WELCOME

RITA Intelligent Transportation Systems
Joint Program Office

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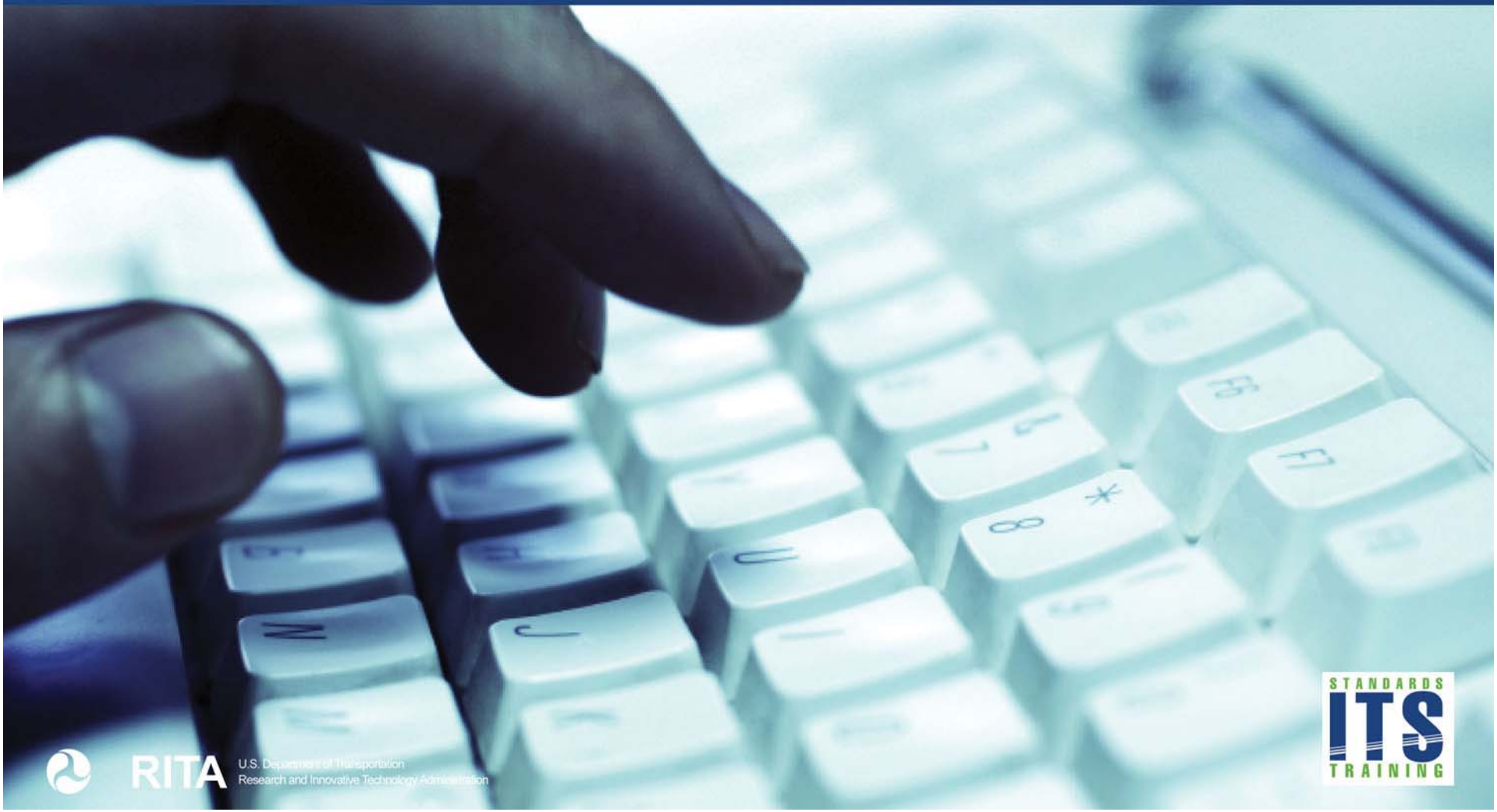

RITA U.S. Department of Transportation
Research and Innovative Technology Administration

STANDARDS ITS TRAINING

A207b:
Building an ITS Infrastructure Based on the Advanced Transportation Controller (ATC) 5201 Standard Part 2 of 2

Instructor

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Target Audience

- Engineering staff
- Traffic management center/operations staff
- Traffic signal maintenance staff
- System developers
- Software developers
- Manufacturers
- Private and public sector users

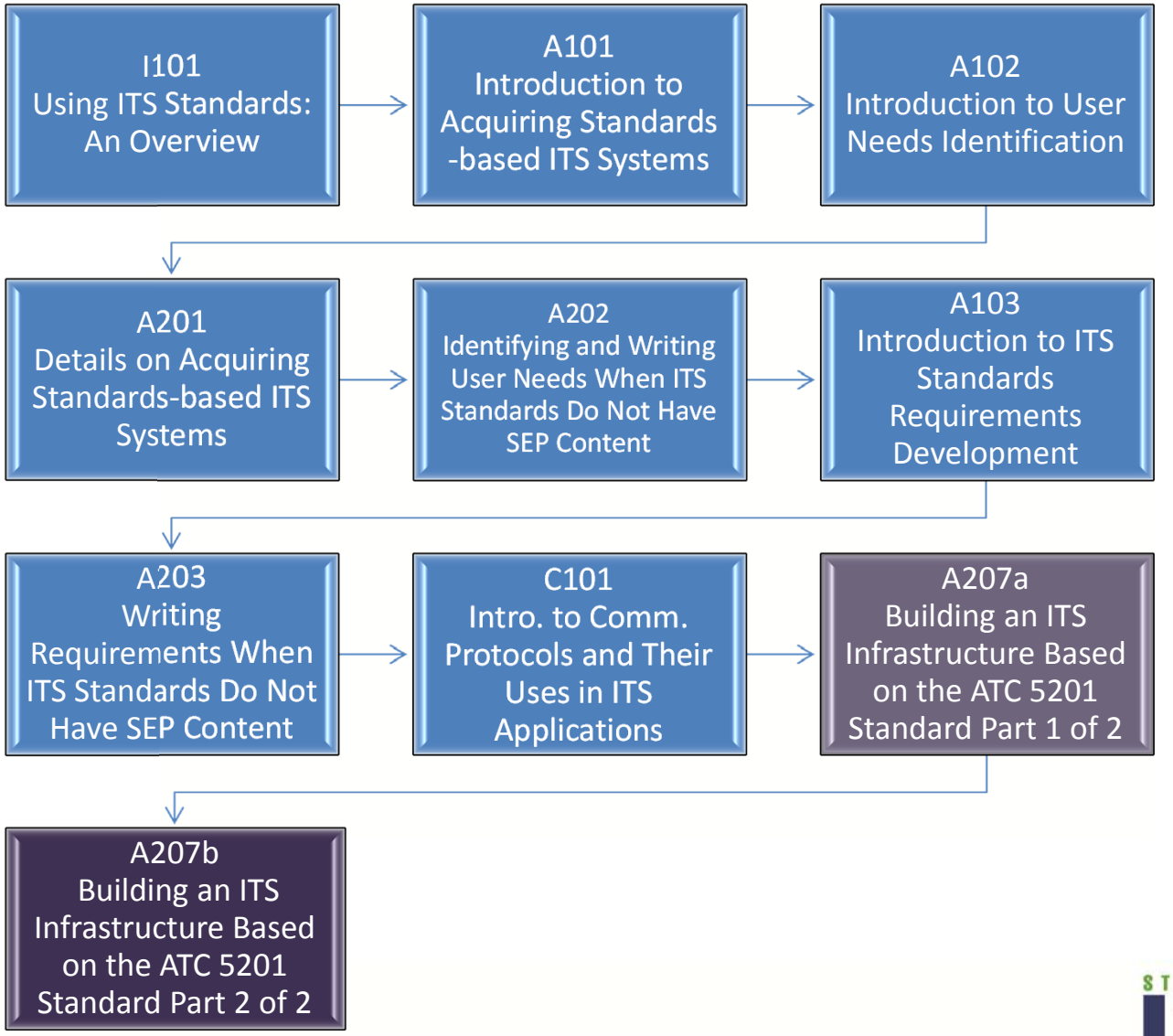
Recommended Prerequisite(s)

- 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

Curriculum Path (Non-SEP)



