STANDARDS ITS TRAINING

WELCOME

RITA Intelligent Transportation Systems Joint Program Office
Welcome

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ACTIVITY
A208:
Using the ATC 5401 Application Programming Interface Standard to Leverage ITS Infrastructures
Instructor

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Target Audience

- Engineering Staff
- TMC/Operations Staff
- System Developers
- Software Developers
- Manufacturers
- Private and Public Sector Users
Recommended Prerequisite(s)

- I101: Using ITS Standards: An Overview
- A101: Introduction to Acquiring Standards-based ITS Systems
- A102: Introduction to User Needs Identification
- A201: Details On Acquiring Standards-based ITS Systems
- A202: Identifying and Writing User Needs When ITS Standards Do Not Have SEP Content
- A103: Introduction to ITS Standards Requirements Development
Recommended Prerequisite(s) (cont.)

- A203: Writing Requirements When ITS Standards Do Not Have SEP Content
- C101: Introduction to the Communications Protocols and Their Uses in ITS Applications
- A207a: Building an ITS infrastructure Based on the ATC 5201 Standard Part 1 of 2
- A207b: Building an ITS infrastructure Based on the ATC 5201 Standard Part 2 of 2
Curriculum Path (Non-SEP)

I101 Using ITS Standards: An Overview

A101 Introduction to Acquiring Standards-based ITS Systems

A102 Introduction to User Needs Identification

A103 Introduction to ITS Standards Requirements Development

A201 Details on Acquiring Standards-based ITS Systems

A202 Identifying and Writing User Needs When ITS Standards Do Not Have SEP Content

A207a Building an ITS Infrastructure Based on the ATC 5201 Standard Part 1 of 2

A207b Building an ITS Infrastructure Based on the ATC 5201 Standard Part 2 of 2

A208 Using the ATC 5401 API Standard to Leverage ITS Infrastructure

C101 Intro. to Comm. Protocols and Their Uses in ITS Applications
Learning Objectives

1. Identify the features of the ATC 5401 Application Programming Interface (API) Standard

2. Describe the ATC 5401 Architecture

3. Describe how the ATC 5401 Standard works with other ITS Standards

4. Specify API Software for system and equipment procurements
Learning Objective #1 – Identify the Features of the ATC 5401 Application Programming Interface (API) Standard

- Sharing resources of the controller and transportation field cabinet system
- Structure of the ATC 5401 Standard
- Features for API Software
Uses for ATC Controller Units Identified

- 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 / Data Distribution
- Connected Vehicle (CV) Applications
  - Safety
  - Eco Driving
Sharing Resources of the Controller and Transportation Field Cabinet System (TFCS)

Learning Objective #1

Housing

Inputs

Controller

Outputs

Monitoring

Power Supply

( Int Comm Bus )

Graphics: Ralph W. Boaz
Basic TFCS Operation

- **Inputs**
- **Controller**
- **Outputs**
- **Monitoring**

Controller/Monitor Communications Used in NEMA TS 2 and ITS Cabinets

Field Sensors

Field Displays

Graphics: Ralph W. Boaz
Sharing Resources of the Controller and TFCS

Intersections Control

Ramp Metering

Connected Vehicle V2I

Other Applications

Graphics: Ralph W. Boaz
ACTIVITY
Which of the following elements of the TFCS is not shared by API Software?

