



W E L C O M E



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

Welcome



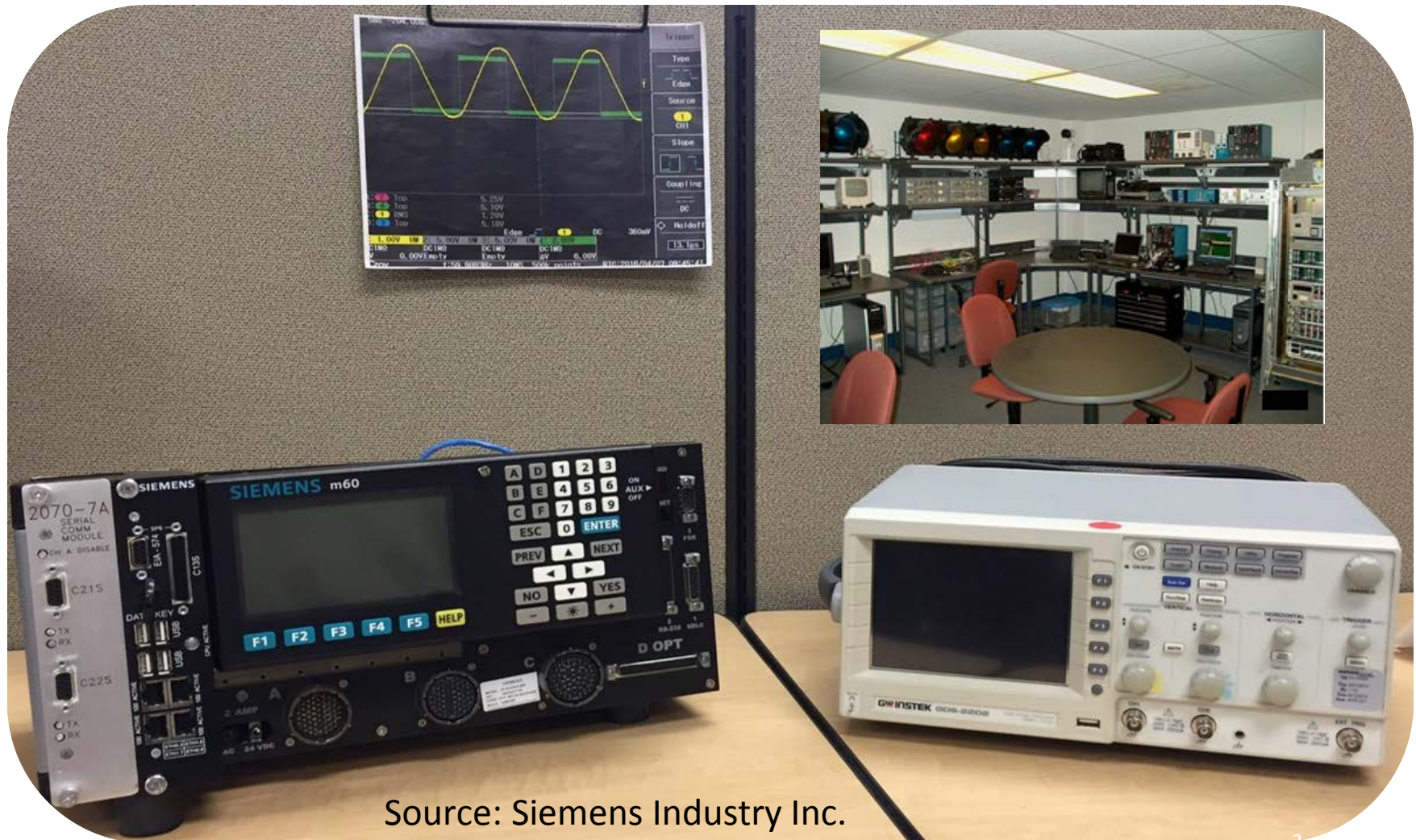
**Ken Leonard, Director
ITS Joint Program Office**
Ken.Leonard@dot.gov

The screenshot shows the homepage of the ITS Professional Capacity Building Program. At the top, it identifies the United States Department of Transportation and the Office of the Assistant Secretary for Research and Technology. The main heading is 'Intelligent Transportation Systems Joint Program Office'. Below this is a navigation menu with categories like 'About', 'ITS Training', 'Knowledge Exchange', 'Technology Transfer', 'ITS in Academics', and 'Media Library'. A central banner features a photo of people in a classroom and a blue text box that reads: '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.' To the right, a 'WHAT'S NEW' section lists recent updates, including new web-based training, an NHI course, and a case study. At the bottom, a 'FREE TRAINING' section lists available courses such as 'Web and Blended Courses from CITE', 'ITS Standards Training', and 'Upcoming T3 Webinars'.

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

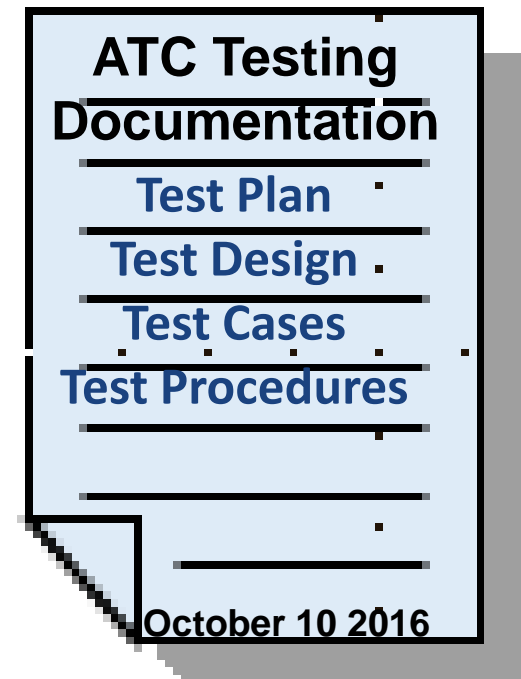
Identify key elements of ATC 5201
Standard Equipment for **Testing**
Documentation

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

Test Process

ATC Testing Documentation

Test Plan

Test Design

Test Cases

Test Procedures

October 10 2016



**Records results
and outcomes**

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



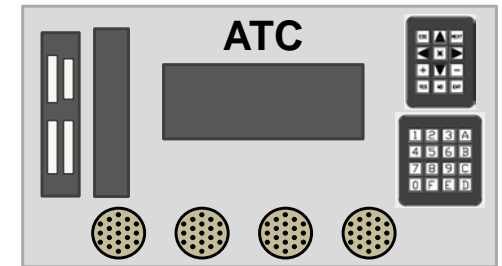
See Modules
A307a and A307b
for details

Photos: Econolite, Intelight, 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**

SUPPLEMENT

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

ATC 5201 v06.24

8 ENVIRONMENTAL AND TEST PROCEDURES


NOTE: All references in this section to NEMA TS2 explicitly refer to the NEMA Standards Publication TS 2-2003 v02.06, *Traffic Controller Assemblies with NTCIP Requirements*.

8.1 General

This section establishes the environmental and operational conditions for a First Article ATC , and defines the minimum test procedures which may be used to demonstrate conformance of an ATC unit with the provisions of the Standard.

Software shall be provided that contains a set of test programs to facilitate testing. This software shall be capable of running individual tests or combinational tests. The combinational tests shall include a single menu function that binds all of the tests into a single module. Tests may be run either from the front panel or by an external serial port. These tests shall include but are not limited to the items in the following outline:

- A testing program shall contain the following:
 1. Introduction to the Test
 2. Installation Instructions
 3. Starting the Software
 4. Running Individual Tests
 5. Test Suite Tree for combination tests
- Individual Processor tests shall include:
 1. Volatile / Dynamic RAM (DRAM) Test
 2. Short-Term Non-Volatile Memory (SRAM) Test
 3. Long-Term Non-Volatile Memory (FLASH) Read/Write Test
 4. Datakey Tests
 5. USB Tests
 6. Ethernet Tests.
- Front Panel (when used) tests shall include:
 1. Display Tests
 2. Keyboard Tests
- I/O tests shall include:
 1. I/O Loop Back Tests
- Asynchronous/Synchronous Communication Port tests shall include:
 1. Loop Back Tests, Single Port and Port to Port
 2. Aggregate throughput tests as defined in Paragraph 0



ATC5201v0624_151004.docx

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What Needs to Be Tested

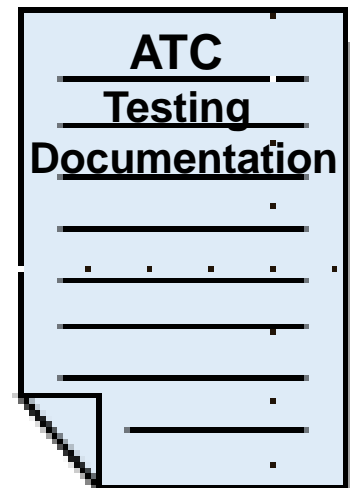
What Is NOT Included in the ATC 5201 v06 Standard

- Applications Programming 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)

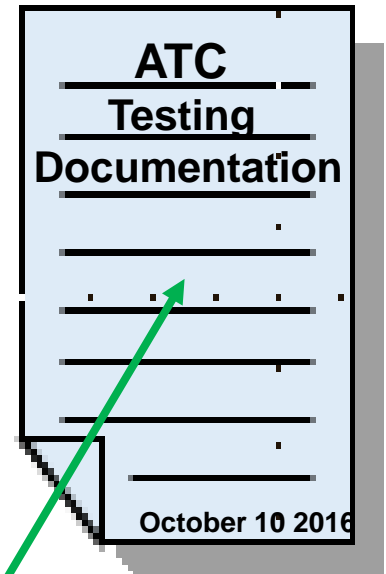
The ATC unit under test shall meet all requirements as defined in NEMA TS2, Section 2.1.8, Nondestructive Transient Immunity, with the following variations:

- Test voltage amplitude shall be 2000 ± 100 V, both positive and negative polarity.

What Needs to Be Tested

Suggested Approach to Preparing Testing Documentation

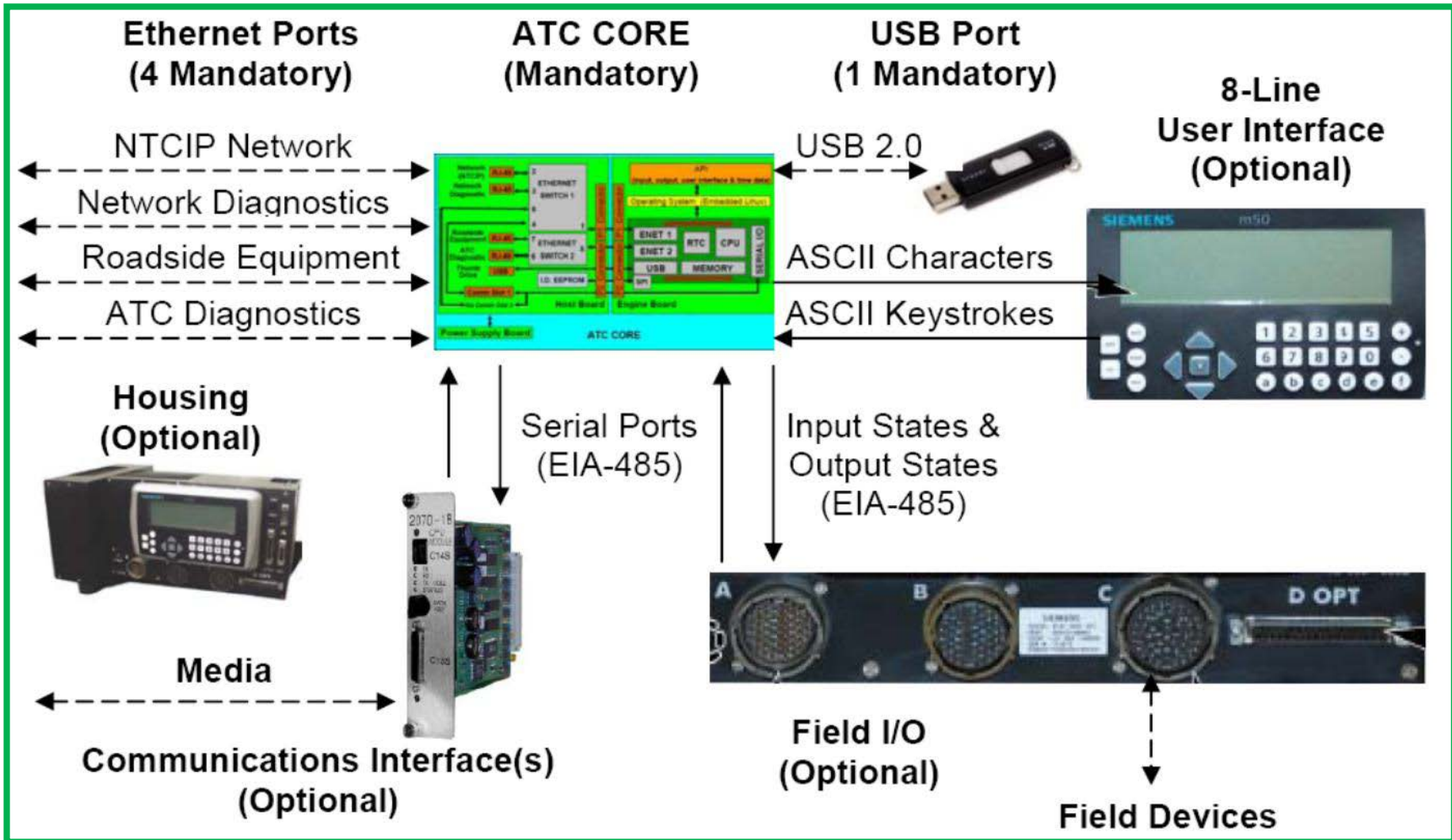
1. Consult Module A307b for guidance on identifying **Mandatory** and **Optional** objects and related **requirements**
2. Identify **essential** areas that must be addressed for conformance to the standard:
 - Operational Voltages
 - I/O Requirements
 - User Interface Requirements
 - CPU Performance and Memory Requirement
 - Other Requirements
3. Consider Cabinet Standards **influence**
4. Assess Agency Procurement **Configuration**