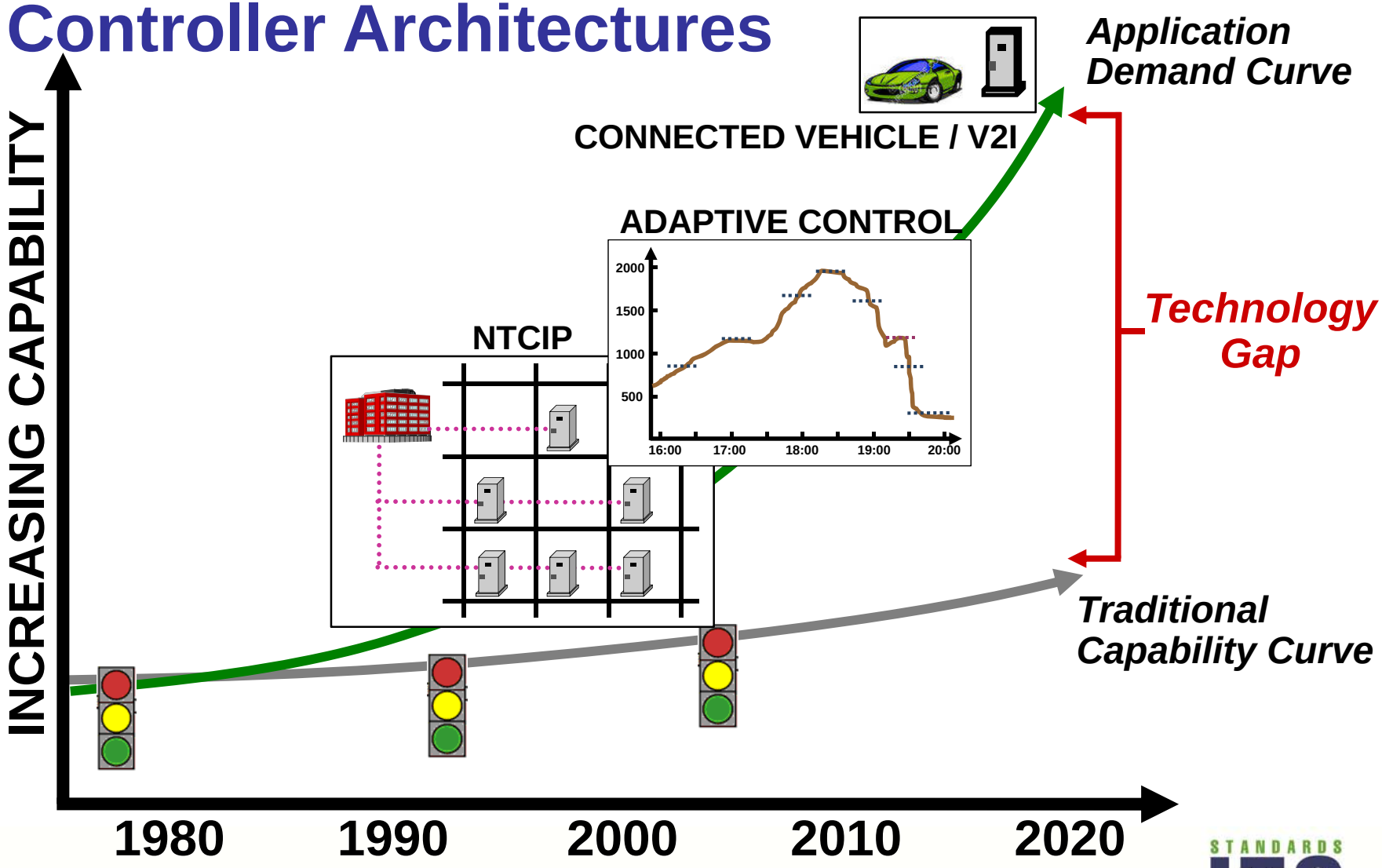
Learning Objectives

1. Explain the purpose of the ATC Family of Standards
2. Identify the basic components and operation of Transportation Field Cabinet Systems
3. Identify the features of the ATC 5201 Standard
4. Describe the ATC 5201 architecture
5. Describe how the ATC 5201 Standard works with other ITS standards
6. Specify ATC equipment for system and equipment procurements

Learning Objective #3 – Identify the Features of the ATC 5201 Advanced Transportation Controller Standard

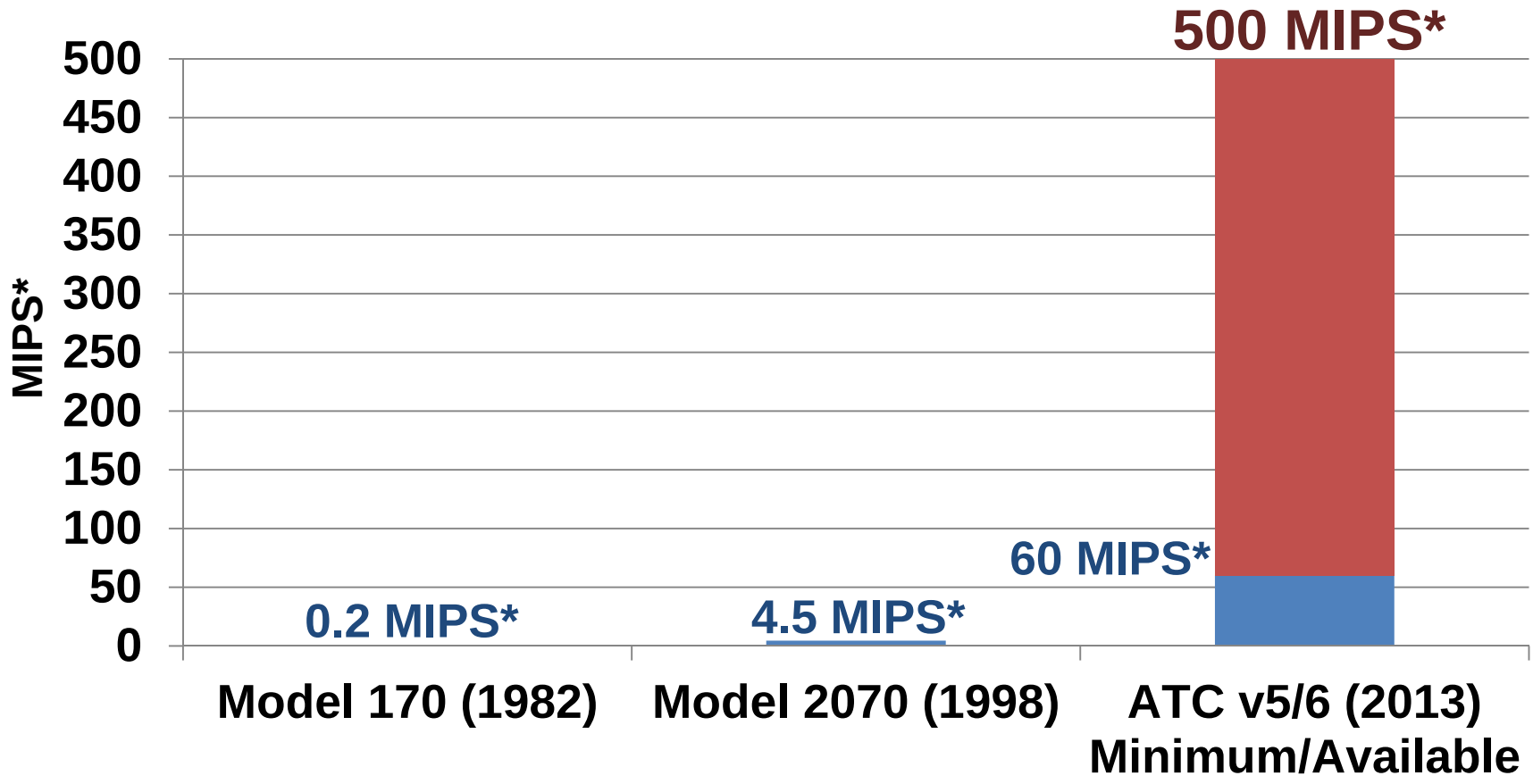
- Problem with traditional transportation controller architectures
- Structure of the ATC 5201 Standard
- Features for ATC controller units

Problem with Traditional Transportation Controller Architectures



Graphics: Ralph W. Boaz

Transportation Controller Comparative Performance



* Millions of Instructions Per Second

Graphics: Ralph W. Boaz

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
- Connected Vehicle (CV) Applications
  - Safety
  - Eco Driving

Purpose of the ATC Family of Standards

- Provide a general purpose field computing platform for transportation applications that is:
  - Open Architecture
  - Modular
  - Multi-Process/Multi-Application
  - Can Grow with Technology
  - Upgrade for Legacy Transportation Field Cabinet Systems (TFCSs)

Structure of the ATC 5201 Standard

Section 1 Introduction

Section 2 Overall Description

Section 3 Functional Requirements

Section 4 Engine Board Details

Section 5 Communication Interface Details

Section 6 Physical and User Interface Details

Section 7 Parallel and Serial I/O Details

Section 8 Environmental and Test Procedures

Structure of the ATC 5201 Standard (cont.)