Answer Choices
a) Outputs
b) Inputs
c) Controller
d) Power
Review of answers

a) Outputs
Incorrect. API Software allows application programs to share the output devices of the TFCS.

b) Inputs
Incorrect. API Software allows application programs to share the input devices of the TFCS.

c) Controller
Incorrect. API Software allows application programs to share the controller unit of the TFCS.

d) Power
Correct. API Software has nothing to do with the distribution of power within the cabinet. The fourth element shared is Monitoring.
Structure of the ATC 5401 Standard

- Section 1 Introduction
- Section 2 Overall Description
- Section 3 Specific Requirements
- Section 4 Application Programming Interface
- Appendices
- Index
Clarification of Terms

- ATC 5401 Standard (aka API Standard) specifies software (aka API Software or “the API”)
- API Software operates on ATC controller units allowing application programs to share the resources of the TFCS
Two Types of Users of API Software

- Operational Users
  - Technicians or transportation engineers that use application programs that run on controllers to perform their operational tasks

- User Developers
  - Software developers that design and develop application programs for ATC equipment
Two Types of Interfaces Provided by API Software

- **User Interfaces**
  - Interfaces defined for Operational Users so that multiple programs can run concurrently on a ATC controller unit

- **Software Interfaces**
  - C language function calls that allow User Developers to create application programs that share the resources of a TFCS
ATC 5401 Sections of Interest to Operational Users

- Section 1 Introduction
- Section 2 Overall Description
- Section 3 Specific Requirements
- Section 4 Application Programming Interface
- Appendices
- Index

Sections of interest to Operational Users
Features for API Software

- Front Panel Management
- Field Input/Output (I/O) Management
- Real-Time Clock
- API Utilities
Front Panel Management

- Front Panel Manager Window
- C function interface
- Application programs able to use dedicated window(s)
- Operational Users interact with window/application program in “focus”
- “Default Window” is the window that has focus when the controller unit is powered up
- Works with screen sizes up to 24 lines x 80 characters
- Screen and keypad defined by the ATC 5201 Standard
ATC Controller Minimum Keypad

Photo: Ralph W. Boaz
Front Panel Manager Window

[Application programs shown are for example purposes only and not included in API Software]

Graphics: Ralph W. Boaz
Example Application Programs

RAMP METER CONTROL

1. Metered Lanes
2. Mainline
3. Addtnl Detect
4. Traff Resp Plns
5. Command Source
6. Time of Day
7. Communications
8. General
9. Utilities
A. Status

[Application programs shown are for example purposes only and not included in API Software]

Graphics: Ralph W. Boaz
Example Application Programs (cont.)

INTERSECTION CONTROL

1. TIMING DATA  
2. PHOVLPASSIGN  
3. PEDCARRYOVER  
4. RECALLDATA  
5. OVEWLAPDATA  
6. START/FLASHDATA  
7. NOSENVEPHASES  
8. DIMMING  
9. OPTIONDATA

PRESS KEYS 1..9 TO SELECT F=HELP

[Application programs shown are for example purposes only and not included in API Software]

Graphics: Ralph W. Boaz
Example Application Programs (cont.)

[Application programs shown are for example purposes only and not included in API Software]

Graphics: Ralph W. Boaz
C Function Interface for Front Panel Management

- General Functions
  - Open, Close, Refresh, Clear Windows

- Window Attribute Functions
  - Character Blink, Backlight, Reverse Video, Underline, Auto Wrap, Scrolling

- Read Functions
  - Poll for Input, Read Character, Read String

- Write Functions
  - Write Character, Write String, Write at Position
Which of the following statements is TRUE regarding the operation of the Front Panel Manager Window?

Answer Choices

a) The Default Window is always position [1] on the Front Panel Manager Window
b) An Intersection Control window comes standard with the API Software
c) Pressing {**,<ESC>} causes the Front Panel Manager Window to be put in focus
d) The Front Panel Manager is designed for an 8 line display only
Review of answers

a) The Default Window is always position [0] on the front panel manager window

Incorrect. The Default Window is user selectable by pressing \{*,[0-F],<ENT>\} while in the Front Panel Manager Window.

b) An Intersection Control Window comes standard with API Software

Incorrect. API Software is defined by the ATC 5401 Standard which does not contain specifications for an Intersection Control Window.

c) Pressing \{**,<ESC>\} causes the Front Panel Manager Window to be put in focus

Correct. This action works regardless of the window that is in focus at the time.

d) The Front Panel Manager is designed for an 8 line display only

Incorrect. The Front Panel Manager will work with various size controller screens.
Field Input/Output (I/O) Management

- C function interface only

- Facilitates application programs to be written so they operate in the various TFCS architectures
  - Caltrans 332-Type Cabinets
  - NEMA TS 1, TS 2 Type 1, TS 2 Type 2 Cabinets
  - ITS Cabinets

- Application programs able to query the API to determine what types of devices are used in the TFCS
Field Input/Output (I/O) Management (cont.)