Mandatory objects are ALWAYS included in all procurement Configuration

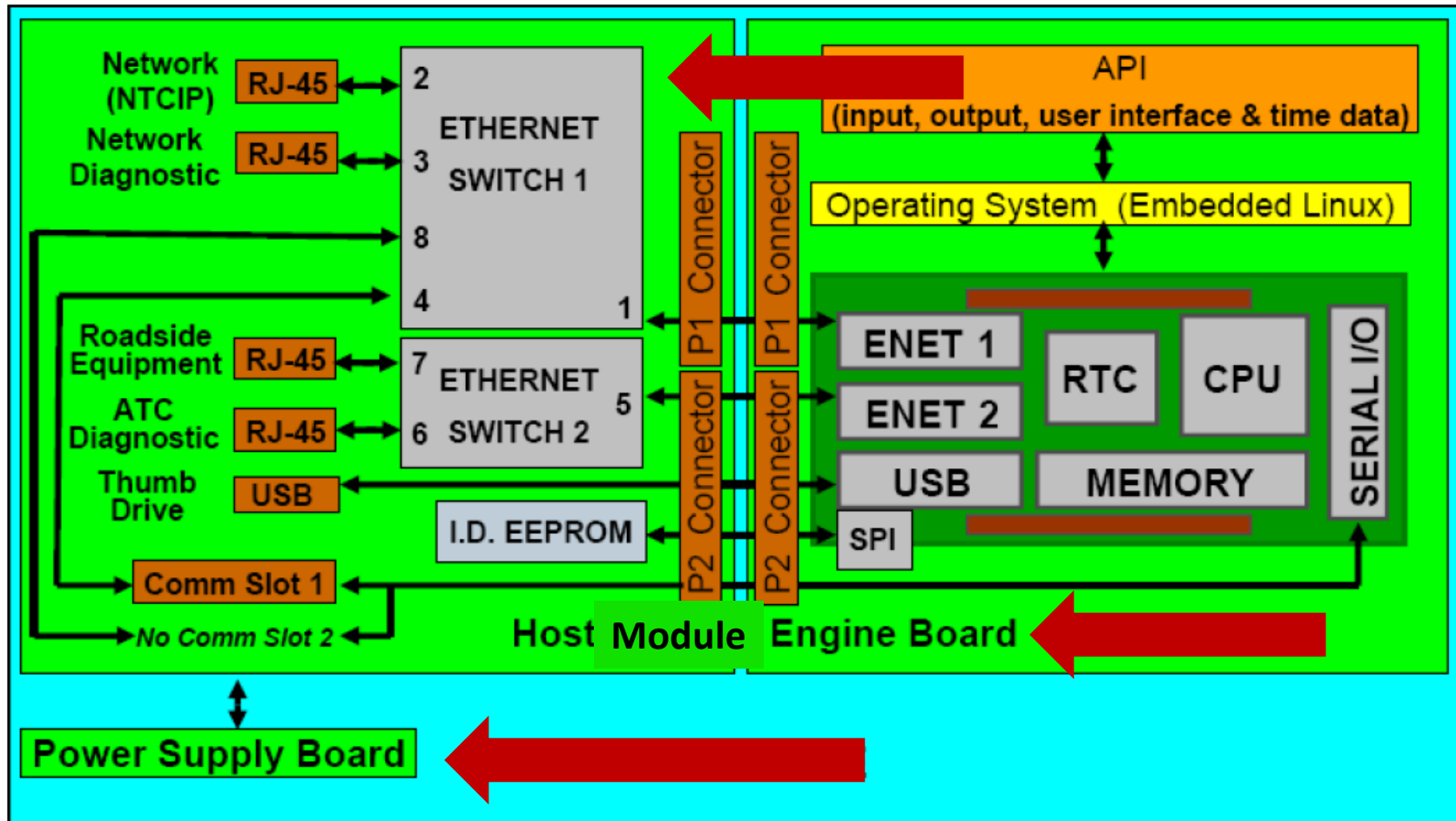
What Needs to Be Tested

Review of Mandatory (Core) + Optional Objects



What Needs to Be Tested

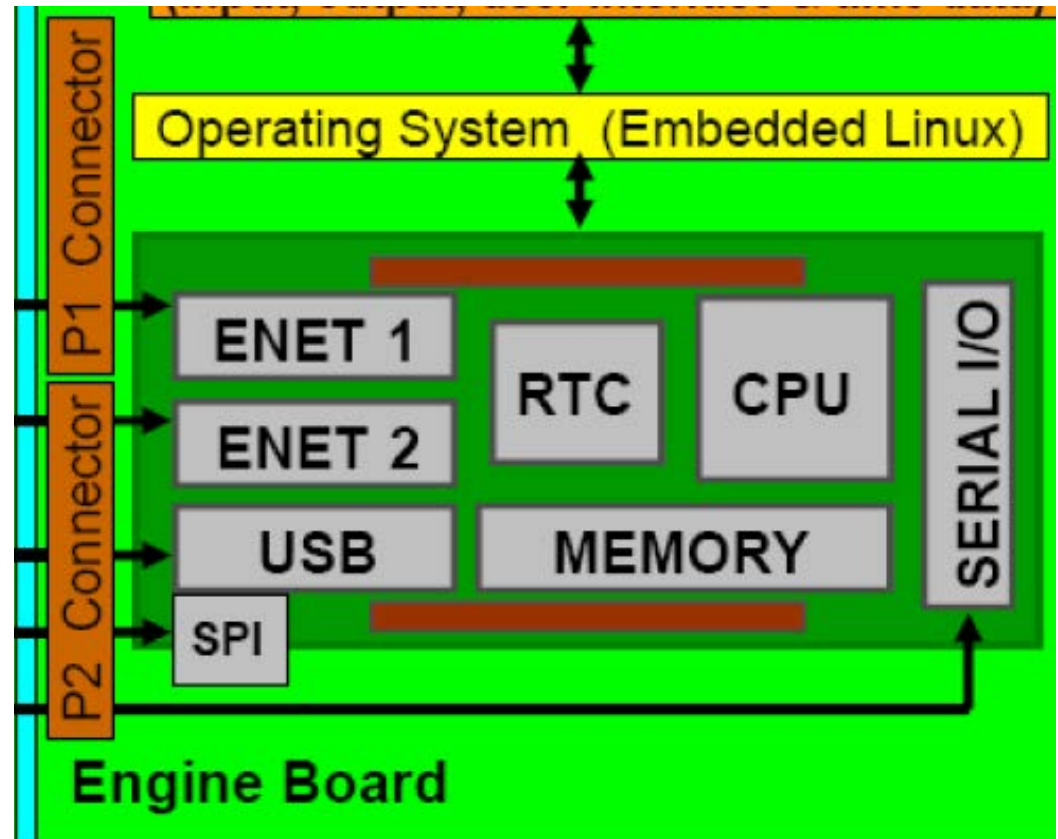
Mandatory Hardware Objects: Engine Board, Memory, and Operating System (OS)



What Needs to Be Tested

Mandatory Engine Board Requirements Must be Tested

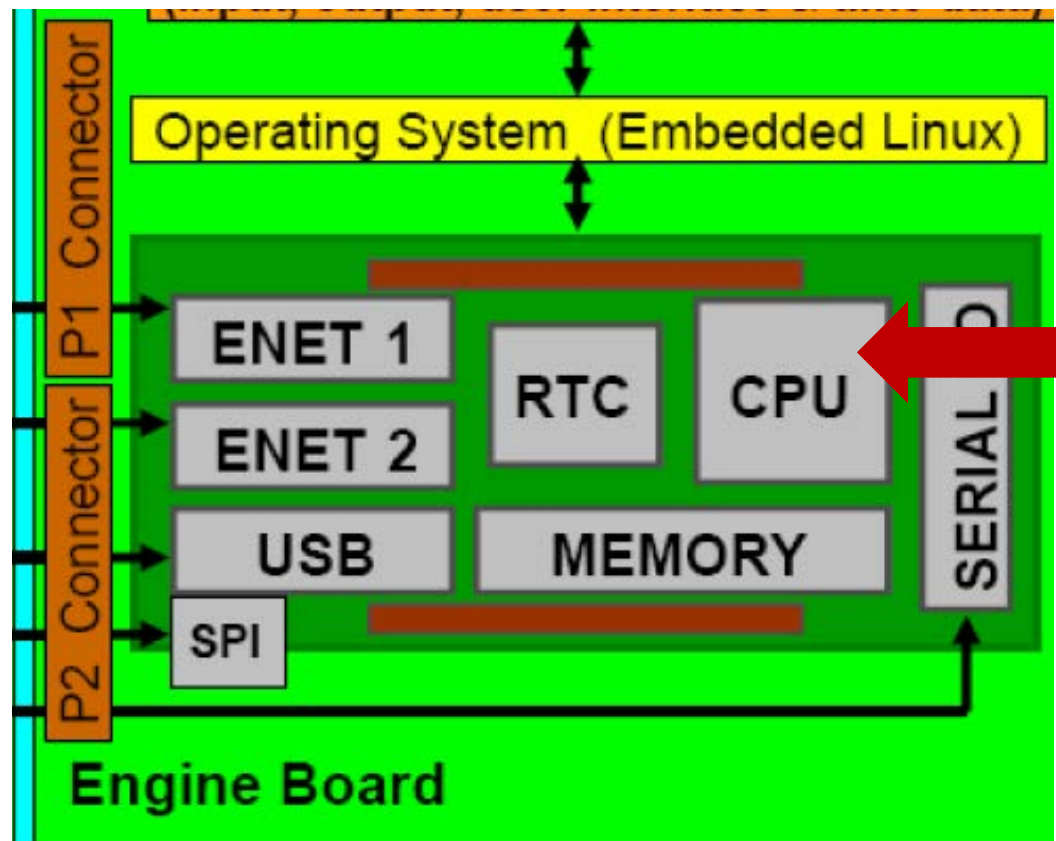
- Microprocessor
- Two Ethernet Ports
- Real Time Clock
- Memory
- Serial Inputs/Outputs
- Serial Peripheral Interface
- Standardized Connectors