Section 9 Performance and Material Requirements

Section 10 Quality Control

Appendix A Linux Operating System and Minimum Kernel Configuration

Appendix B Required Device Driver Interfaces

Appendix C Historical Background of Traffic Controllers

Major Transportation Field Cabinet Systems (TFCSs)

NEMA TS 1

Model 33X

Photos: Econolite and Ralph W. Boaz

Major Transportation Field Cabinet Systems (TFCSs) (cont.)

NEMA TS 2 Type 1

ITS Cabinet v01

Photos: Ralph W. Boaz

Features for ATC Controller Units

Major Operational Features

- Manage/Configure Applications
- Manage External Devices
- Facilitate Ease of Maintenance and Future Hardware/Software Updates

Manage/Configure Controller Applications

2.3.1.1 Install/Update Applications Software Quickly and Efficiently

2.3.1.2 Install/Upgrade Operating System (O/S) Quickly and Efficiently

2.3.1.3 Manage Clock/Calendar Function and Synchronize with Reliable External Source

2.3.1.4 Configure and Verify Parameters for Particular Local Applications

Manage/Configure Controller Applications (cont.)

2.3.1.5 Upload/Download Data Block(s) as needed to Transfer Files and Accommodate Bulk Transfers of New Application Databases

2.3.1.6 Monitor and Verify Present Applications Status

2.3.1.7 Allow Operator Control of Application Execution

2.3.1.8 Facilitate the Long-Term Storage of Data for Logging and other Data Storage Applications

Manage External Devices

2.3.2.1 Manage/Control a Variety of External Field Devices

2.3.2.2 Monitor the Output and Status of a Variety of External Field Devices

Facilitate Ease of Maintenance and Future Hardware/Software Updates

2.3.3.1 Maintain/Update Controller Hardware

2.3.3.2 Maintain/Update Controller Software

2.3.3.3 Support Diagnostics

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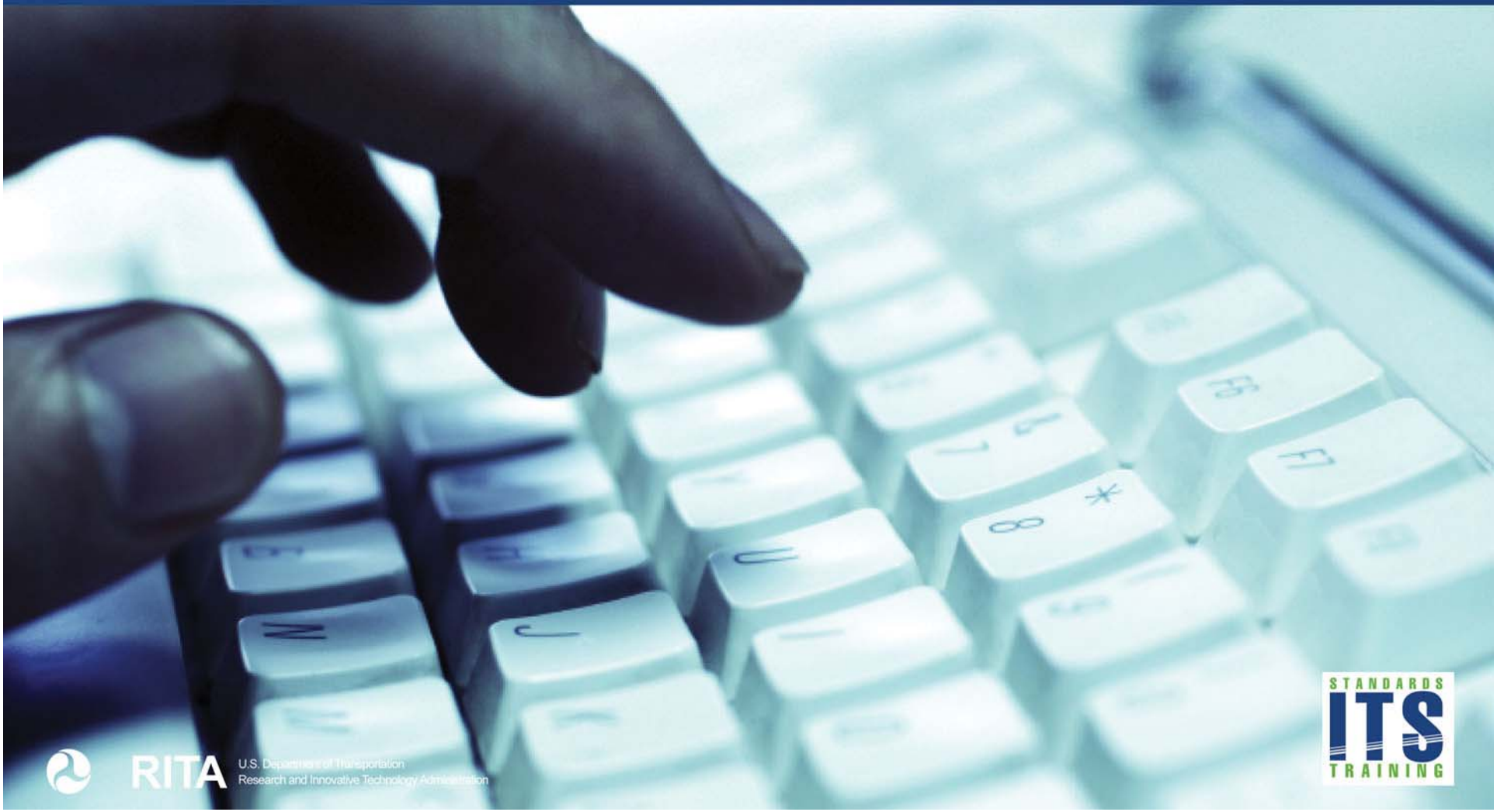

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Which of the following is NOT a purpose of the ATC standards program?

Answer Choices

a) General purpose field computing platform
b) Grow with technology
c) Open architecture
d) Compact

Review of answers

a) General purpose field computing platform

Incorrect. Defining a general purpose field computing platform for the transportation community is the primary purpose of the ATC standards program.

b) Grow with technology

Incorrect. Being able to grow with technology is a purpose of the ATC standards program mitigating obsolescence.

c) Open architecture

Incorrect. Being an open architecture so that anyone can build products for it is a purpose of the ATC standards program.

d) Compact

Correct. Being compact is not a purpose of the ATC standards program, however, the modular architecture is conducive to creating units of various sizes.

Which of the following is NOT a major feature of ATC controller units?

Answer Choices

a) Manage/Configure applications

b) Windows operating system

c) Manage external devices

d) Facilitate ease of maintenance and future hardware/software updates

Review of answers

a) Manage/Configure applications

Incorrect. Managing and configuring application programs are major features of ATC controller units.

b) Windows operating system

Correct. A Windows operating system is not a major feature of the ATC controller. A Linux O/S is used.

c) Manage external devices

Incorrect. Being able to manage external devices is a major feature of ATC controller units.

d) Facilitate ease of maintenance and future hardware/software updates

Incorrect. Making it easy to maintain controller units and make updates are major features of ATC controllers.