- Application programs “register” to access a Field I/O device
- Application programs have “read access” to all input and output field devices
- Application programs “reserve” exclusive “write access” to output points of a Field I/O Device
Application Programs Reserving Outputs

Front Panel Manager Ver 1.00

Select Window: 0-F
Set Default: *, 0-F

0 Ramp Meter Prgrm
1 Signal Program
2 Emergency Mngmnt
3 Data Distributor
4 System Checker
5
6
7
8
9

[MORE-UP/DN ARROW] CONFIG INFO-NEXT]

Graphics: Ralph W. Boaz
C Function Interface for Field I/O Management

- **General Functions**
  - Register/Deregister, Enable/Disable Field I/O, Get/Reset Field I/O Status

- **Input Configuration Functions**
  - Get Field Inputs, Get/Set Input Filter

- **Output Configuration Functions**
  - Set/Get Field Output Reservations, Set/Get Field Outputs

- **Frame Functions**
  - Set/Get Frame Schedule, Read/Write Frames

- **Transition Buffer Functions**
  - Set/Get/Read Transition Buffer
C Function Interface for Field I/O Management (cont.)

- Watchdog/Health Monitor Functions
  - Watchdog Register/Deregister, Watchdog Set/Get Reservation, Health Monitor Register/Deregister, Health Monitor Heartbeat, Health Monitor Reset

- Fault/Volt Monitor Functions
  - Set/Get Volt Monitor

- CMU/MMU/Channel Functions
  - Set/Get Faults, Channel Mapping
C Function Interface for Real-Time Clock Management

- Set/Get Time Functions
- Daylight Saving Time (DST) Functions
- Time Source and Signaling Functions
Which of the following is TRUE in regards to the Field I/O Management of API Software?

Answer Choices

a) All application programs may have read access to all of the input points

b) All application programs may have write access to all of the input points

c) All application programs may have write access to all of the output points

d) Application programs must communicate with each other to avoid writing to the same output points
Review of Answers

a) All application programs may have read access to all of the input points

Correct. There are no restrictions on applications reading input points.

b) All application programs may have write access to all of the input points

Incorrect. No application program has write access to input points.

c) All application programs may have write access to all of the output points

Incorrect. Application programs must reserve exclusive write access to modify an output point.

d) Application programs must communicate with each other to avoid writing to the same output points

Incorrect. The reservation system used by API Software makes communication unnecessary for this purpose.
API Utilities

- ATC Configuration Window
- Standard Utilities
  - Setting System Time
  - Setting Ethernet Ports
  - Selecting System Services
  - Getting Linux and API information
  - Viewing Host EEPROM Information
- Extensible so additional utilities may be added
- Utilities differ from application programs
- C function interface
ATC Configuration Window

SELECT ITEM: 0 - F
0 System Time
2 System Services
4 Host EEPROM Info
6
8
[UP/DN ARROW]

1 Ethernet Config
3 Linux/API Info
5
7
9
[FRONT PANEL - NEXT]

Graphics: Ralph W. Boaz
System Time Utility

System Time

Date: 06/13/2013
Time: 01:00:00
T-Zone: -07:00
DST/Status: Enable/Active

Change

Date
Time
T-M-Zone
DST
MM/DD/YYYY
hh:mm:ss
hh:mm
enable/dis
[UP/DN ARROW] [APPLY-ENT] [QUIT-**NEXT]
Ethernet Configuration Utility