What Needs to Be Tested

Mandatory Engine Board

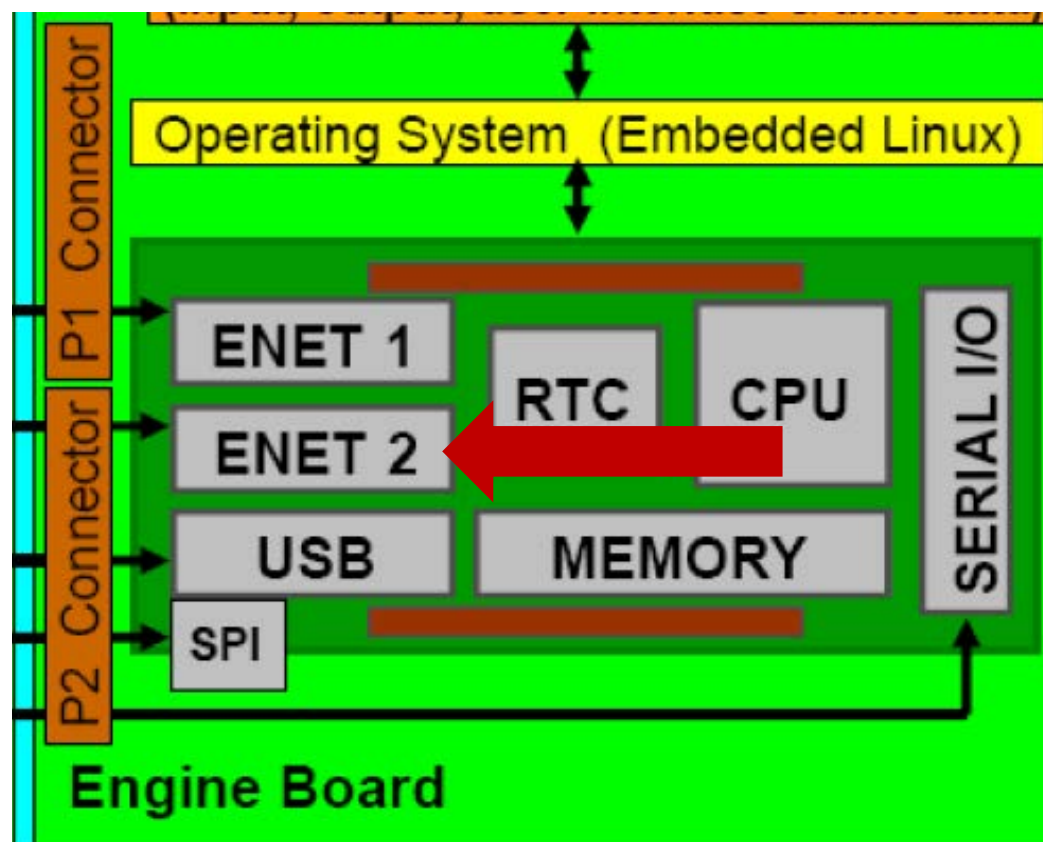
- Microprocessor



What Needs to Be Tested

Mandatory Engine Board

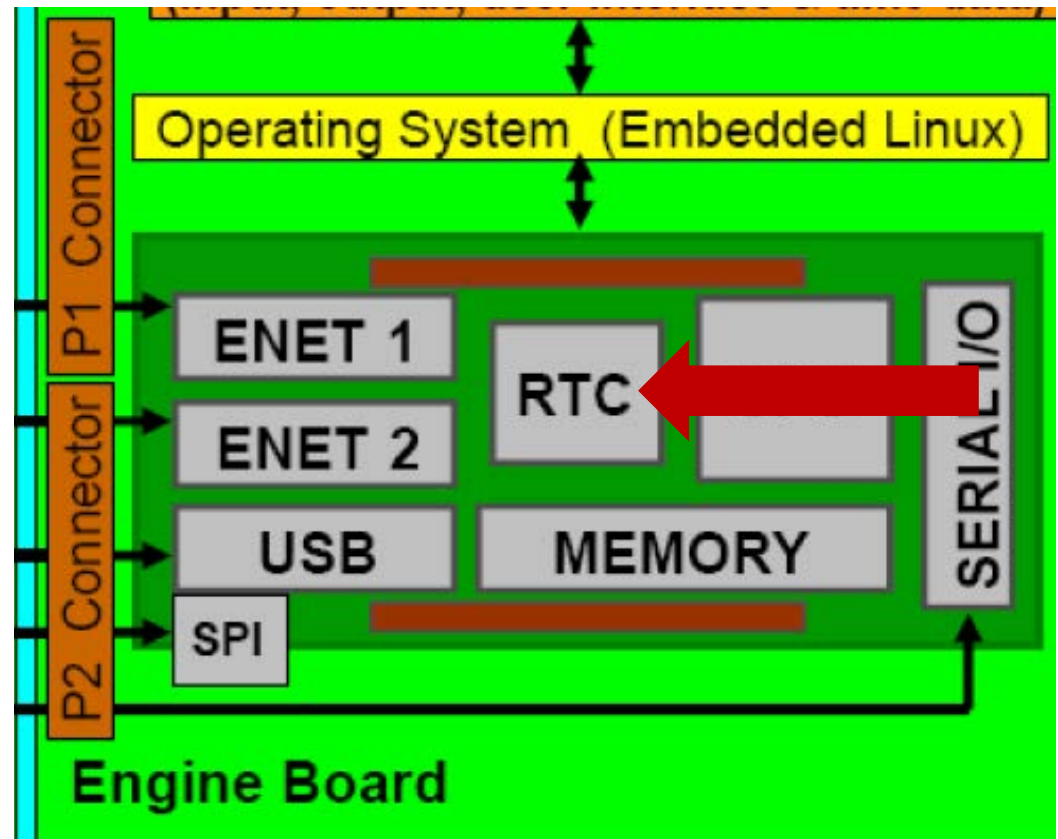
- Microprocessor
- Two Ethernet Ports



What Needs to Be Tested

Mandatory Engine Board

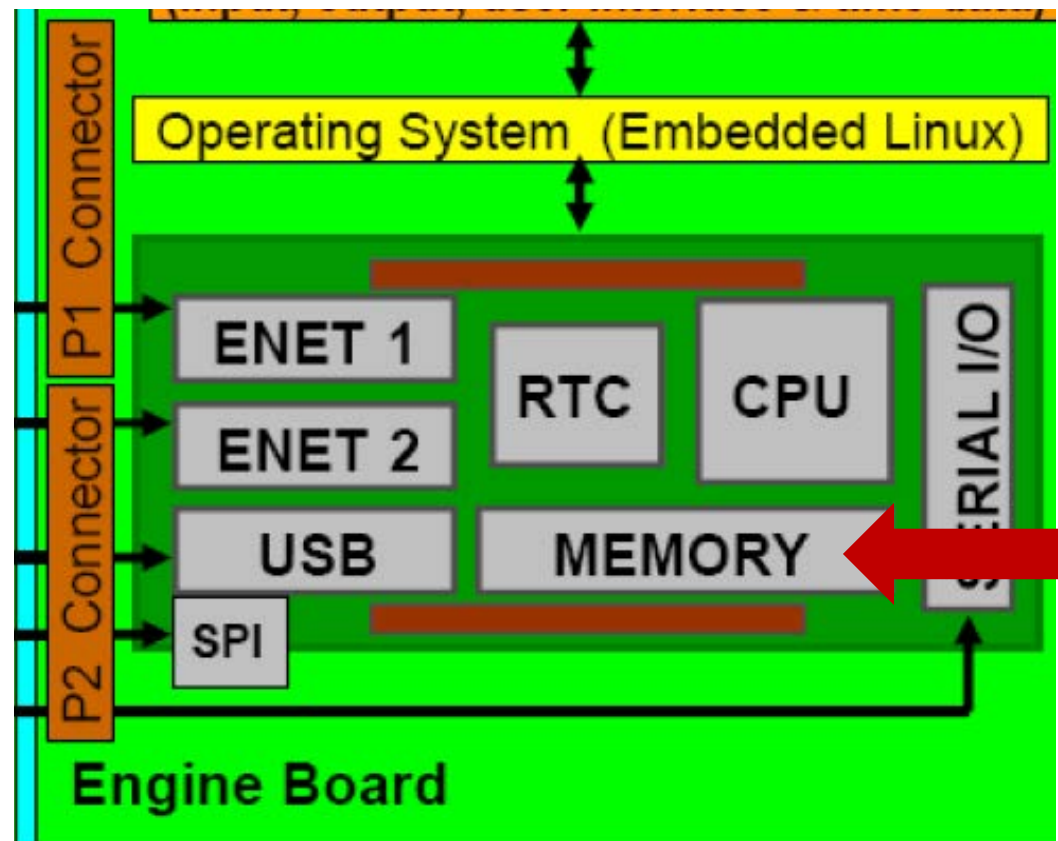
- Microprocessor
- Two Ethernet Ports
- Real Time Clock



What Needs to Be Tested

Mandatory Engine Board

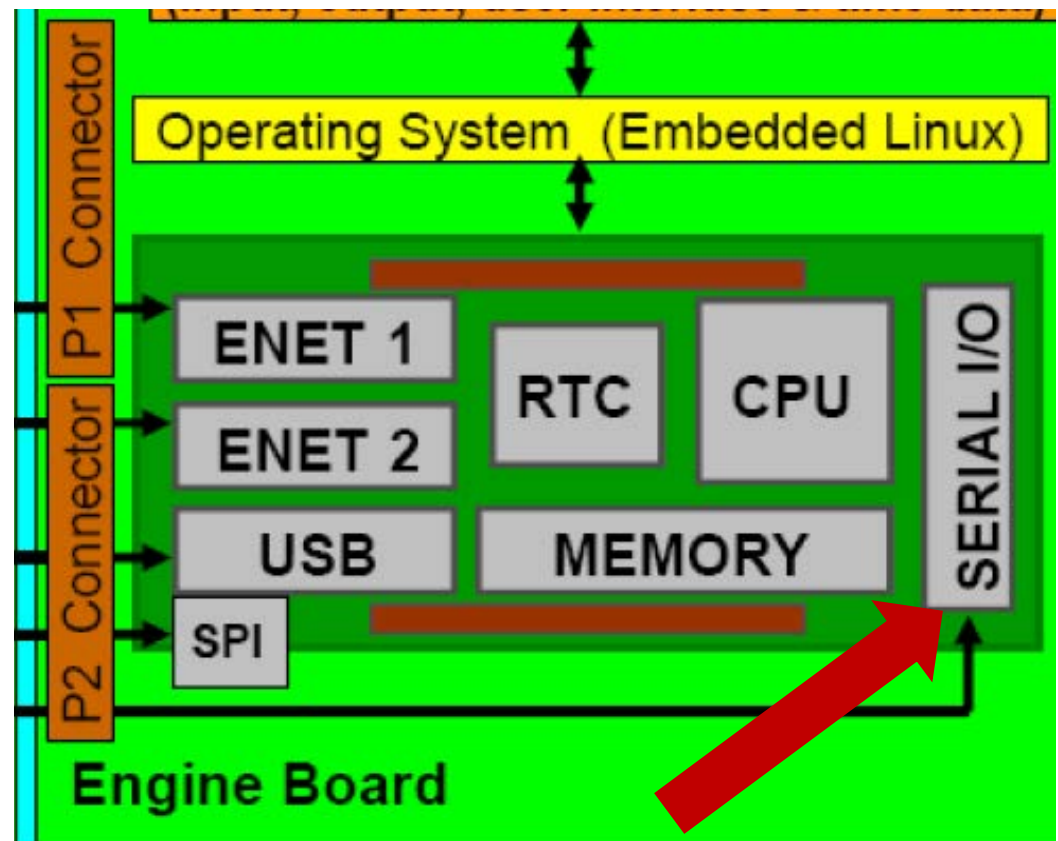
- Microprocessor
- Two Ethernet Ports
- Real Time Clock
- Memory



What Needs to Be Tested

Mandatory Engine Board

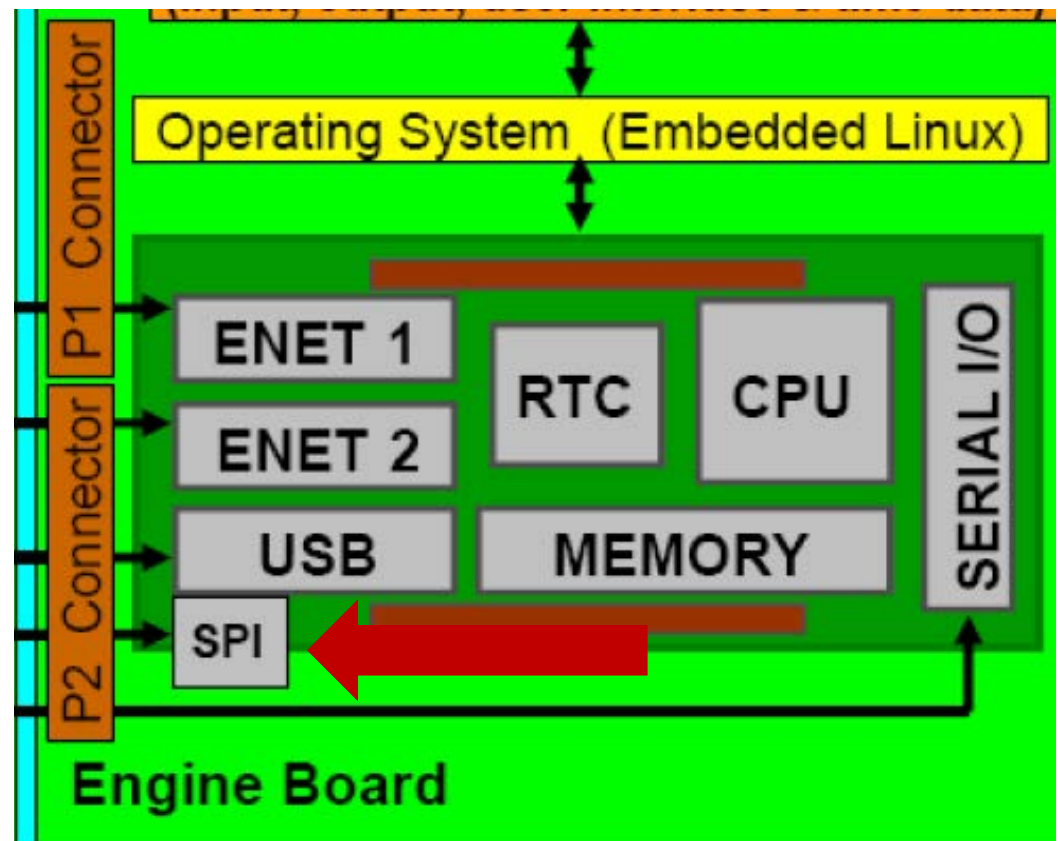
- Microprocessor
- Two Ethernet Ports
- Real Time Clock
- Memory
- Serial Inputs/Outputs