Summary of Learning Objective #3

Identify the Features of the ATC 5201 Advanced Transportation Controller Standard

- Problem with traditional transportation controller architectures
- Structure of the ATC 5201 standard
- Features for ATC controller units

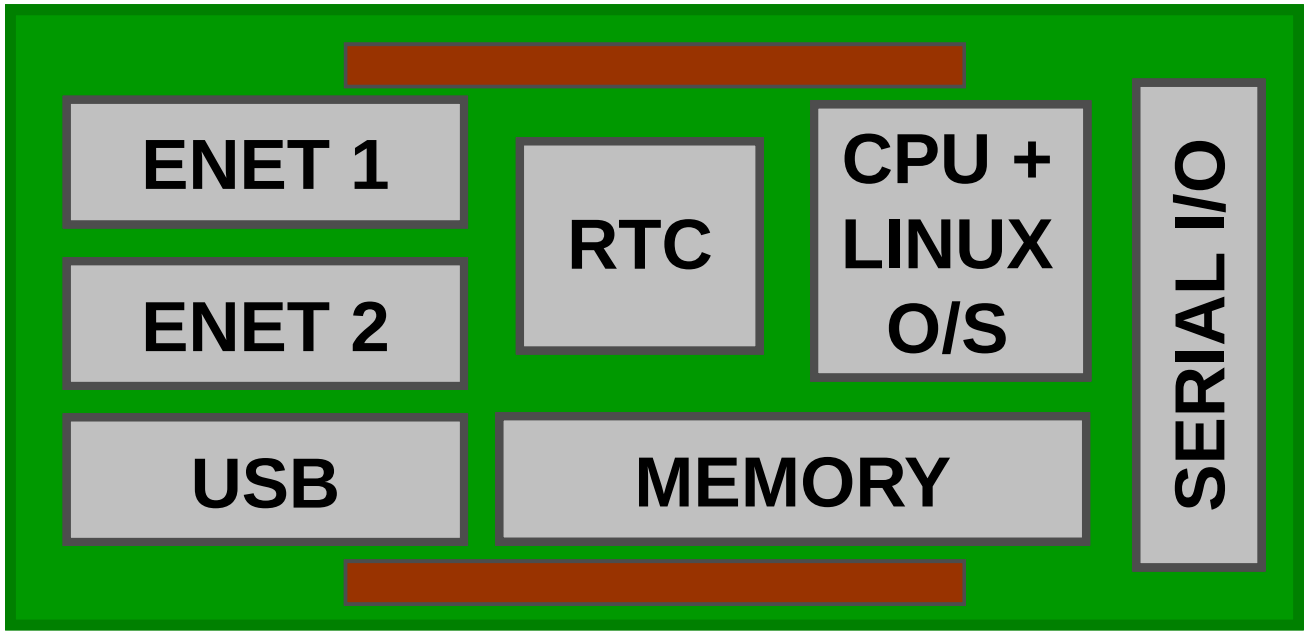
Learning Objective #4 – Describe the ATC 5201 Architecture

- Key elements of the ATC 5201 architecture
- Describe how the ATC 5201 Standard and ATC 5401 Standard work together
- ATC software portability, compatibility, and interchangeability

Key Elements of the ATC 5201 Architecture

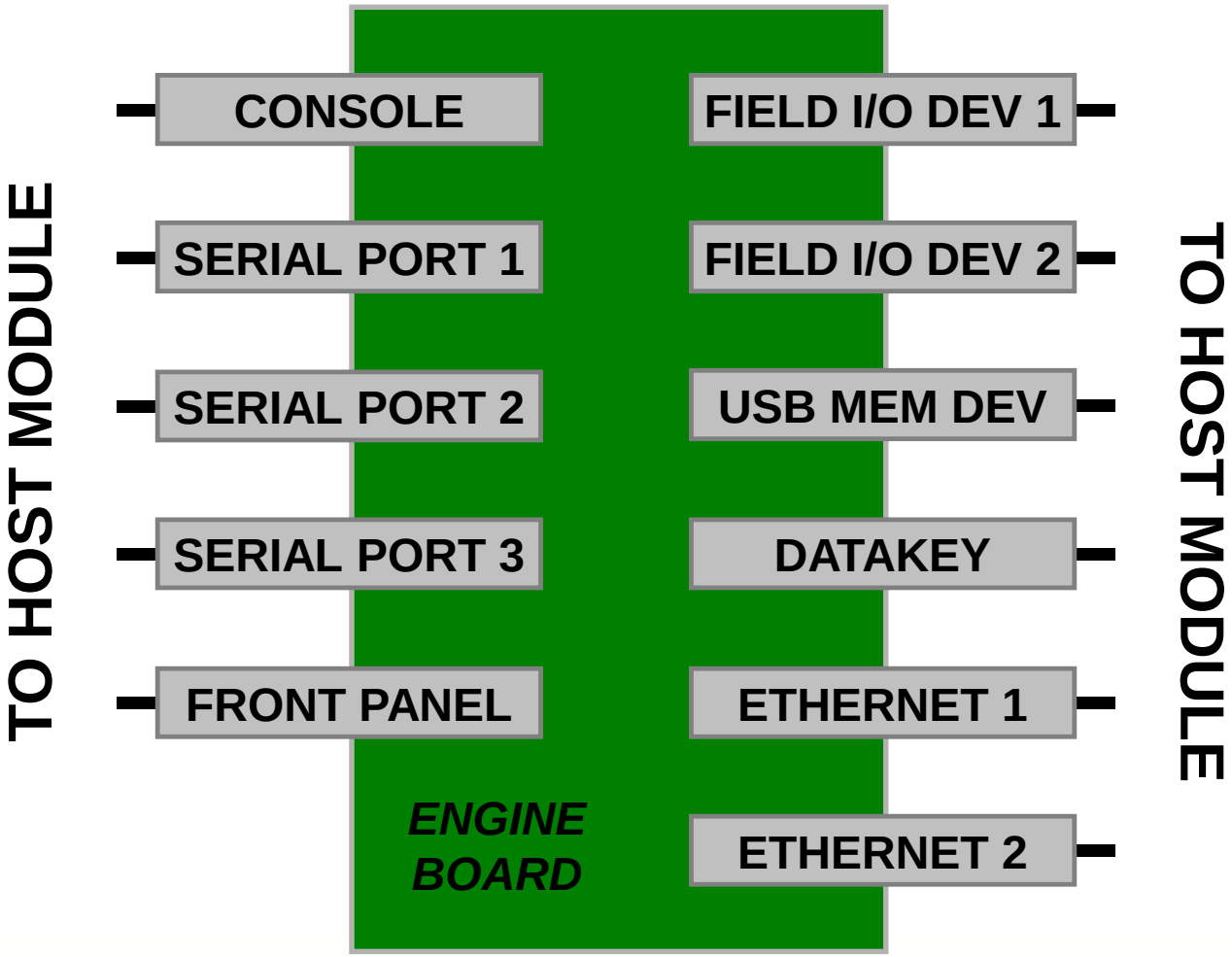
- Based on an “Engine Board” concept
- Computational capability can grow with technology
- Uses Linux operating system
  - Open source, multi-process, multi-application
- Mechanical requirements only for physical interfaces
- Works with all major transportation field cabinet system standards and specifications
- Source code portability for application software
  - Single application program only unless ATC 5401 Application Programming Interface is specified