Port Enabled: Yes

Packets Sent GD: 120154243 BD: 9898416
Packets Rcvd GD: 782143860 BD: 28328078
IP Address: 192.168.001.065
Subnet Mask: 255.255.255.000

[UP/DN ARROW] [APPLY-ENT] [QUIT-**NEXT]
Systems Services Utility

ENABLE/DISABLE SYSTEM SERVICES

SERVICE
Bluetooth
Signal Phase & Timing

STATUS
Enabled
Enabled

CHANGE
enable or disable
enable or disable
enable or disable

[UP/DN ARROW] [APPLY-ENT] [QUIT-**NEXT]

Graphics: Ralph W. Boaz
C Function Interface for API Utilities

- General Functions – Open/Close Configuration Window, Reserve/Release Resource
- Time of Day Functions – Set/Get Time, Set/Get DST, Time Source Selection
- "ATCConfigurationMenu.txt" file for adding utilities to ATC Configuration Window

  configitemname1, executablepathname1
  configitemname2, executablepathname2
  configitemname3, executablepathname3
  configitemname4, executablepathname4
ACTIVITY
Which of the following is not a standard utility provided in API Software?

**Answer Choices**

a) Ethernet Configuration  
b) Bluetooth Configuration  
c) Linux/API Information  
d) System Time
Review of answers

a) Ethernet Configuration
Incorrect. Ethernet is a standard utility allowing Operational Users to set the Ethernet ports of the controller.

b) Bluetooth Configuration
Correct. There is no utility for Bluetooth communications currently in the API Software. A utility could be created and added for Bluetooth, however.

c) Linux and API Information
Incorrect. Linux/API information is a standard utility in API Software allowing Operational Users to get information on the Linux Board Support Package and the API Software libraries.

d) System Time
Incorrect. Setting system time is a standard utility in API Software allowing Operational Users to set the time.
Summary of Learning Objective #1

Identify the features of the ATC 5401 Application Programming Interface (API) Standard

- Sharing Resources of the Controller and Transportation Field Cabinet System
- Structure of the ATC 5401 Standard
- Features for API Software
Learning Objective #2 – Describe the ATC 5401 Architecture

- Key Elements of the ATC 5401 Architecture
- Describe How the ATC 5401 Standard and ATC 5201 Standard Work Together
- ATC Software Portability, Compatibility and Interchangeability
Key Elements of the ATC 5401 Architecture

- Based on an “Engine Board” concept specified in ATC 5201
- Uses Linux operating system
  - Open source, multi-process, multi-application
- Allows multiple application programs to operate concurrently ATC controller units
- Shares resources of the front panel, field I/O elements of the TFCS, and the real-time clock
- Source code portability, compatibility and interchangeability for application programs
ATC Engine Board

- ENET 1
- ENET 2
- USB
- MEMORY
- RTC
- CPU + LINUX O/S
- SERIAL I/O

Graphics: Ralph W. Boaz
Example Engine Board

- DRAM
- CPU
- ENET 1&2
- Flash Memory
- RTC
- Serial I/O
- SRAM
- USB
ATC Layered S/W Architecture

- **APPLICATION LAYER**
  - APPLICATION SW
  - API
  - LINUX OS & DEVICE DRIVERS

- **API SOFTWARE LAYER**
  - HARDWARE & OS DEFINED BY ATC 5201 STANDARD
  - INTERFACE & BEHAVIOR DEFINED BY ATC 5401 STANDARD

- **HARDWARE LAYER**
  - ATC BOARD SUPPORT PACKAGE LAYER

- **OPERATIONAL USER**

Graphics: Ralph W. Boaz
API Software manages access to Front Panel, Field I/O Ports, and Real-Time Clock

Resources managed by the API

Graphics: Ralph W. Boaz
ATC Software Portability, Compatibility and Interchangeability