What Needs to Be Tested

Mandatory Engine Board

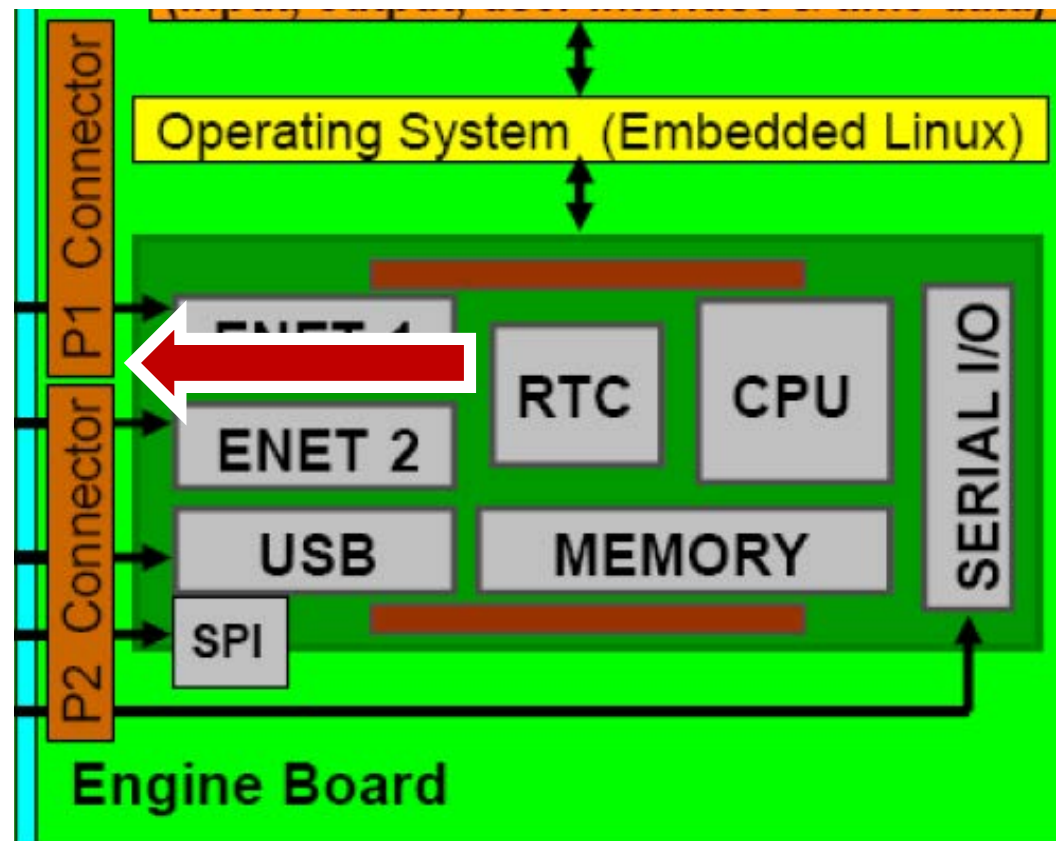
- Microprocessor
- Two Ethernet Ports
- Real Time Clock
- Memory
- Serial Inputs/Outputs
- Serial Peripheral Interface



What Needs to Be Tested

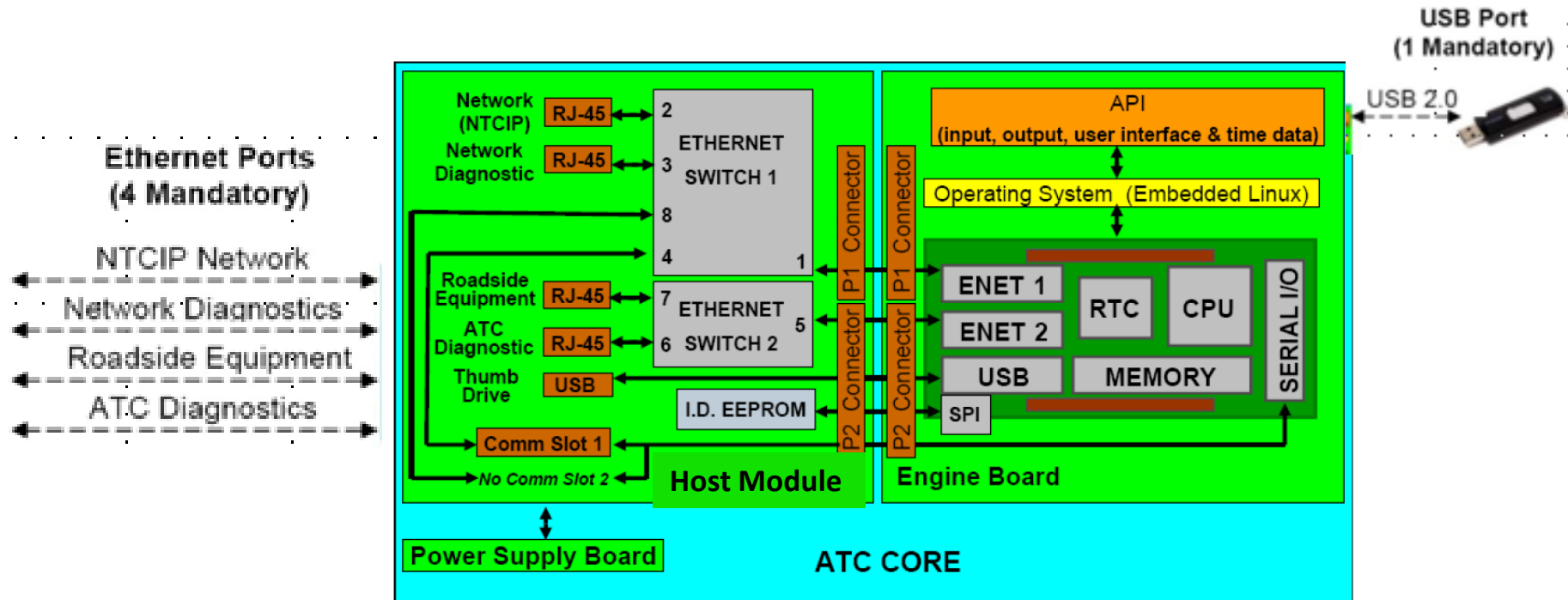
Mandatory Engine Board

- Microprocessor
- Two Ethernet Ports
- Real Time Clock
- Memory
- Serial Inputs/Outputs
- Serial Peripheral Interface
- Standardized Connectors



What Needs to Be Tested

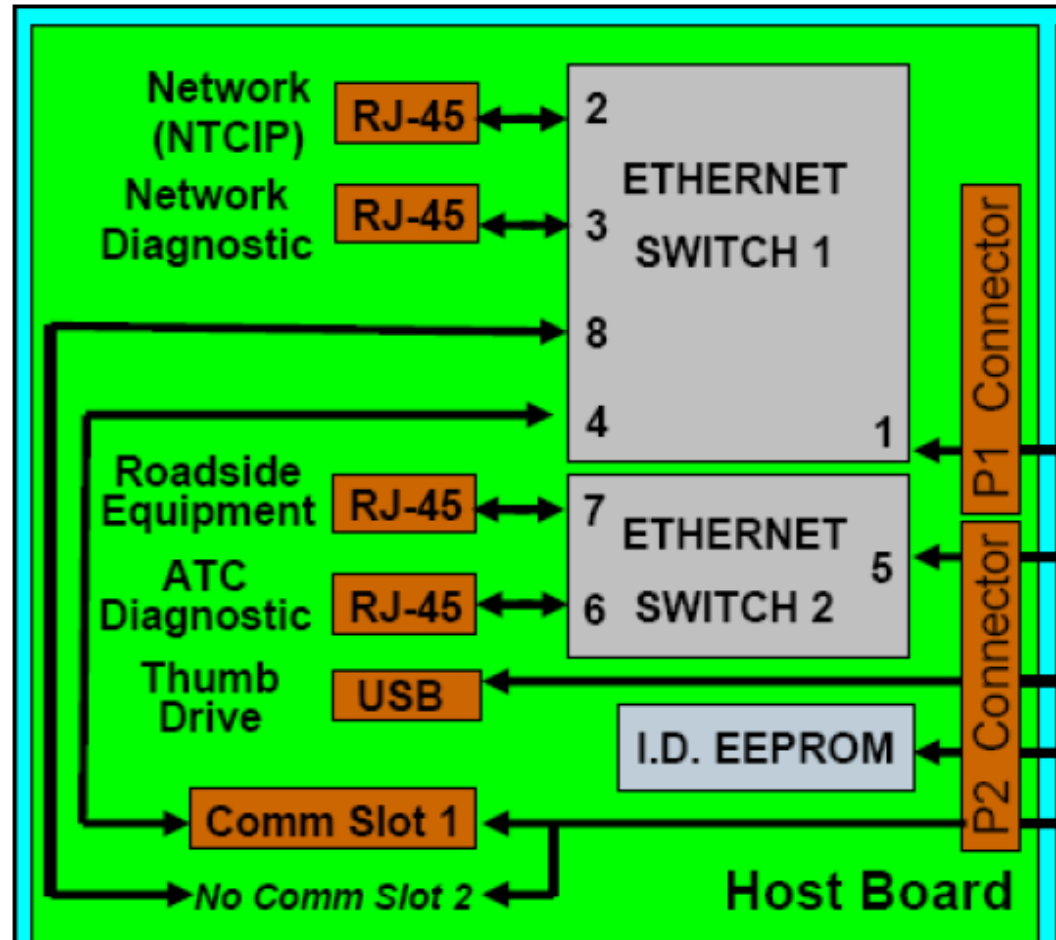
Mandatory Objects: Host Module Ethernet Ports/Internet Protocol (IP) Communications



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



What Needs to Be Tested

Mandatory User Interface Requirements Must Be Tested

Source: Module A307b

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



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

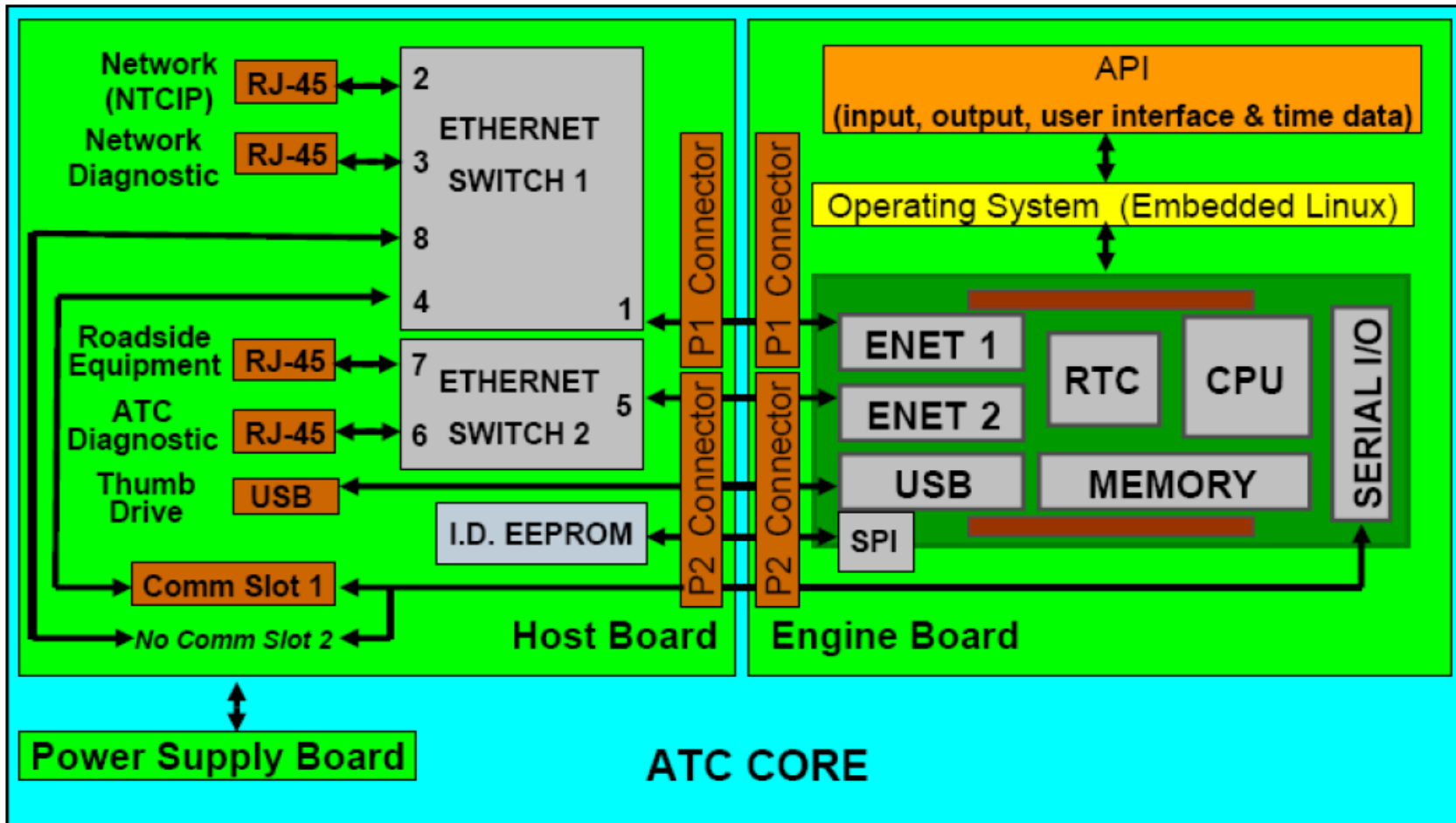


- EIA-574, 9-pin “D” connector for an external front panel
- OR**
- Keyboard, Liquid Crystal Display (LCD), Bell

EXAMPLE

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.