ATC Engine Board Concept



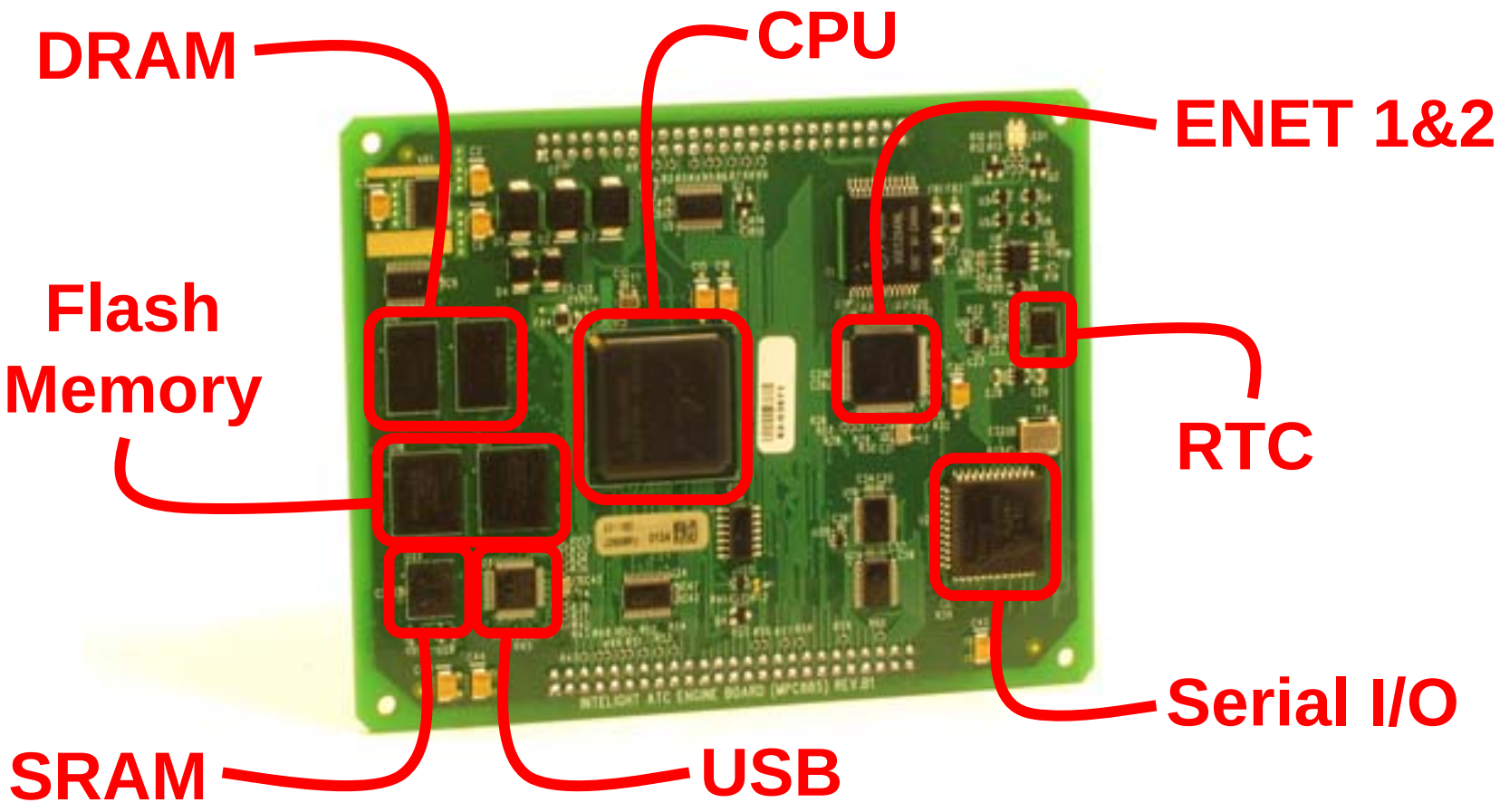
Graphics: Ralph W. Boaz

Engine Board Interfaces



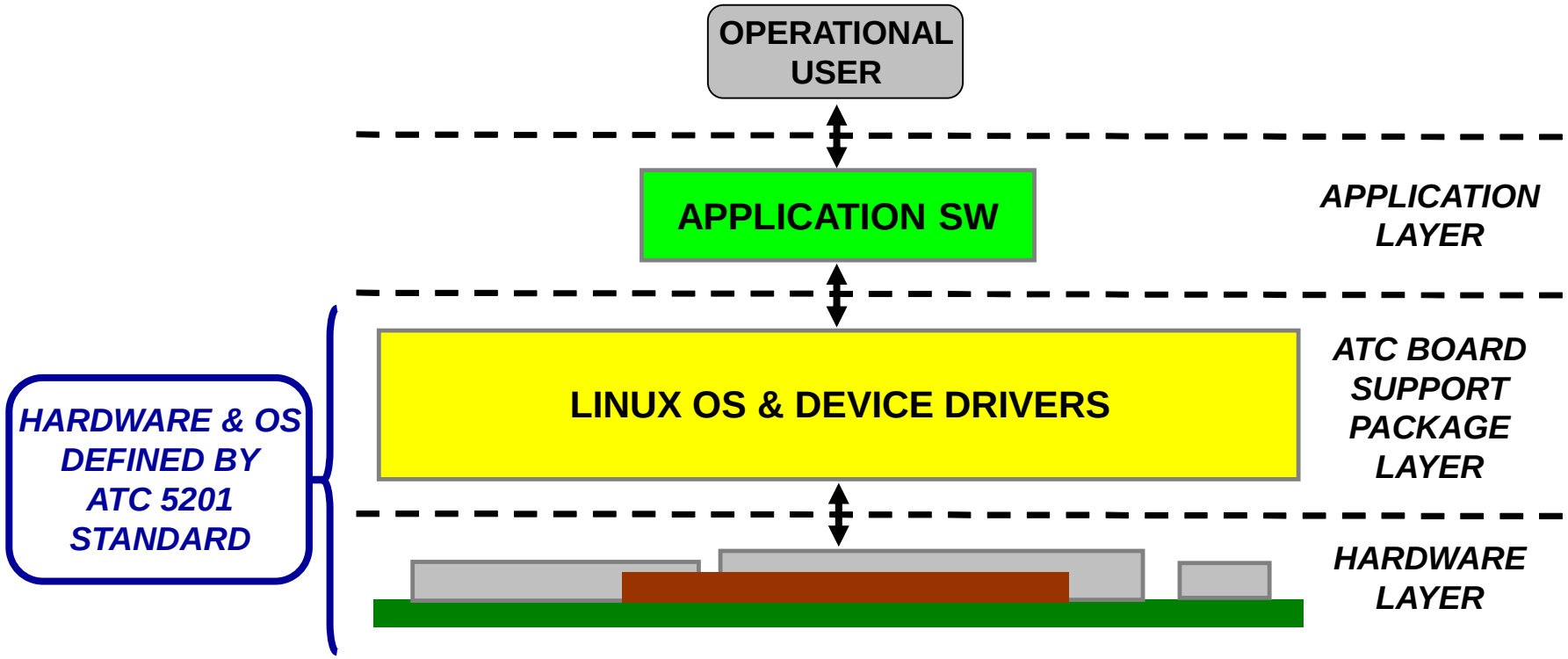
Graphics: Ralph W. Boaz

Example Engine Board



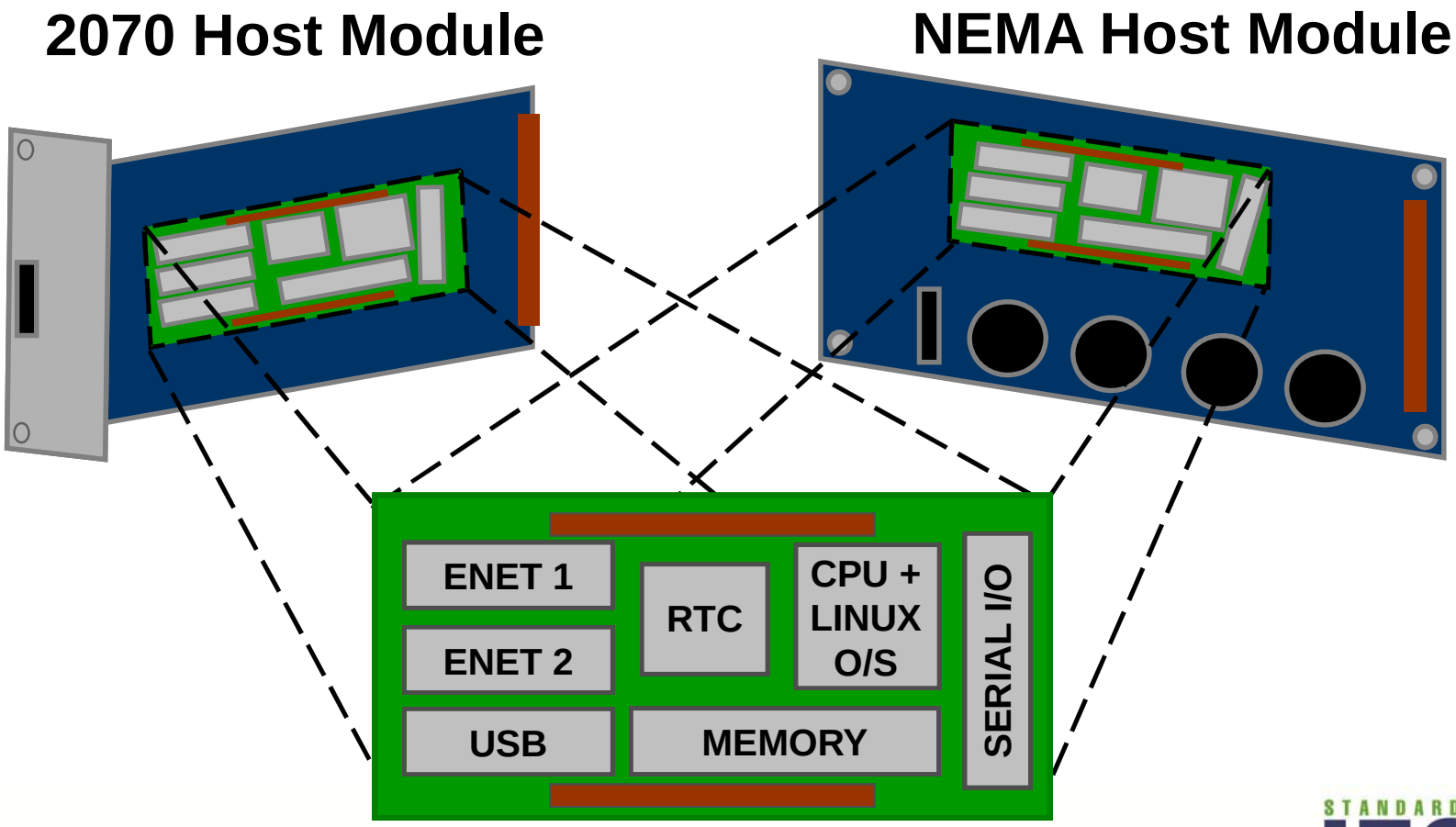
Graphics: Ralph W. Boaz Photo: Intelight

