appendix “A” & “B”
5. Board Support Package of software development tools and libraries
6. Diagnostic and Acceptances Test source code and instructions
Apply the Process and Write a Test Plan to Verify ATC 5201 v06 Requirements

NRTM Shows the **Mandatory Objects** That Must Be Tested

Standard requires these Minimal Set

<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>UN001</td>
<td>Compliant to ATC 5201 v06</td>
<td></td>
<td></td>
<td>M</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR001</td>
<td>Configuration shall include Engine Board</td>
<td>M</td>
<td>Yes</td>
<td>Verify to ATC 5201 Engine Board section</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR002</td>
<td>Configuration shall include Host Module</td>
<td>M</td>
<td>Yes</td>
<td>Verify to ATC 5201 Host Module section</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR003</td>
<td>Configuration shall include Power Supply</td>
<td>M</td>
<td>Yes</td>
<td>Verify to ATC 5201 Power Supply section</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR004</td>
<td>Configuration shall include Appendix A and B</td>
<td>M</td>
<td>Yes</td>
<td>Verify Appendix “A”, “B” to Linux shell listing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR005</td>
<td>Vendor shall supply Board Support Package</td>
<td>M</td>
<td>Yes</td>
<td>Verify receipt of BSP for use by SW vendor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR006</td>
<td>Vendor shall include DAT software source code</td>
<td>M</td>
<td>Yes</td>
<td>Verify receipt of BSP for use for Shop Testing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR007</td>
<td>Vendor shall independent lab environmental test report</td>
<td>M</td>
<td>Yes</td>
<td>Verify per ATC 5201 environmental test</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR008</td>
<td>Configuration shall include IP communications to TMC</td>
<td>M</td>
<td>Yes</td>
<td>Verify to ATC 5201 network switch section</td>
</tr>
</tbody>
</table>
Apply the Process and Write a Test Plan to Verify ATC 5201 v06 Requirements

NRTM shows the **Mandatory Objects** That Must 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>UN001</td>
<td>Compliant to ATC 5201 v06</td>
<td>FR001</td>
<td>Configuration shall include Engine Board</td>
<td>M</td>
<td>Yes</td>
<td>Verify to ATC 5201 Engine Board section</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR002</td>
<td>Configuration shall include Host Module</td>
<td>M</td>
<td>Yes</td>
<td>Verify to ATC 5201 Host Module section</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR003</td>
<td>Configuration shall include Power Supply</td>
<td>M</td>
<td>Yes</td>
<td>Verify to ATC 5201 Power Supply section</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR004</td>
<td>Configuration shall include Appendix A and B</td>
<td>M</td>
<td>Yes</td>
<td>Verify Appendix “A”, “B” to Linux shell listing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR005</td>
<td>Vendor shall supply Board Support Package</td>
<td>M</td>
<td>Yes</td>
<td>Verify receipt of BSP for use by SW vendor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR006</td>
<td>Vendor shall include DAT software source code</td>
<td>M</td>
<td>Yes</td>
<td>Verify receipt of BSP for use for Shop Testing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR007</td>
<td>Vendor shall independent lab environmental test report</td>
<td>M</td>
<td>Yes</td>
<td>Verify per ATC 5201 environmental test</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR008</td>
<td>Configuration shall include IP communications to TMC</td>
<td>M</td>
<td>Yes</td>
<td>Verify to ATC 5201 network switch section</td>
</tr>
</tbody>
</table>
Apply the Process and Write a Test Plan to Verify ATC 5201 v06 Requirements

NRTM shows the **Optional Objects** That Must be Tested

These objects are Selected by Agency

<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>UN001</td>
<td>Installation in NEMA TS2 Type 2 cabinet</td>
<td>FR010</td>
<td>ATC configuration shall include TS2 Type 2 FIO</td>
<td>O</td>
<td>Yes</td>
<td>Verify to ATC 5201 FIO section for TS2</td>
</tr>
<tr>
<td>UN002</td>
<td>Use of existing signal control application</td>
<td>FR020</td>
<td>Signal control source code shall compile and load using Board Support Package tool</td>
<td>O</td>
<td>Yes</td>
<td>Verify to ATC 5201 Board Support Package section</td>
</tr>
<tr>
<td>UN003</td>
<td>Technician enter data while displaying status</td>
<td>FR030</td>
<td>ATC configuration shall include Front Panel</td>
<td>O</td>
<td>Yes</td>
<td>Verify to ATC 5201 Front Panel section</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR040</td>
<td>ATC Front Panel shall include 8 lines for data entry plus 8 lines for status</td>
<td>O</td>
<td>Yes</td>
<td>8 lines are minimum for ATC 5201, 16 lines is special provision</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR050</td>
<td>ATC Front panel data entry keys shall conform to the ATC 5201 key codes</td>
<td>O</td>
<td>Yes</td>
<td>Verify using DAT application by pressing each key, observe code</td>
</tr>
</tbody>
</table>
Apply the Process and Write a Test Plan to Verify ATC 5201 v06 Requirements