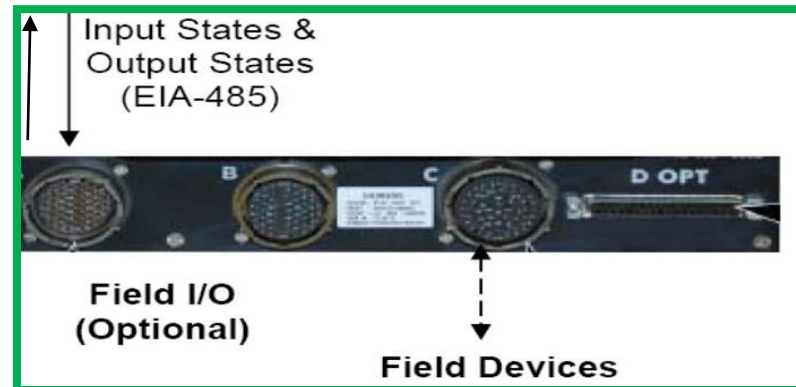
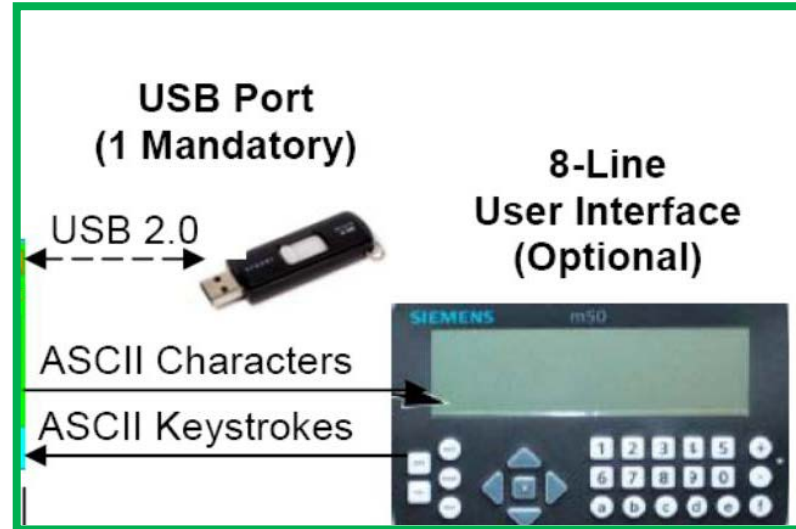
5.6.3 Power Interruptions

The transportation controller shall meet the power interruption requirements per Section 2.1.4 of the NEMA TS 2 Standard.

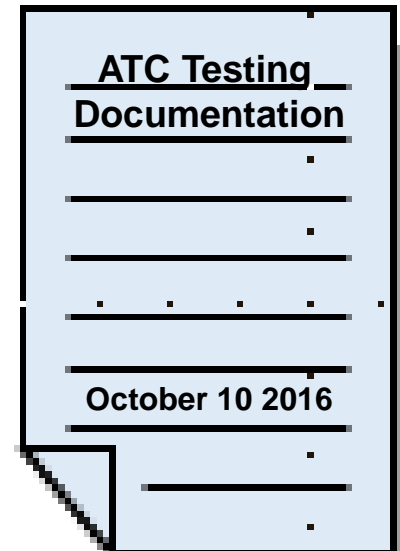


What Needs to Be Tested

Optional Objects Examples



Must be Tested, if Included in an Agency Procurement Configuration



CASE STUDY



U.S. Department of Transportation
ITS Joint Program Office
Image Source: Thinkstock USDOT

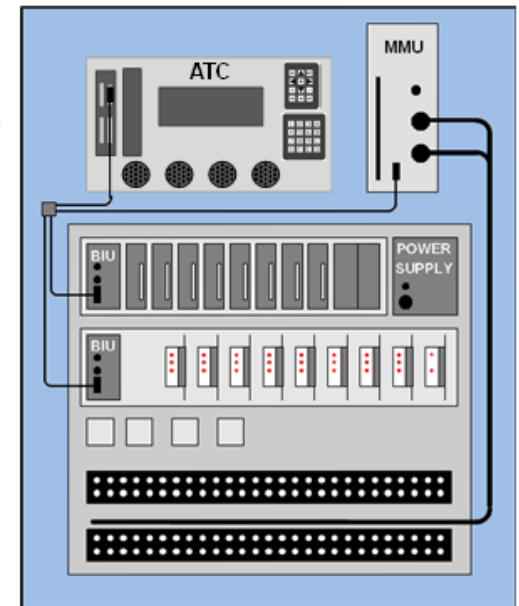
Case Study: NEMA TS 2 Cabinet Compatibility Requirements

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



NEMA TS 2 CABINET

**Housing
(Optional)**





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

User Need ID	User Need	FR ID	Functional Requirement	Conformance	Support	Additional Specifications
UN001	Compliant to ATC 5201 v06			M	Yes	
		FR001	Configuration shall include Engine Board	M	Yes	Verify to ATC 5201 Engine Board section
		FR002	Configuration shall include Host Module	M	Yes	Verify to ATC 5201 Host Module section
		FR003	Configuration shall include Power Supply	M	Yes	Verify to ATC 5201 Power Supply section
		FR008	Configuration shall include IP communications to TMC	M	Yes	Verify to ATC 5201 network switch section

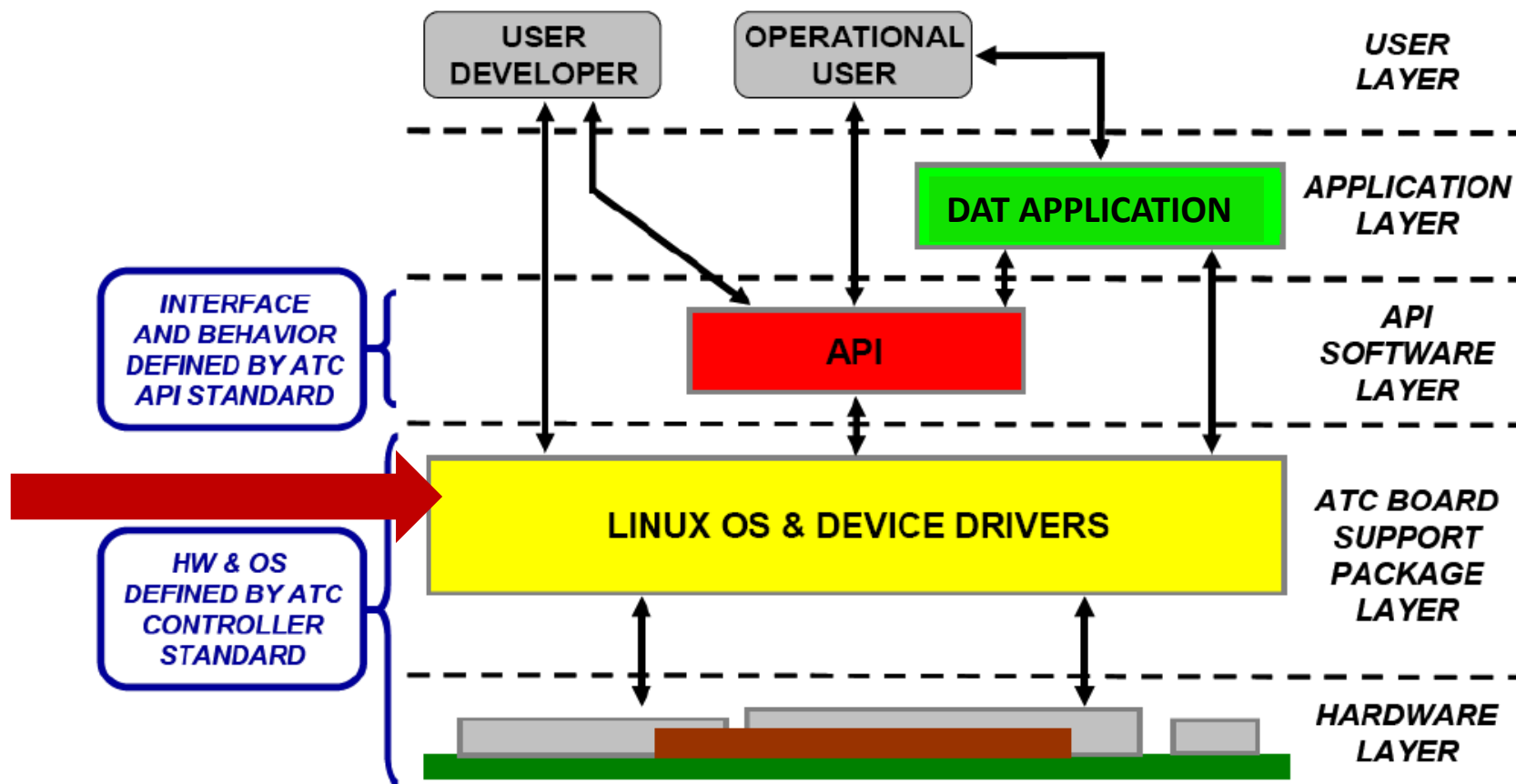
Entries can be extended to include Mandatory and Optional FR as per agency procurement configuration



What Needs to Be Tested

Mandatory (Core) Software Objects Must Be Tested

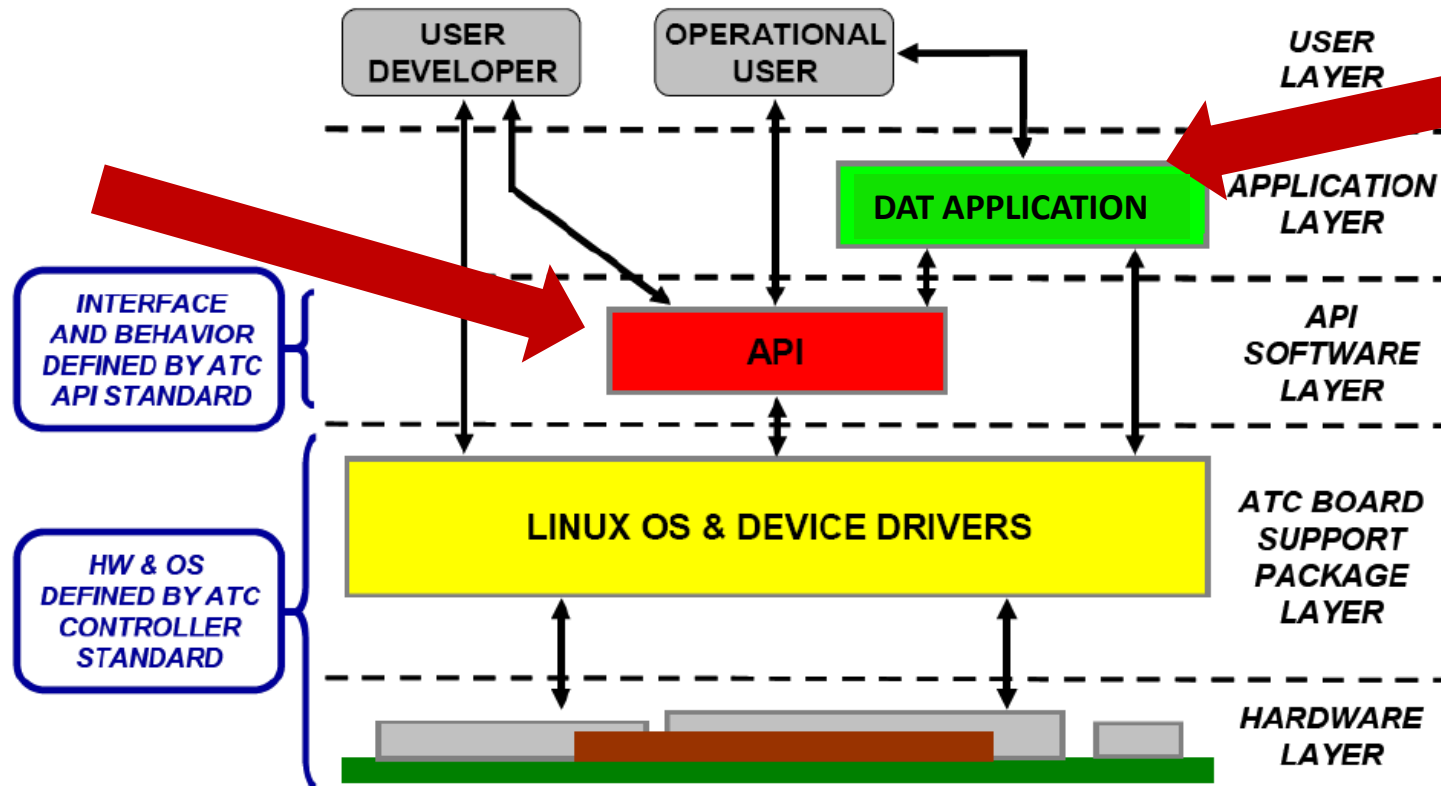
Mandatory Linux OS and Drivers always require testing



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>
- ATC includes an Open Source Linux OS

**ATC
Manufacturer XYZ**

**Open Source
Declaration**

Version 2.3

October 8, 2016

Capture Open Source Linux IP Obligations Within the Contract Terms and Conditions

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

remember!