Linux Board Support Package (BSP) and Layered Architecture Allows Any Qualified Processors to be Used on an Engine Board



Graphics: Ralph W. Boaz

Controllers Meeting Other Standards Built Using the Engine Board



Graphics: Ralph W. Boaz

Engine Board Hardware Upgrade Capability

- Engine boards have identical pinout – future boards may plug into existing host boards
- Computational capability can grow with technology
- No hardware changes required to the rest of the controller unit or changes to the TFCS

Examples of ATC Controller Units

Photos: Econolite, Intelight, McCain, Peek, and Trafficware

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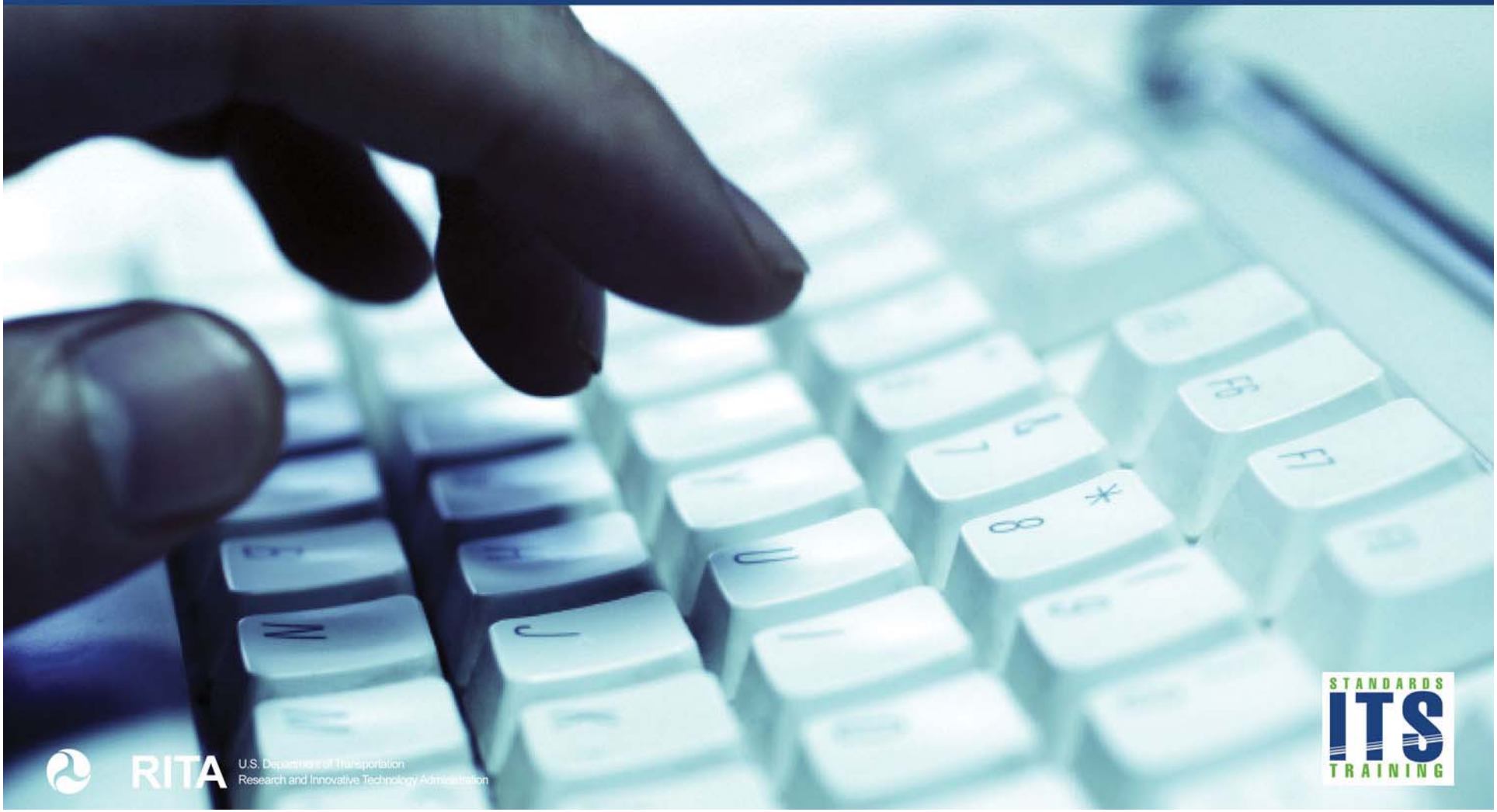

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Which of the following is critical to being able to replace an Engine Board with a more powerful Engine Board in the future?

Answer Choices

a) Identical pinout
b) New host module
c) Same processor family
d) Same Engine Board manufacturer

Review of Answers

a) Identical pinout

Correct. Identical pinout is essential to allow a new Engine Board to replace a previous one.

b) New host module

Incorrect. Generally, the Host Module of the existing controller can remain the same although, over time, it is conceivable that a new Host Module may be necessary.

c) Same processor family

Incorrect. Generally, the Linux BSP allows any qualified processor to be used on an Engine Board.

d) Same Engine Board manufacturer

Incorrect. Any manufacturer that adheres to the ATC 5201 Standard can produce replacement Engine Boards.

Describe How the ATC 5201 Standard and ATC 5401 Standard Work Together

ATC 5401 Application Programming Interface (API) Standard

- Provides a “window-like” interface to support the use of multiple application programs running concurrently on a single controller
- Allows application software to be written that can operate in any ATC controller unit in any major TFCS
- Multiple application programs can share the resources of the controller and transportation field cabinet system
  - Front Panel, Field Inputs/Outputs, Real-Time Clock