Portability

- The ease with which applications software and data can be transferred from one application platform to another
- Ability to move, with minimal changes, application software between computers
Portability Achieved Through Compiling and Linking Software

Application Software

Compiling and Linking Using Application Source Code and API Software Libraries

ATC Engine Board From Vendor 1
ATC Engine Board From Vendor 2
ATC Engine Board From Vendor 3

Graphics: Ralph W. Boaz
ATC Software Portability, Compatibility and Interchangeability

Compatibility

- Two or more systems or components perform their required functions while sharing the same environment
- The two components (or systems) do not need to communicate with each other
Compatibility Achieved Through Linux O/S and API Software

Application Software 1

Application Software 2

Application Software 3

Linux O/S and API Software

ENET 1

ENET 2

RTC

CPU

MEMORY

SERIAL I/O

USB

ATC Engine Board From Vendor

Graphics: Ralph W. Boaz
ATC Software Portability, Compatibility and Interchangeability

Interchangeability

- Same functional and physical characteristics so as to be equivalent in performance and durability (subjective)
- Ability to exchange devices of the same type without alteration to the device or adjoining items (adjustments permitted, subjective)
Interchangeability Possible If Application Features Are Equivalent

Application Software 1

Application Software 2

Application Software 3*

Linux O/S and API Software

Application Software 4*

ENET 1
ENET 2
USB
MEMORY
RTC
CPU
SERIAL I/O

ATC Engine Board From Vendor

* Indicates applications are of the same type

Graphics: Ralph W. Boaz
Which of following parts of the ATC Engine Board is not managed by API Software?

Answer Choices

a) Front Panel Port
b) Real-Time Clock
c) General Purpose Serial I/O Ports
d) Field I/O Ports
Review of answers

a) Front Panel Port
Incorrect. API Software controls the front panel port providing a windowing capability for application programs.

b) Real-Time Clock
Incorrect. API Software a System Time Utility and clock functions to allow users and application programs to set the real-time clock.

c) General Purpose Serial I/O Ports
Correct. Use of the general purpose serial ports is controlled by Linux not the API Software.

d) Field I/O Ports
Incorrect. API Software manages the Field I/O ports of the engine board.
Summary of Learning Objective #2

Describe the ATC 5401 Architecture

- Key Elements of the ATC 5401 Architecture
- Describe How the ATC 5401 Standard and ATC 5201 Standard Work Together
- ATC Software Portability, Compatibility and Interchangeability
Learning Objective #3 – Describe How the ATC 5401 Standard Works With Other ITS Standards

- Transportation Field Cabinet Systems
- ITS Communications Standards
- Consider New Ways To Solve ITS Issues
ATC 5401 Standard Works with all of the Major Transportation Field Cabinet Systems

- ATC 5201 Standard specifies controller units that work with Model 332 Cabinets, NEMA TS 1 and TS 2 Type 2 Cabinets, NEMA TS 2 Type 1 Cabinets and ITS Cabinets
- API Software provides internal cabinet interfaces suitable for all of the major TFCSs
- Application software can be made portable, compatible, and interchangeable to controllers designed for any TFCS through compilation with API libraries
ATC 5201 Standard and ATC 5401 Standard Provide Computational Power and Interfaces for ITS Communications

- Most TFCSs that use 170 controller units will require replacement hardware in order to fully utilize NTCIP Actuated Signal Control (ASC) communications
- ATC standards provide the capability to support multiple applications using different (or same) types of NTCIP communications simultaneously
- ATC standards provide interface and computational power for applications such as Adaptive Control and Vehicle to Infrastructure (V2I) Integration
ATC Controller Units in Different TFCSs

Model 332 Cabinet  NEMA TS 2 Type 1

Graphics: Ralph W. Boaz
ATC 5401 Working With Other ITS Standards

Example Applications

- Signal Control App w/ASC
- Field Master App w/FMS
- Ramp Meter App w/RMC
- SPAT Message Service