ACTIVITY



Question

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



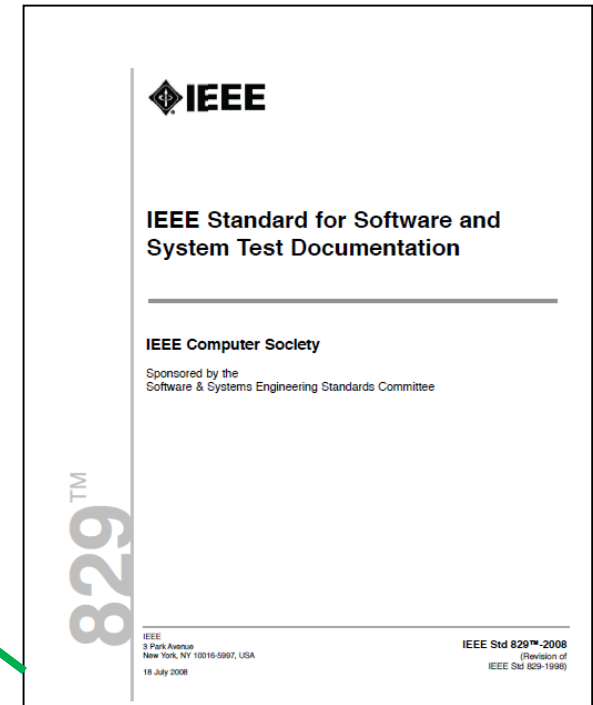
Learning Objective 2

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

Purpose of a Well-Written Documentation Based on IEEE 829-2008

Test Documentation Purpose

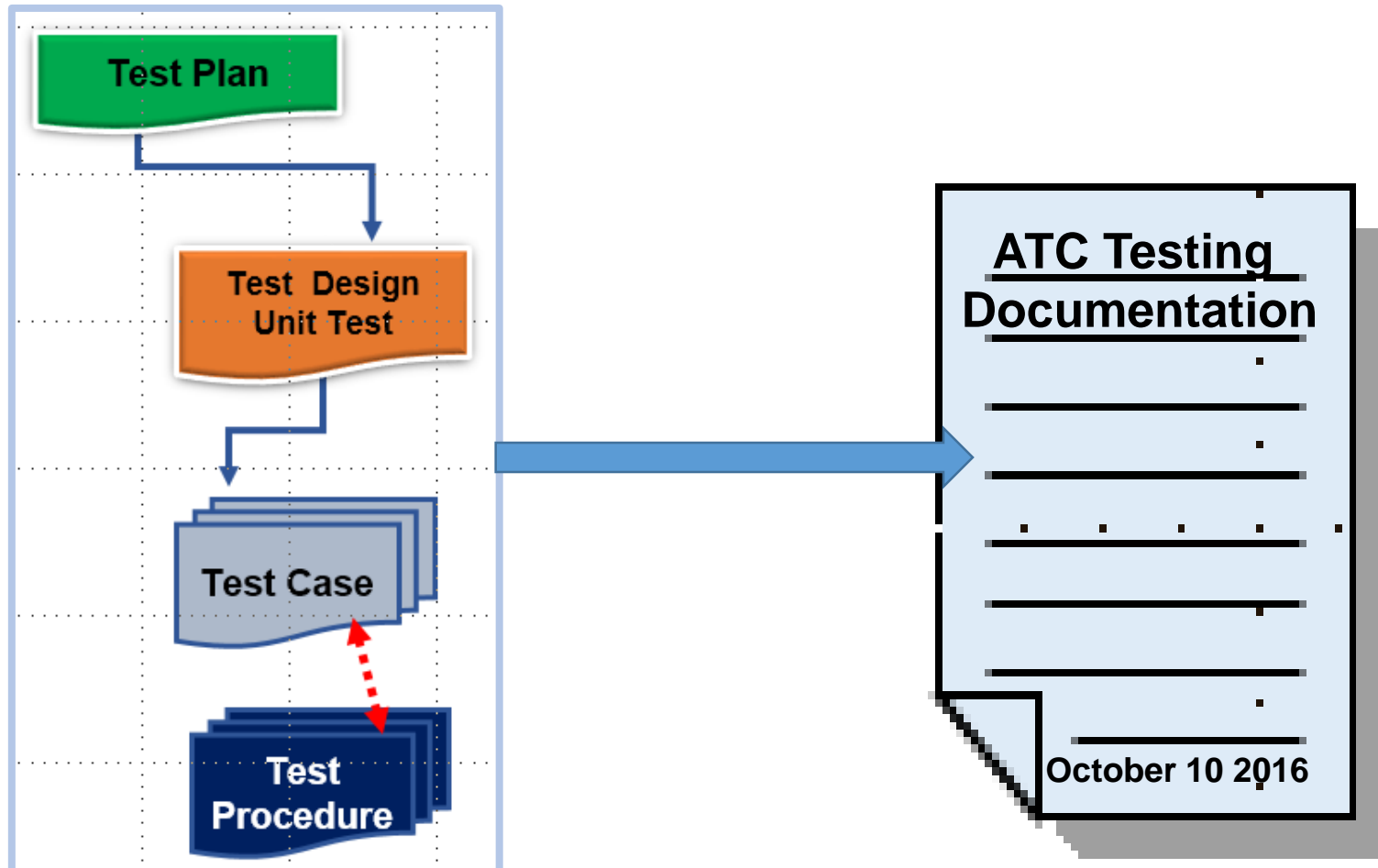
- Test documentation is a general term used to describe unambiguous and **common understanding** among all stakeholders to:
 - Outline what to test (**requirements**)
 - Describe how to test (process)
 - **IEEE 829-2008** formats are used to prepare documentation
- For whom and why do we need test documentation?



Purpose of a Well-Written Documentation Based on IEEE 829-2008

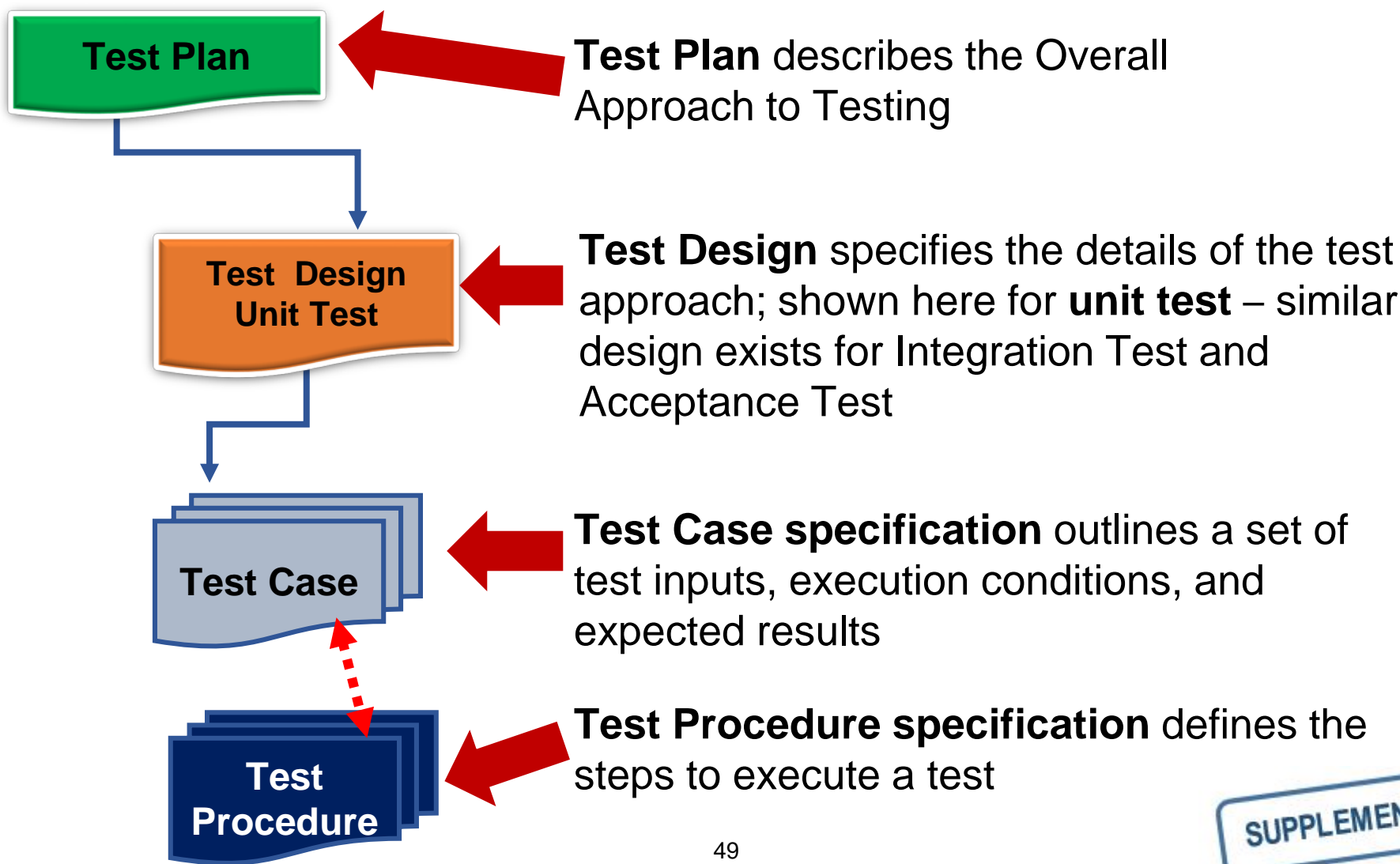
Test Documentation Purpose (cont.)

Key part of test documentation is ATC Test Plan, which identifies Test Design, Test Case, and Test Procedure documents



Structure of a Well-Written Documentation Based on IEEE 829-2008

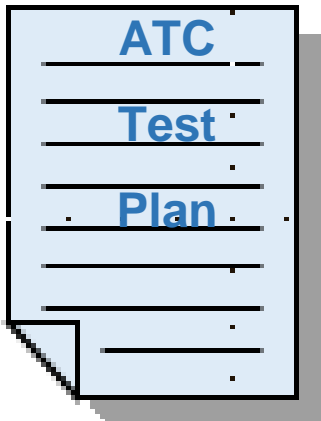
Test Plan Structure Based on IEEE 829-2008



SUPPLEMENT

Structure of a Well-Written Documentation Based on IEEE 829-2008

Test Plan Outlines the Testing Process Used to Verify Requirements

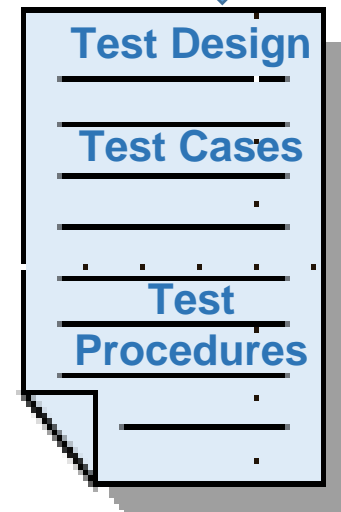


- ATC Test Plan is an **Agency-prepared** document that is used to document the following:

- 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

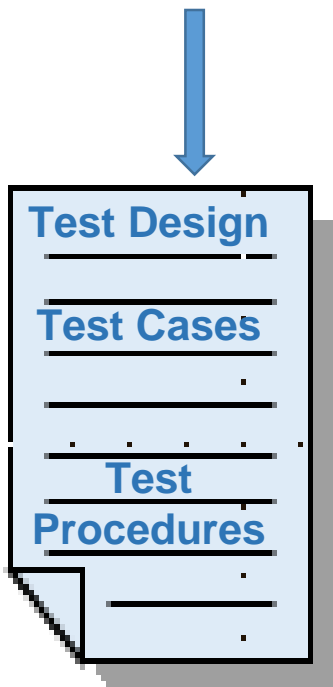


Source: FHWA ITS Lab

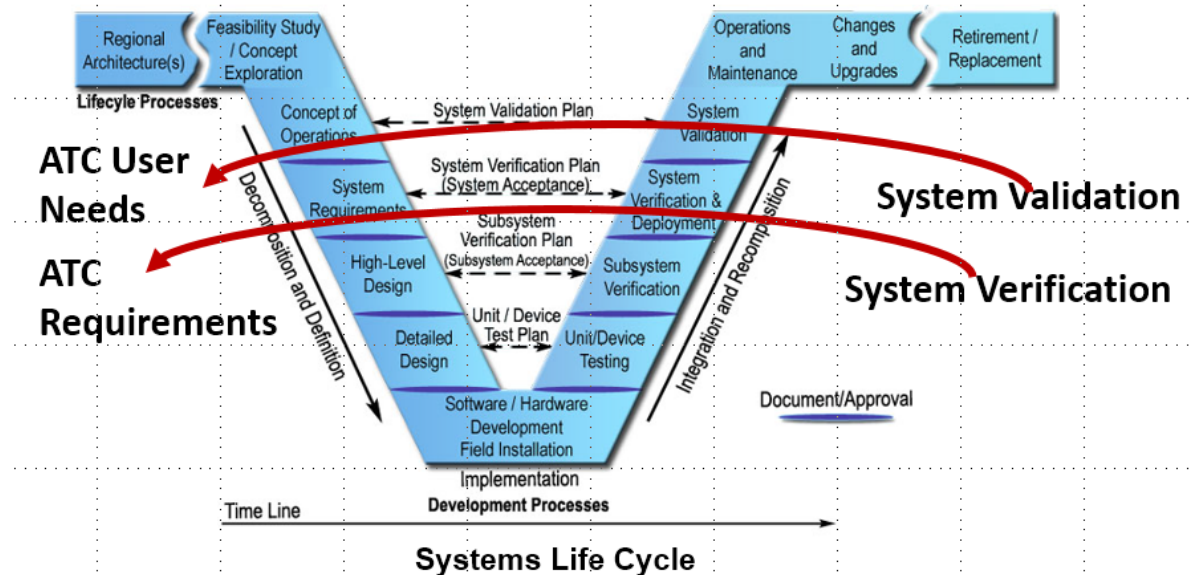
Purpose, Structure, and Content of a Well-Written Documentation Based on IEEE 829-2008

Test Design Specification/Test Cases/Test Procedures

- 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**



How will documentation be used?