Application Programming Interface

```
            F R O N T   P A N E L   M A N A G E R   V E R   1 . 0 0
S E L E C T   W I N D O W :   0 - F          S E T   D E F A U L T :   * , 0 - F
  0   R a m p   M e t e r   P r g r m       1 * S i g n a l   P r o g r a m
  2   E m e r g e n c y   M n g m n t       3   D a t a   D i s t r i b u t o r
  4   S y s t e m   C h e c k e r           5
  6                                         7
  8                                         9
[ M O R E -   U P / D N   A R R O W ]      [ C O N F I G   I N F O -   N E X T ]
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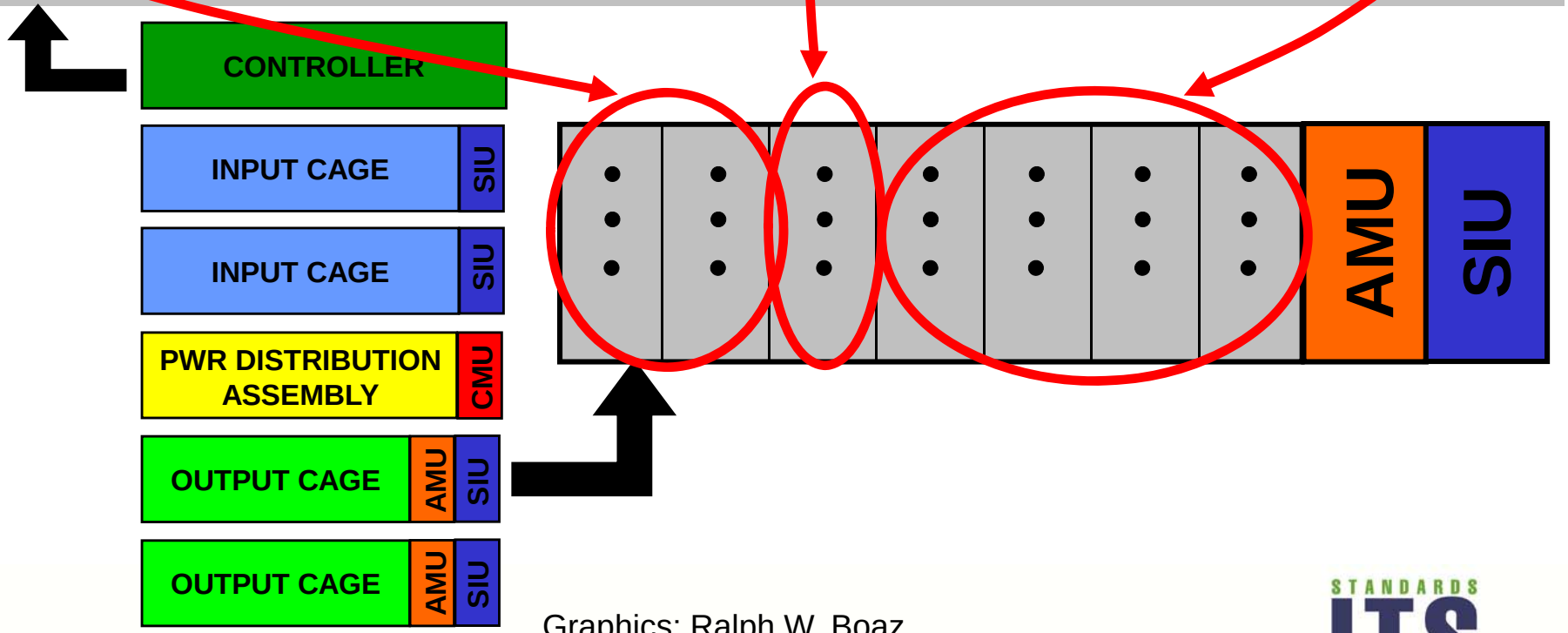