API Software

- ENET 1
- ENET 2
- CPU + LINUX O/S
- SERIAL IO
- USB
- MEMORY

API Software

- ENET 1
- ENET 2
- CPU + LINUX O/S
- SERIAL IO
- USB
- MEMORY

ATC 5401 Standard

ATC 5201 Standard

NTCIP, Other Standards

TFCS Standards & Specifications

Graphics: Ralph W. Boaz

Learning Objective #3
Consider New Ways To Solve ITS Issues

- Open systems promotes innovation from more sources
- ATC 5401 Standard is opening up new markets for 3rd party software
- New methods to solve ITS problems
  - Software duplicated in field devices may be able to run as applications on an ATC controller
  - Field devices may be more cost effective
  - Custom applications
- Good system engineering practices essential
ACTIVITY
Learning Objective #3

What must a User Developer do to make an application portable and compatible on two different ATC controllers in different TFCS architectures? Choose the best answer.

Answer Choices

a) Write the application software so that it uses the ATC 5401 function calls whenever they are applicable
b) Compile and link the application source code with API libraries

c) Compile and link the application source code for the ATC Engine Board used in each controller
d) All the above
Review of answers

a) Write the application software so that it uses the ATC 5401 function calls whenever they are applicable

Incorrect. This is an essential part of making the software portable and compatible but there are others. Note that software will also need to use function calls appropriate for appropriate TFCS architectures.

b) Compile and link the application source code with API libraries

Incorrect. This is an essential part of making the software portable and compatible between TFCS architectures but there are others.

c) Compile and link the application source code for the ATC Engine Board used in each controller

Incorrect. This is an essential part of making the software portable and compatible between TFCS architectures but there are others.

d) All of the above

Correct. This is the best answer.
Summary of Learning Objective #3

Describe How the ATC 5401 Standard Works With Other ITS Standards

- Transportation Field Cabinet Systems
- ITS Communications Standards
- Consider New Ways To Solve ITS Issues
Learning Objective #4 – Specify API Software for System and Equipment Procurements

- Discuss how ATC 5401 fits in the Systems Life Cycle
- Develop migration strategies and mitigate deployment issues
- Creating a specification based on the ATC 5401 Standard
How ATC 5401 Fits in the Systems Life Cycle

- TFCSs (including controllers) can be considered a subsystem of a Center-to-Field (C2F) system
- TFCSs may be in place for multiple C2F systems and generations of C2F systems
- ATC controller units may extend the life of a C2F system
- Deployment of the ATC 5201 and ATC 5401 standards may occur at any stage in the life of a C2F system
Develop Migration Strategies

- Have a written plan and policy for deploying ATC equipment as part of a strategic plan
- Procurement specifications and procurement process must be integrated with the strategic plan
- Factors that may influence the migration strategy:
  - Working with existing TFCS
  - Moving to new TFCS architectures
  - New projects
  - Scheduled maintenance
(cont.)
Develop Migration Strategies (cont.)

- Factors that may influence the migration strategy: (cont.)
  - Upgrading to ATC hardware while using an agency’s current application software
  - Upgrading to new operational software
  - Compatibility with existing or planned system software
  - Training operational staff
Mitigating Deployment Issues

- Although the API 5401 v02 has been published, complete API Software meeting the standard is not yet available.
- USDOT has started a project to create a reference implementation of API Software (APIRI) for public use in 2015.
- APIRI project includes development of a validation suite (APIVS) to test API Software on an ATC Engine Board.
Open Source API Reference Implementation

Software Vendors

Open Source API (APIRI)

Consultants

Manufacturers

Agencies

Photos: Intelight, McCain, Econolite, Peek

Graphics: Ralph W. Boaz
Benefits of Open Source API Reference Implementation

- Consistent with the Linux O/S open source concept
- Promotes collaboration of developers across transportation industry
- Provides forum for users to express ideas and concerns
- Promotes quick bug fixes and alternative solutions to issues
- Facilitates introduction of new application developers
- Lowers cost to the industry
- Best opportunity for consistent API Software behavior
API Validation Suite (APIVS)