Source: <http://www.fhwa.dot.gov/cadiv/segb/>

Purpose, Structure, and Content of a Well-Written Documentation Based on IEEE 829-2008

Documentation for Reporting Test Results/Outcomes

**Test Plan Execution
(Process)**

Prepared During and After Testing

Chronological record
of execution of tests

Event during the
testing process that
requires investigation

Summarizes the
results of the
testing activities

**Level Test Log
(LTL)**

**Anomaly
Report (AR)**

**Level Interim
Test Status
Report (LITSR)**

**Level Test
Report (LTR)**

Summarizes the results/evaluations/
recommendations

ACTIVITY



Question

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

Key Elements of ATC 5201 Standard v06 Tied to What Is Covered by a Test Plan

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

Key Elements of ATC 5201 Standard v06 Tied to What Is Covered by a Test Plan

NRTM Identifies “What Is to Be Tested”

NRTM Contains NEMA TS2 ATC Configuration with Requirements

UN ID	User Need	FR ID	Functional Requirement	Conformance	Support	Additional Specifications
6.5.1	NEMA TS 2 Equipment	5.2.1	NEMA TS 2 Type 2 Interfaces	M	Yes	ATC 5201 v06 used with NEMA TS 2 Cabinet Configuration
		5.6.1	NEMA Operating Voltages	M	Yes	
		5.6.2	NEMA Operating Frequencies	M	Yes	
		5.6.3	NEMA Power Interruptions	M	Yes	
7.3.1	Minimum Display Size	5.3.3	Text-Based Display Size	O	Yes/NO	

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

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



ID numbers
are user-assigned

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6.1.4 User Interface Operation

6.1.4.1 Keyboard, LCD and Bell Operation

Keyboard



Elements of ATC 5201 Standard v06 Tied to What Is Covered by a Test Plan

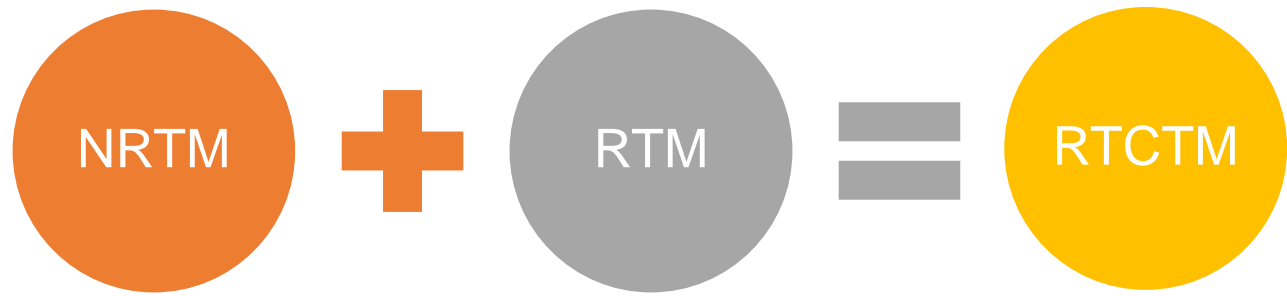
NRTM + RTM Specify Procurement Configuration, Which Answers What an Agency Desires in ATC Units

Both NRTM and RTM are used in the development of an RTCTM, which actually states what will be tested

Project Needs

Standard


Test will be done according to what is in RTCTM



Key Elements of ATC 5201 Standard v06 Tied to What Is Covered by a Test Plan

RTCTM Traces Each Requirement to Test Cases, Which Are Used in the Testing Process

RTCTM Connects Requirements to Test Cases to Be Developed



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

Key Elements of the Conformance Statement

How Does Test Case Perform Conformance to the ATC Standard ?

ID: TC001	Title: Power Fail / Restart
Objective: This is a Mandatory Requirement Test Case	<ol style="list-style-type: none">1. To verify power fail and restart conformance to ATC 52012. The test case verifies that the ATC is unaffected by service power interruptions between zero and 475 ms3. 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

Identify Key Elements of ATC 5201 Standard v06 Tied to What Is Covered by a Test Plan

A Test Procedure Is *the* Last Step in Testing Process; It “*Brings Out*” Results

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

Step	Test Procedure	Results
1	Set input voltage to 120 VAC	DUT restarts and runs the FIT test
2	Set input frequency to 60 Hz	DUT runs the FIT test continually
3	Interrupt the power for 500 ms	DUT issues Power Down, does not restart
4	Interrupt power for 1,000 ms	DUT issues Power Down and restarts





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

ver	Section	Wording	Implemented
v5.2b v6.0	5.4.3 4.4.3	Operates as 4 Serial Peripheral Interface (SPI) device selects Operates as 4-bit binary, 16 SPI devices	4-bit binary Per v6.0
v5.2b v6.0	8.3 7.3	Two internal 100BASE-TX Hub Two internal switches or two VLANS	Two internal switches

ACTIVITY





Question

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



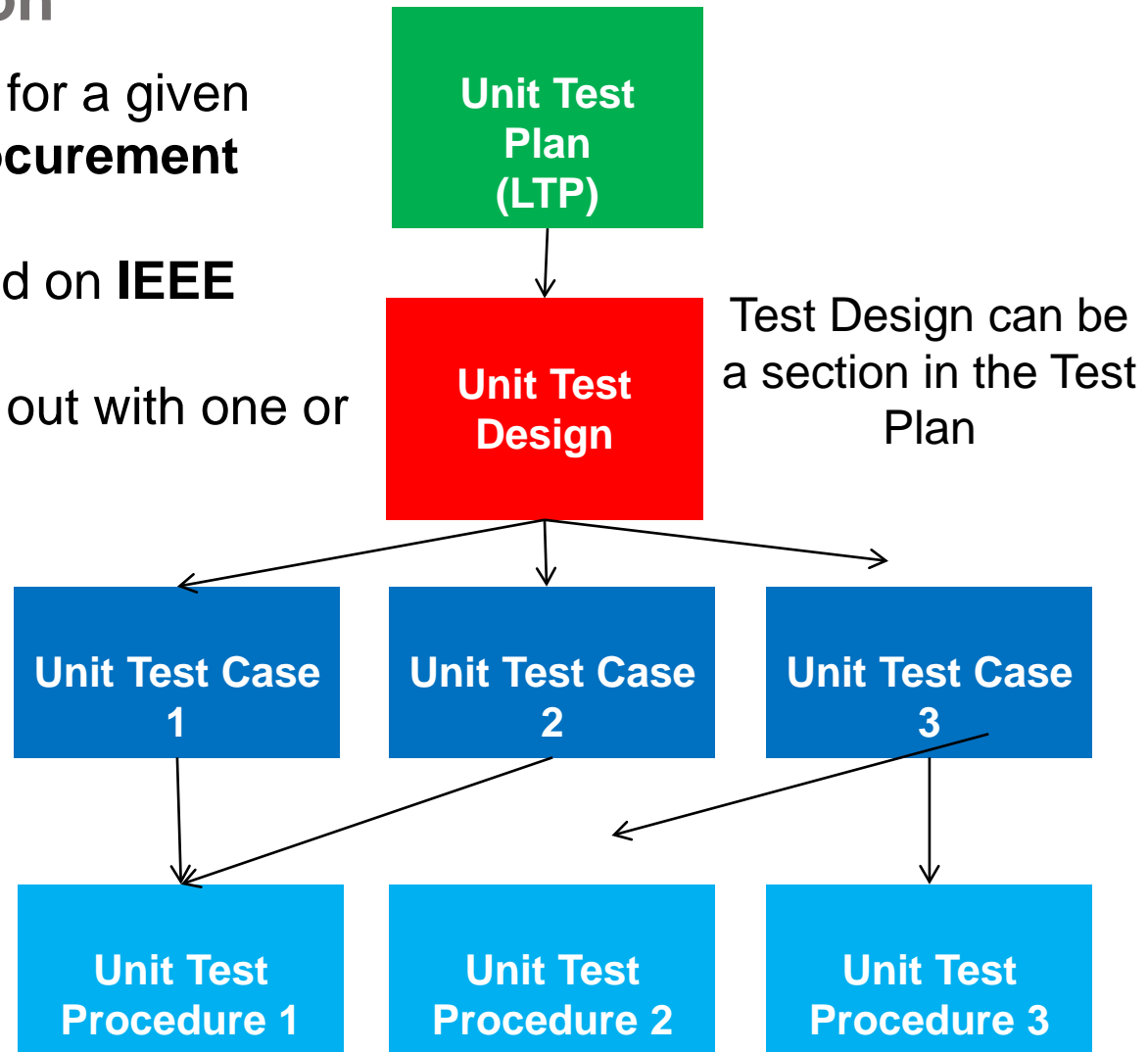
Learning Objective 4

Describe the **testing** of ATC using sample testing documentation

Applying Testing Documentation to ATC Testing Process

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



Applying Testing Documentation to ATC Testing Process

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
ATC Communications Test Plan v01:01
13 October 2016, City of Midsize
- 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.)

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

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

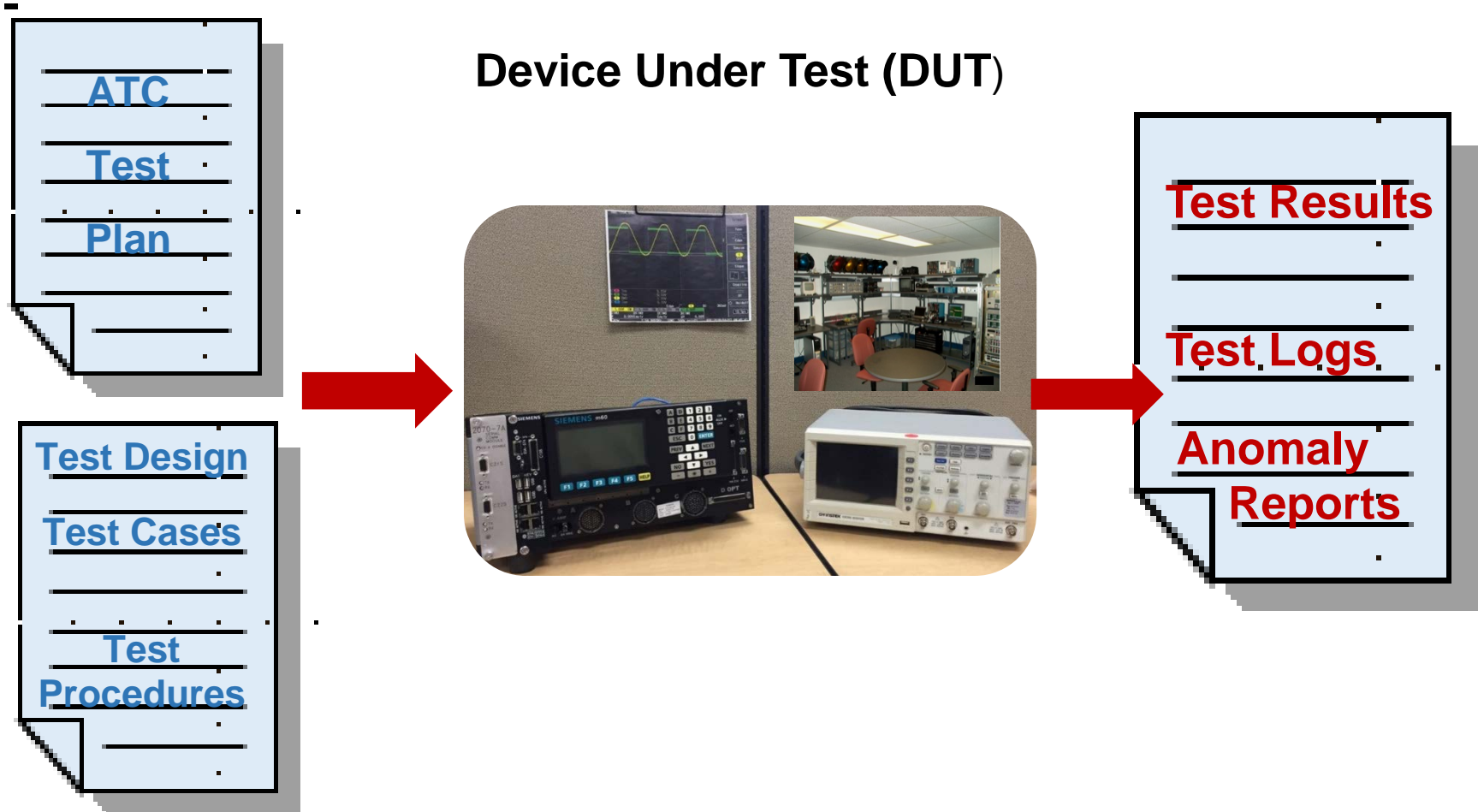
Verify environmental compliance, either

- 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

SUPPLEMENT

Applying Testing Documentation to ATC Testing Process

ATC Testing Process



CASE STUDY



U.S. Department of Transportation
ITS Joint Program Office
Image Source: Thinkstock USDOT