NRTM Shows the **Optional Objects** That Must Be Tested

These objects are Selected by Agency

<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>UN001</td>
<td>Installation in NEMA TS2 Type 2 cabinet</td>
<td>O</td>
<td>Yes</td>
<td>Verify to ATC 5201 FIO section for TS2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UN002</td>
<td>Use of existing signal control application</td>
<td>O</td>
<td>Yes</td>
<td>Verify to ATC 5201 Board Support Package section</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UN003</td>
<td>Technician enter data while displaying status</td>
<td>O</td>
<td>Yes</td>
<td>Verify to ATC 5201 Front Panel section</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FR030</td>
<td>ATC configuration shall include Front Panel</td>
<td>O</td>
<td>Yes</td>
<td>Verify using DAT application by pressing each key, observe code</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FR040</td>
<td>ATC Front Panel shall include 8 lines for data entry plus 8 lines for status</td>
<td>O</td>
<td>Yes</td>
<td>8 lines are minimum for ATC 5201, 16 lines is special provision</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FR050</td>
<td>ATC Front panel data entry keys shall conform to the ATC 5201 key codes</td>
<td>O</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Test Traceability Matrix

### ATC 5201 Test Traceability

#### Traceability: Requirements to Test Case to Test Procedure

<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>FR001</td>
<td></td>
<td>TC001</td>
<td>Power Fail Immunity: Power Interruption of &lt; 500 mS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TP001</td>
<td>Verify DUT operation is unaffected</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TP003</td>
<td>Verify no Power Down signal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TC002</td>
<td>Restart Operation: Power Failure of &gt; 1,000 mS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TP004</td>
<td>Verify DUT restarts</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TP005</td>
<td>Verify Power Down signal</td>
</tr>
<tr>
<td>FR002</td>
<td></td>
<td>TC 003</td>
<td>Time Accuracy during variable power failures</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TP006</td>
<td>500 mS: Verify time accuracy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TP007</td>
<td>1 hour: Verify time accuracy</td>
</tr>
</tbody>
</table>
### Prepare RTCTM for Testing Documentation

<table>
<thead>
<tr>
<th>Rq. ID</th>
<th>Requirement</th>
<th>TC ID</th>
<th>ATC 5201 Reference and Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR010</td>
<td>ATC configuration shall include TS-2 Type 2 FIO</td>
<td>TC010</td>
<td>7.2.2 Parallel Connections to NEMA TS-1 or TS-2 Type 2 Cabinets</td>
</tr>
<tr>
<td>FR020</td>
<td>Signal control source code shall compile and load using Board Support Package tool</td>
<td>TC020</td>
<td>3.3.1 Board Support Package</td>
</tr>
<tr>
<td>FR030</td>
<td>ATC configuration shall include Front Panel</td>
<td>TC030</td>
<td>6.1.1 Minimum User Interface</td>
</tr>
<tr>
<td>FR040</td>
<td>ATC Front Panel shall include 8 lines for data entry plus 8 lines for status</td>
<td>TC040</td>
<td>6.1.4.1 Keyboard, LCD and Bell Operation</td>
</tr>
<tr>
<td>FR050</td>
<td>ATC Front panel data entry keys shall conform to the ATC 5201 key codes</td>
<td>TC050</td>
<td>Table 6-4 Configuration Command Codes</td>
</tr>
</tbody>
</table>

**All requirements from NRTM now entered in RTCTM**

**Each requirement traced to a design-element in the standard sections**

A Test Case will be carried out in testing process
Check for Error Conditions

- **Positive testing:**
  - **Validate** input value, i.e., Key Code
  - **Expected outputs** from Device Under Test (DUT) in Table 6-6

- **Negative testing:**
  - Assert **invalid input** values or sequences per the test procedure, such as invalid key codes.
  - **Errors** are examined for next action on test continuity.

See Table 6-6: Key Press Codes
Address Consequences of Testing Boundary and Error Conditions

Testing for Boundary Conditions

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

- Boundary is valid, DUT should:
  - **Process** successfully
  - **Respond** accordingly

- If error conditions occur, DUT should:
  - Respond with **error** message
  - Remain in **normal** operation
  - **No** communications loss
Example: Testing for Boundary Conditions

<table>
<thead>
<tr>
<th>ID: TC001</th>
<th>Title: Power Fail / Restart</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective:</strong></td>
<td>To verify power fail and restart conformance to ATC 5201</td>
</tr>
<tr>
<td></td>
<td>The test case verifies that the ATC is unaffected by service power interruptions between zero and 475 ms</td>
</tr>
<tr>
<td></td>
<td>The Test Case verifies that the ATC restarts when service power is interrupted for a period of time greater than 550 ms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inputs:</th>
<th>Service Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outcome(s):</strong></td>
<td>475 ms interruption: ATC operation is unaffected, ATC time clock does not drift</td>
</tr>
<tr>
<td></td>
<td>550 ms, 750 ms and 1000 ms interruptions: ATC restarts</td>
</tr>
</tbody>
</table>

| Environmental Needs: | Room temperature, power interruption measured by oscilloscope |

| Special Procedural Requirements: | Repeat at 100 VAC and 135 VAC |

| Intercase Dependencies: | None |
Address Consequences of Testing Boundary and Error Conditions