- APIVS software runs on a PC
- Test fixture used to host an ATC Engine Board with API Software
- PC uses test scripts written in XML (Extensible Markup Language) to drive testing of the Engine Board and API Software on the test fixture
- Crossover cables used to connect inputs to outputs of the Engine Board and exercise API Software functionality
- To be made available as open source project
API Validation Suite Test Fixture

Graphics: Ralph W. Boaz
API Validation Suite Test Environment

Graphics: Ralph W. Boaz
Creating a Specification Based on the ATC 5401 Standard

- Specification for API Software a part of ATC controller (or Engine Board) procurement (see PCB Module A207b)
- Require API Software that conforms to ATC 5401 v02.17 when the APIRI is available
- Establish a contractual commitment from Engine Board suppliers to provide operational API Software for their Engine Boards once the APIRI is available
- Require the Tool Chain and Source Code Used to Produce the Linux Environment for the Engine Board
Creating a Specification Based on the ATC 5401 Standard

- Require demonstration from manufacturers that each of the API interfaces are operational and multiple programs run concurrently
- Have a certification from manufacturer that the ATC being purchased passed testing using the APIVS (when it is available)
Additional Guidance When Procuring Application Software

- Prior to purchase, have application providers demonstrate their software on the agency’s current ATC units.
- Establish a contractual commitment from application software providers to supply software compatible with the API once the APIRI is available.
- Purchase support services with application software.
- Separate specifications for ATC 5201 and ATC 5401 equipment from that of any application programs.
What is NOT a benefit of the API Reference Implementation?

Answer Choices
a) Guarantees bug-free software
b) Lowers development cost to the industry
c) Best opportunity for consistent API Software behavior
d) Promotes collaboration of developers across the transportation industry
Review of Answers

a) Guarantees bug-free software

Correct. This is not a benefit of the APIRI. In any non-trivial software, there are bound to be unexpected behaviors.

b) Lowers development cost to the industry

Incorrect. This is a benefit of the APIRI. In this joint effort of industry developers, costs are reduced for everyone.

c) Best opportunity for consistent API Software behavior

Incorrect. This is a benefit of the APIRI. A common source defining proper software behavior creates the most consistency.

d) Promotes collaboration of developers across the transportation industry

Incorrect. This is a benefit of the APIRI. Solutions and improvements by individuals are discussed, assessed and tested by a group of developers prior to being added to the APIRI.
Summary of Learning Objective #4

Specify API Software for System and Equipment Procurements

- Discuss how ATC 5401 fits in the Systems Life Cycle
- Develop migration strategies and mitigate Deployment Issues
- Creating a specification based on the ATC 5401 Standard
What We Have Learned

1. API Software is grouped into the following feature areas: __Front__ Panel Management, Field __I/O__ Management, Real-Time __Clock__ Management and API __Utilities__.

2. The ATC 5201 and ATC 5401 define a layered architecture that provides for application software __portability__, __compatibility__ and __interchangeability__.

3. ATC 5401 Standard defines API Software which will work with all major __TFCS__ architectures in use today.

4. The API Open Source __Reference Implementation__ will promote collaboration of developers across the transportation industry.
Resources

- Caltrans Transportation Electrical Equipment Specifications (TEES), 12 March 2009
- Intelligent Transportation System (ITS) Standard Specification for Roadside Cabinets v01.02.17b
- NEMA Standards Publication TS 1-1989 Traffic Control Systems
- NEMA Standards Publication TS 2-2003 v02.06 Traffic Controller Assemblies with NTCIP Requirements
- Institute of Transportation Engineers  
  [http://www.ite.org/standards/](http://www.ite.org/standards/)
- ITS PCB Training  
QUESTIONS?