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**



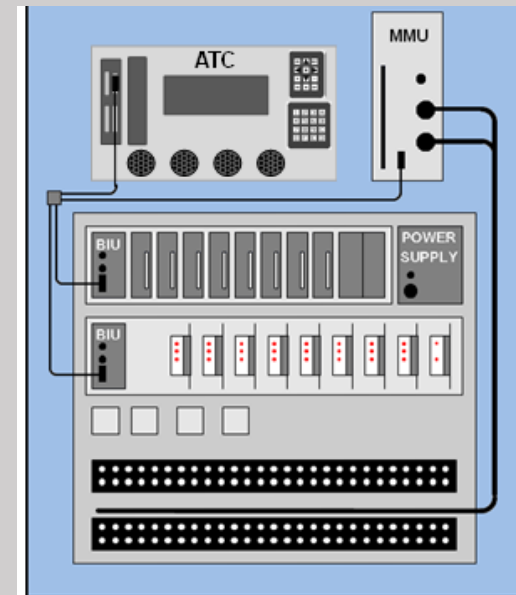
EXAMPLE

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

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



NEMA TS 2 CABINET

EXAMPLE



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

- 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:

TS2 Type 1 Wiring

Existing Signal Control App

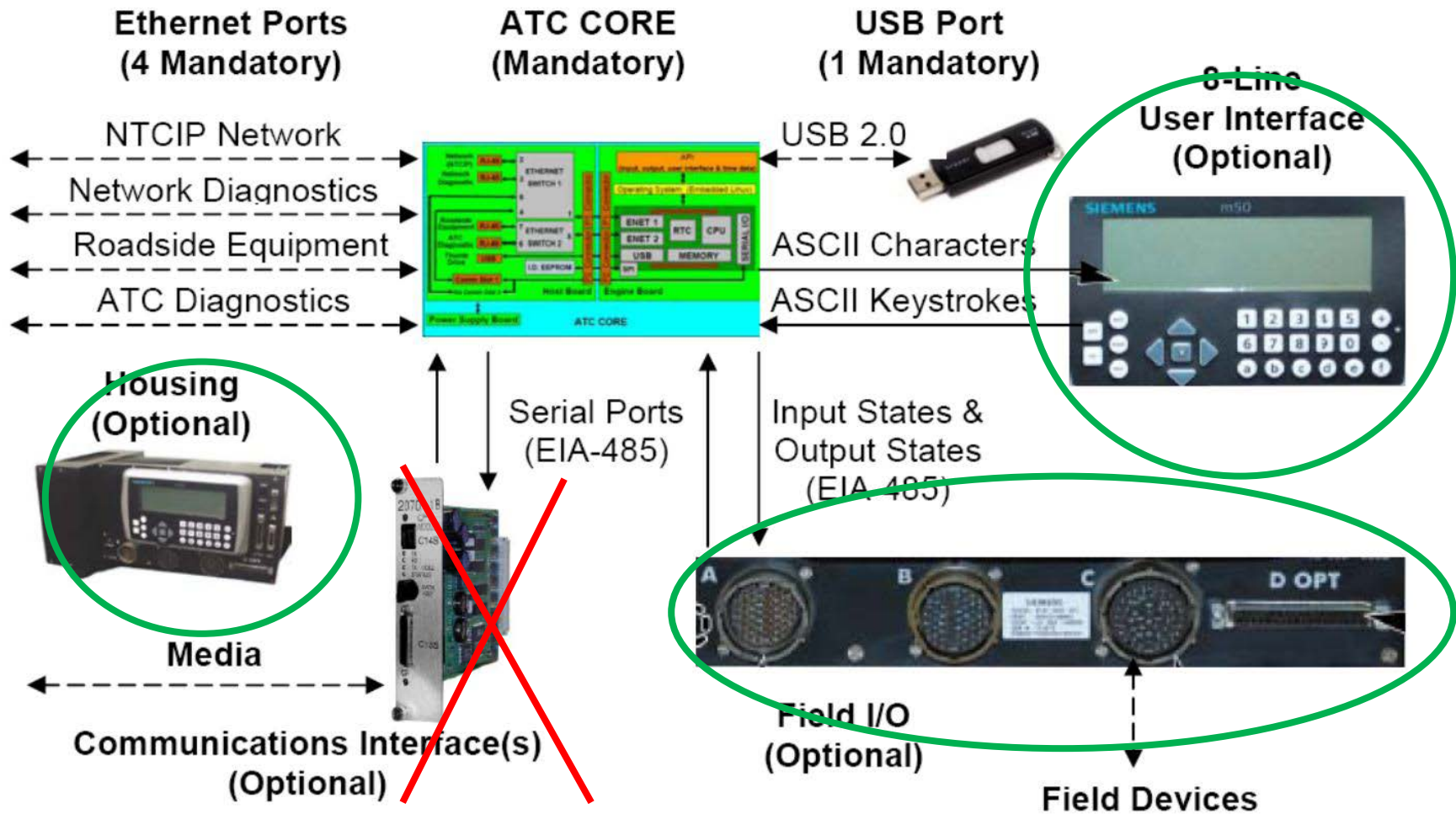
Text Data Entry

IP Comm



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

Let's Determine What Needs to Be Tested





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

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





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

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

User Need ID	User Need	FR ID	Functional Requirement	Conformance	Support	Additional Specifications
UN001	Compliant to ATC 5201 v06			M	Yes	
		FR001	Configuration shall include Engine Board	M	Yes	Verify to ATC 5201 Engine Board section
		FR002	Configuration shall include Host Module	M	Yes	Verify to ATC 5201 Host Module section
		FR003	Configuration shall include Power Supply	M	Yes	Verify to ATC 5201 Power Supply section
		FR004	Configuration shall include Appendix A and B	M	Yes	Verify Appendix "A", "B" to Linux shell listing
		FR005	Vendor shall supply Board Support Package	M	Yes	Verify receipt of BSP for use by SW vendor
		FR006	Vendor shall include DAT software source code	M	Yes	Verify receipt of BSP for use for Shop Testing
		FR007	Vendor shall independent lab environmental test report	M	Yes	Verify per ATC 5201 environmental test
		FR008	Configuration shall include IP communications to TMC	M	Yes	Verify to ATC 5201 network switch section

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

NRTM shows the Mandatory Objects That Must Be Tested

← All are to be tested

User Need ID	User Need	FR ID	Functional Requirement	Conformance	Support	Additional Specifications
UN001	Compliant to ATC 5201 v06			M	Yes	
		FR001	Configuration shall include Engine Board	M	Yes	Verify to ATC 5201 Engine Board section
		FR002	Configuration shall include Host Module	M	Yes	Verify to ATC 5201 Host Module section
		FR003	Configuration shall include Power Supply	M	Yes	Verify to ATC 5201 Power Supply section
		FR004	Configuration shall include Appendix A and B	M	Yes	Verify Appendix "A", "B" to Linux shell listing
		FR005	Vendor shall supply Board Support Package	M	Yes	Verify receipt of BSP for use by SW vendor
		FR006	Vendor shall include DAT software source code	M	Yes	Verify receipt of BSP for use for Shop Testing
		FR007	Vendor shall independent lab environmental test report	M	Yes	Verify per ATC 5201 environmental test
		FR008	Configuration shall include IP communications to TMC	M	Yes	Verify to ATC 5201 network switch section

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

User Need ID	User Need	FR ID	Functional Requirement	Conformance	Support	Additional Specifications
UN001	Installation in NEMA TS2 Type 2 cabinet			<input type="radio"/>	Yes	
		FR010	ATC configuration shall include TS2 Type 2 FIO	<input type="radio"/>	Yes	Verify to ATC 5201 FIO section for TS2
UN002	Use of existing signal control application			<input type="radio"/>	Yes	
		FR020	Signal control source code shall compile and load using Board Support Package tool	<input type="radio"/>	Yes	Verify to ATC 5201 Board Support Package section
UN003	Technician enter data while displaying status			<input type="radio"/>	Yes	
		FR030	ATC configuration shall include Front Panel	<input type="radio"/>	Yes	Verify to ATC 5201 Front Panel section
		FR040	ATC Front Panel shall include 8 lines for data entry plus 8 lines for status	<input type="radio"/>	Yes	8 lines are minimum for ATC 5201, 16 lines is special provision
		FR050	ATC Front panel data entry keys shall conform to the ATC 5201 key codes	<input type="radio"/>	Yes	Verify using DAT application by pressing each key, observe code

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

← All are to be tested

User Need ID	User Need	FR ID	Functional Requirement	Conformance	Support	Additional Specifications
UN001	Installation in NEMA TS2 Type 2 cabinet			O	Yes	
		FR010	ATC configuration shall include TS2 Type 2 FIO	O	Yes	Verify to ATC 5201 FIO section for TS2
UN002	Use of existing signal control application			O	Yes	
		FR020	Signal control source code shall compile and load using Board Support Package tool	O	Yes	Verify to ATC 5201 Board Support Package section
UN003	Technician enter data while displaying status			O	Yes	
		FR030	ATC configuration shall include Front Panel	O	Yes	Verify to ATC 5201 Front Panel section
		FR040	ATC Front Panel shall include 8 lines for data entry plus 8 lines for status	O	Yes	8 lines are minimum for ATC 5201, 16 lines is special provision
		FR050	ATC Front panel data entry keys shall conform to the ATC 5201 key codes	O	Yes	Verify using DAT application by pressing each key, observe code

Test Traceability Matrix

ATC 5201 Test Traceability

Traceability: Requirements to Test Case to Test Procedure

Req ID	Req	Test Case ID	Test Case	Test Proc ID	Test Procedure
FR001	The DUT shall not restart when subjected to power interruption of < 500 mS				
		TC001	Power Fail Immunity: Power Interruption of < 500 mS		
				TP001	Verify DUT operation is unaffected
				TP003	Verify no Power Down signal
		TC002	Restart Operation: Power Failure of > 1,000 mS		
				TP004	Verify DUT restarts
				TP005	Verify Power Down signal
FR002	The DUT shall maintain time of day during power failures				
		TC 003	Time Accuracy during variable power failures		
				TP006	500 mS: Verify time accuracy
				TP007	1 hour: Verify time accuracy

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

Prepare RTCTM for Testing Documentation

All requirements from NRTM now entered in RTCTM

Each requirement traced to a design-Element in the standard sections

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

A Test Case will be carried out in testing process

Address Consequences of Testing Boundary and Error Conditions

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

Key	ASCII DATA (TEXT)	ASCII DATA (HEX)
0	0	30
1	1	31
2	2	32
3	3	33
4	4	34
5	5	35
6	6	36
7	7	37
8	8	38
9	9	39
A	A	41
B	B	42
C	C	43
D	D	44
E	E	45
F	F	46
(UP ARROW)	ESC [A	1B 5B 41
(DOWN ARROW)	ESC [B	1B 5B 42
(RIGHT ARROW)	ESC [C	1B 5B 43
(LEFT ARROW)	ESC [D	1B 5B 44
ESC	ESC O B	1B 4F 53
NEXT	ESC O P	1B 4F 50
YES	ESC O Q	1B 4F 51
NO	ESC O R	1B 4F 52
*	*	2A
+	+	2B
-	-	2D
ENTER	CR	0D
Double Key Press (P1; P2)	ESC [K P1 P2	1B 5B 4B P1 P2
Vendor Specific Key 1	ESC O V	1B 4F 56
Vendor Specific Key 2	ESC O W	1B 4F 57
Vendor Specific Key 3	ESC O X	1B 4F 58
Vendor Specific Key 4	ESC O Y	1B 4F 59
Vendor Specific Key 5	ESC O Z	1B 4F 5A
Vendor Specific Key 6	ESC O [1B 4F 5B
Vendor Specific Key 7	ESC O \	1B 4F 5C
Vendor Specific Key 8	ESC O]	1B 4F 5D
Vendor Specific Key 9	ESC O ^	1B 4F 5E
Vendor Specific Key 10	ESC O _	1B 4F 5F
Vendor Specific Key 11	ESC O `	1B 4F 60
Vendor Specific Key 12	ESC O a	1B 4F 61
Vendor Specific Key 13	ESC O b	1B 4F 62
Vendor Specific Key 14	ESC O c	1B 4F 63
Vendor Specific Key 15	ESC O d	1B 4F 64
Vendor Specific Key 16	ESC O e	1B 4F 65



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

Address Consequences of Testing Boundary and Error Conditions

Example: Testing for Boundary Conditions

ID: TC001	Title: Power Fail / Restart
Objective:	To verify power fail and restart conformance to ATC 5201 The test case verifies that the ATC is unaffected by service power interruptions between zero and 475 mS 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):	475 mS interruption: ATC operation is unaffected, ATC time clock does not drift 550 mS, 750 mS and 1000 mS interruptions: ATC restarts
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

Test #	Service VAC	OFF mS	Expected	Actual
TC1.1	100	475	Unaffected	
TC1.2	100	475	Unaffected	
TC1.3	100	475	Unaffected	
TC1.4	100	550	Restart	
TC1.5	100	750	Restart	
TC1.6	100	1000	Restart	
TC1.7	135	475	Unaffected	
TC1.8	135	475	Unaffected	
TC1.9	135	475	Unaffected	
TC1.10	135	550	Restart	
TC1.11	135	750	Restart	
TC1.12	135	1000	Restart	



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



Question – True or False

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!