Example: Testing for Boundary Conditions

<table>
<thead>
<tr>
<th>Test #</th>
<th>Service VAC</th>
<th>OFF mS</th>
<th>Expected</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC1.1</td>
<td>100</td>
<td>475</td>
<td>Unaffected</td>
<td></td>
</tr>
<tr>
<td>TC1.2</td>
<td>100</td>
<td>475</td>
<td>Unaffected</td>
<td></td>
</tr>
<tr>
<td>TC1.3</td>
<td>100</td>
<td>475</td>
<td>Unaffected</td>
<td></td>
</tr>
<tr>
<td>TC1.4</td>
<td>100</td>
<td>550</td>
<td>Restart</td>
<td></td>
</tr>
<tr>
<td>TC1.5</td>
<td>100</td>
<td>750</td>
<td>Restart</td>
<td></td>
</tr>
<tr>
<td>TC1.6</td>
<td>100</td>
<td>1000</td>
<td>Restart</td>
<td></td>
</tr>
<tr>
<td>TC1.7</td>
<td>135</td>
<td>475</td>
<td>Unaffected</td>
<td></td>
</tr>
<tr>
<td>TC1.8</td>
<td>135</td>
<td>475</td>
<td>Unaffected</td>
<td></td>
</tr>
<tr>
<td>TC1.9</td>
<td>135</td>
<td>475</td>
<td>Unaffected</td>
<td></td>
</tr>
<tr>
<td>TC1.10</td>
<td>135</td>
<td>550</td>
<td>Restart</td>
<td></td>
</tr>
<tr>
<td>TC1.11</td>
<td>135</td>
<td>750</td>
<td>Restart</td>
<td></td>
</tr>
<tr>
<td>TC1.12</td>
<td>135</td>
<td>1000</td>
<td>Restart</td>
<td></td>
</tr>
</tbody>
</table>
Test Tools and Equipment Available

ATC Testing Tools Available

- DAT is not a **required** deliverable for compliance to ATC 5201, but typically available from ATC manufacturers.

- DAT is delivered as **Source Code**.

- DAT is **compiled** and loaded into ATC using the **BSP**.

- DAT **instructions** inform the operator how to compile, link, and load the DAT.

- **Executing** the DAT **performs** a **self-test** of the ATC hardware, operating system, and low-level drivers.

- Once DAT executes successfully, **other applications** such as signal control can be **loaded in place** of the DAT.

- Operational **failures** can then be attributed to the **application**, not the ATC or Linux components.

- Custom-made **loopback** cables from **Input to Output** are typical.
Available Training Modules

Professional Capacity Building (PCB) Training Available

- **Additional Information on Test Design, Test Cases, and Test Procedures:**
  - T203 How to Develop Test Cases for an ITS Standards-Based Test Plan Part 1 of 2
  - T203 How to Develop Test Cases for an ITS Standards-Based Test Plan Part 2 of 2
  - T204 How to Develop Test Procedures for ITS Standards-Based Test Plan, Part 1 of 2
  - T204 How to Develop Test Procedures for ITS Standards-Based Test Plan, Part 2 of 2
  - T312 Applying Your Test Plan to a Transportation Sensor System (TSS) Based on the NTCIP 1209 Standard v02
  - T309 Applying Your Test Plan to Ramp Meter Control (RMC) Units Based on the NTCIP 1207 Standard v02
ACTIVITY
Manufacturer will have a single ATC that conforms to all versions of the ATC 5201 Standard?

**Answer Choices**

a) True

b) False
Review of Answers

a) True

Incorrect. Versions of ATC 5201 contain conflicting sections, so that no ATC conforms to all versions.

b) False

Correct! Manufacturer supplies a Conformance Statement that covers the ATC 5201 version and includes a list of items that could affect software compatibility.
Module Summary

Identify key elements of ATC 5201 Standard equipment for testing documentation

Describe within the context of a systems engineering lifecycle the role of a test plan and the testing to be undertaken

Describe the application of good testing documentation for transportation controller equipment based on the ATC 5201 v06 Standard

Describe the testing of ATC using sample testing documentation
We have Now Completed the ATC Curriculum

**Module A307a:** Understanding **User Needs** for Advanced Transportation Controllers Based on ATC 5201 Standard v06.

**Module A307b:** Understanding **Requirements** for Advanced Transportation Controllers Based on ATC 5201 Standard v06.

**Module T307:** Applying Your **Test Plan** to the Advanced Transportation Controller Based on ATC 5201 Standard v06.
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!