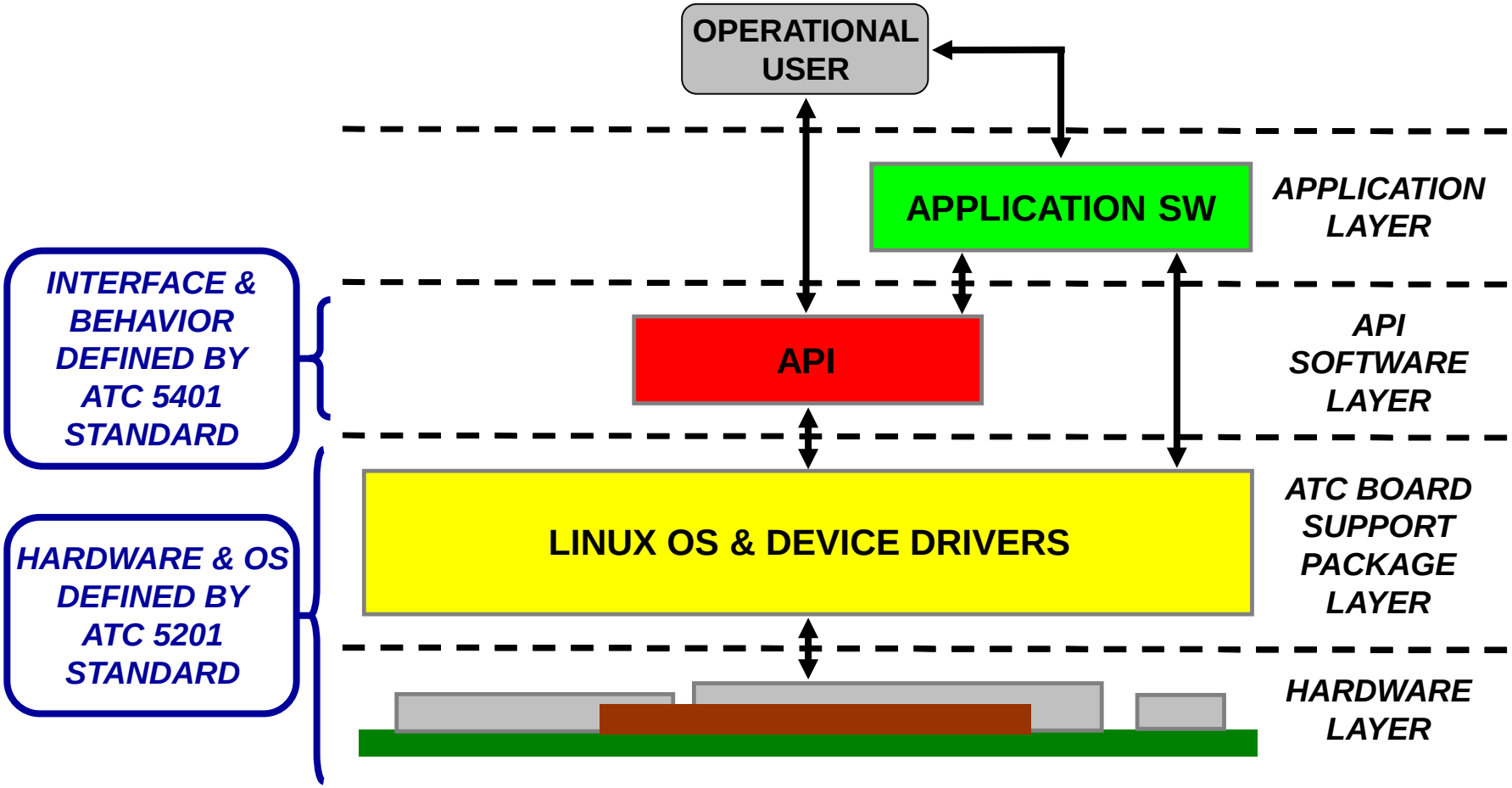


Graphics: Ralph W. Boaz

ATC Layered S/W Architecture



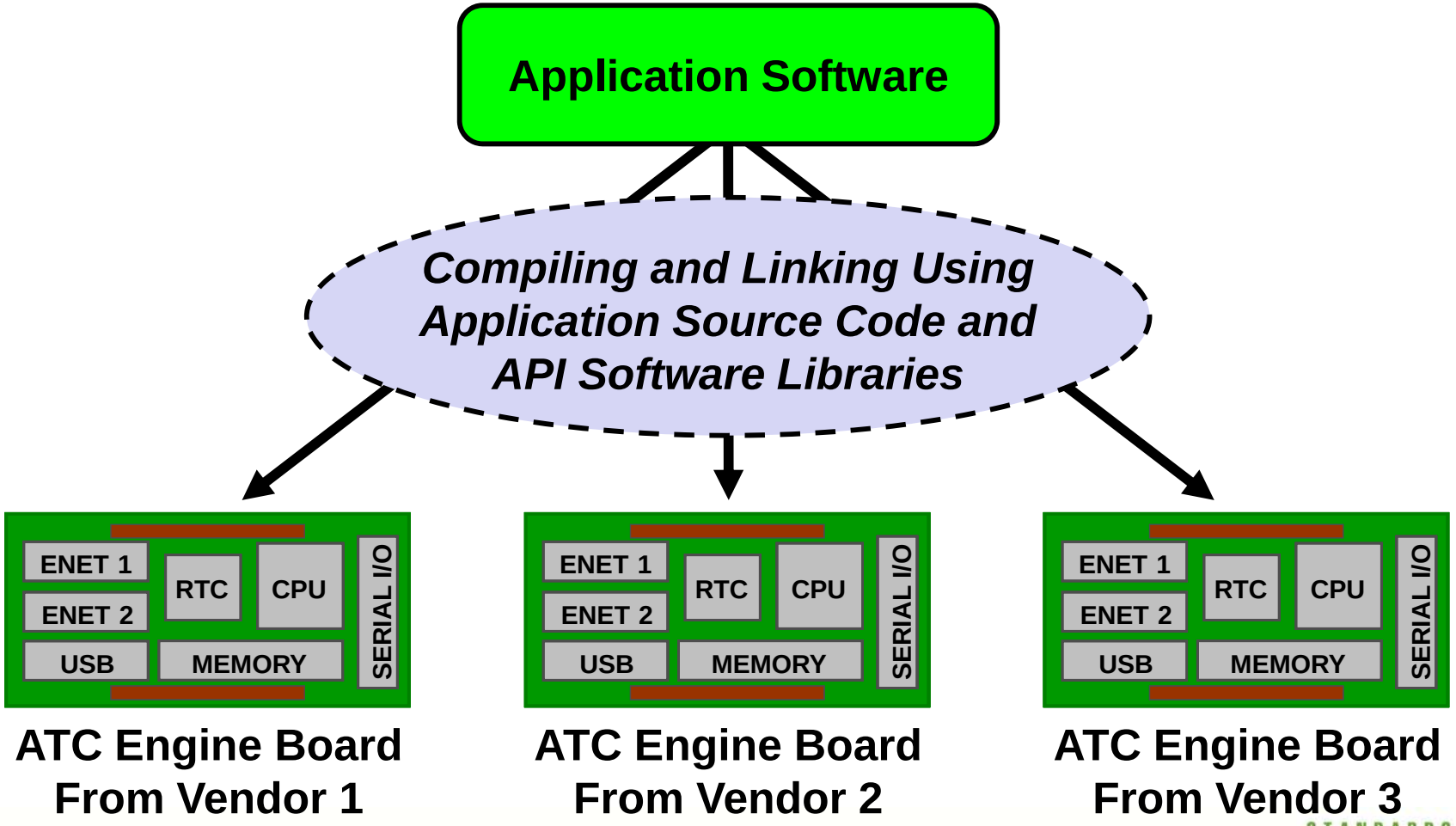
Graphics: Ralph W. Boaz

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



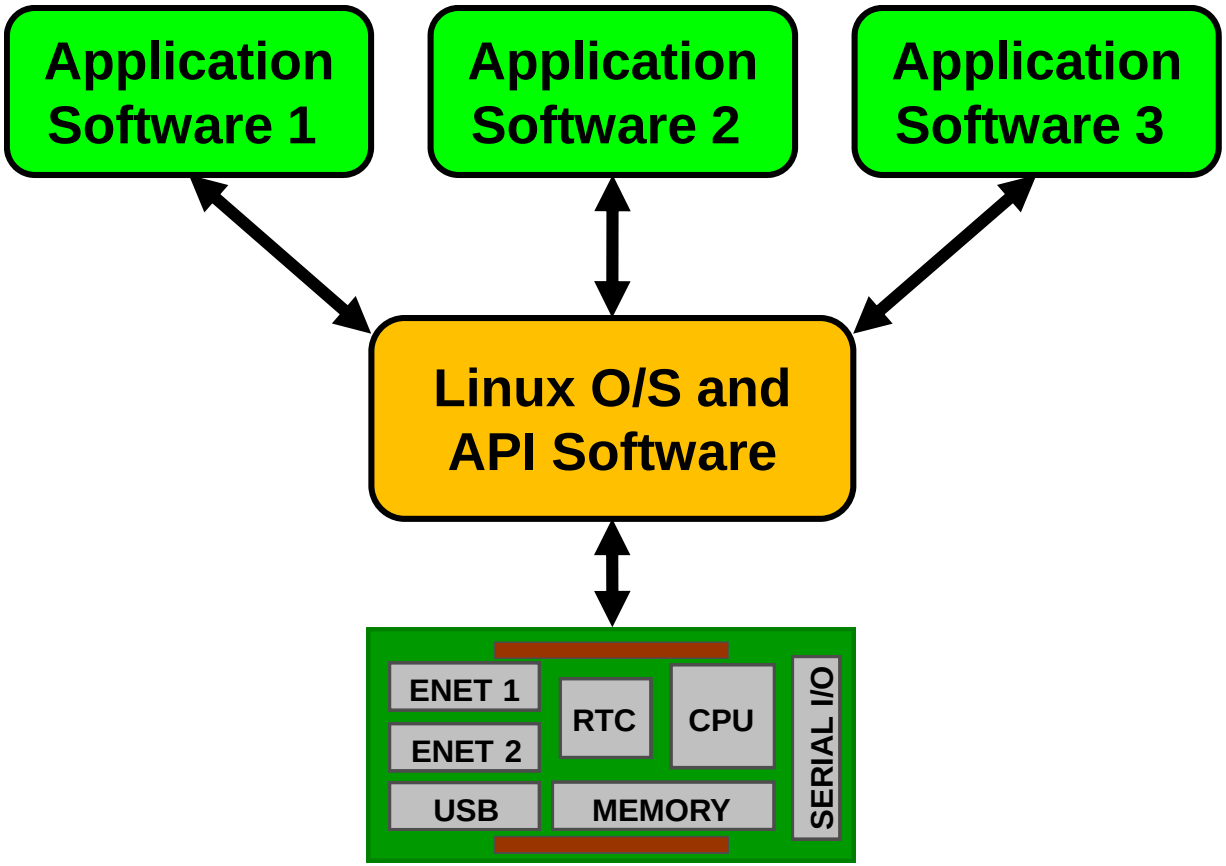
Graphics: Ralph W. Boaz

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



ATC Engine Board From Vendor

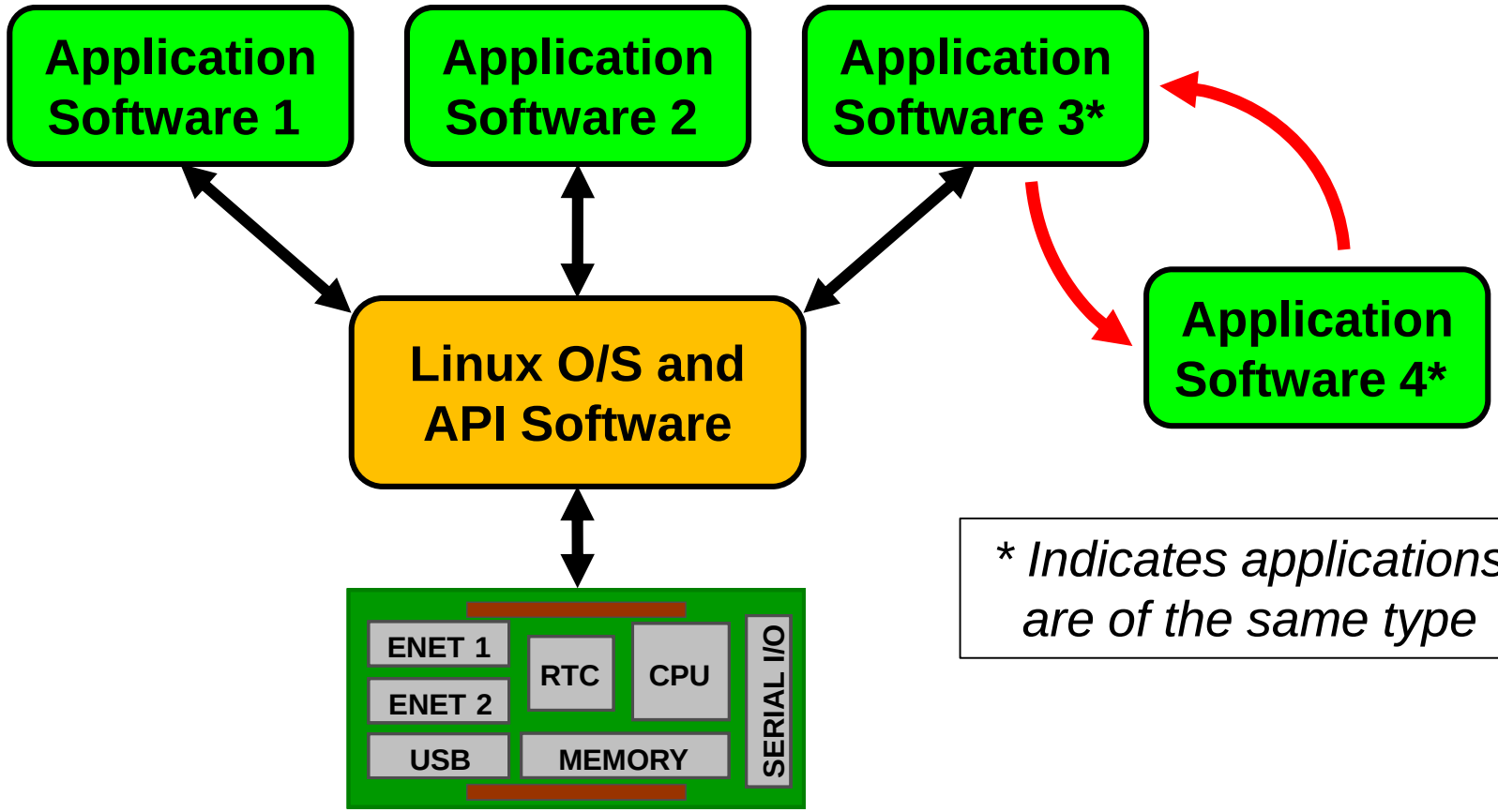
Graphics: Ralph W. Boaz

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 (subjective)



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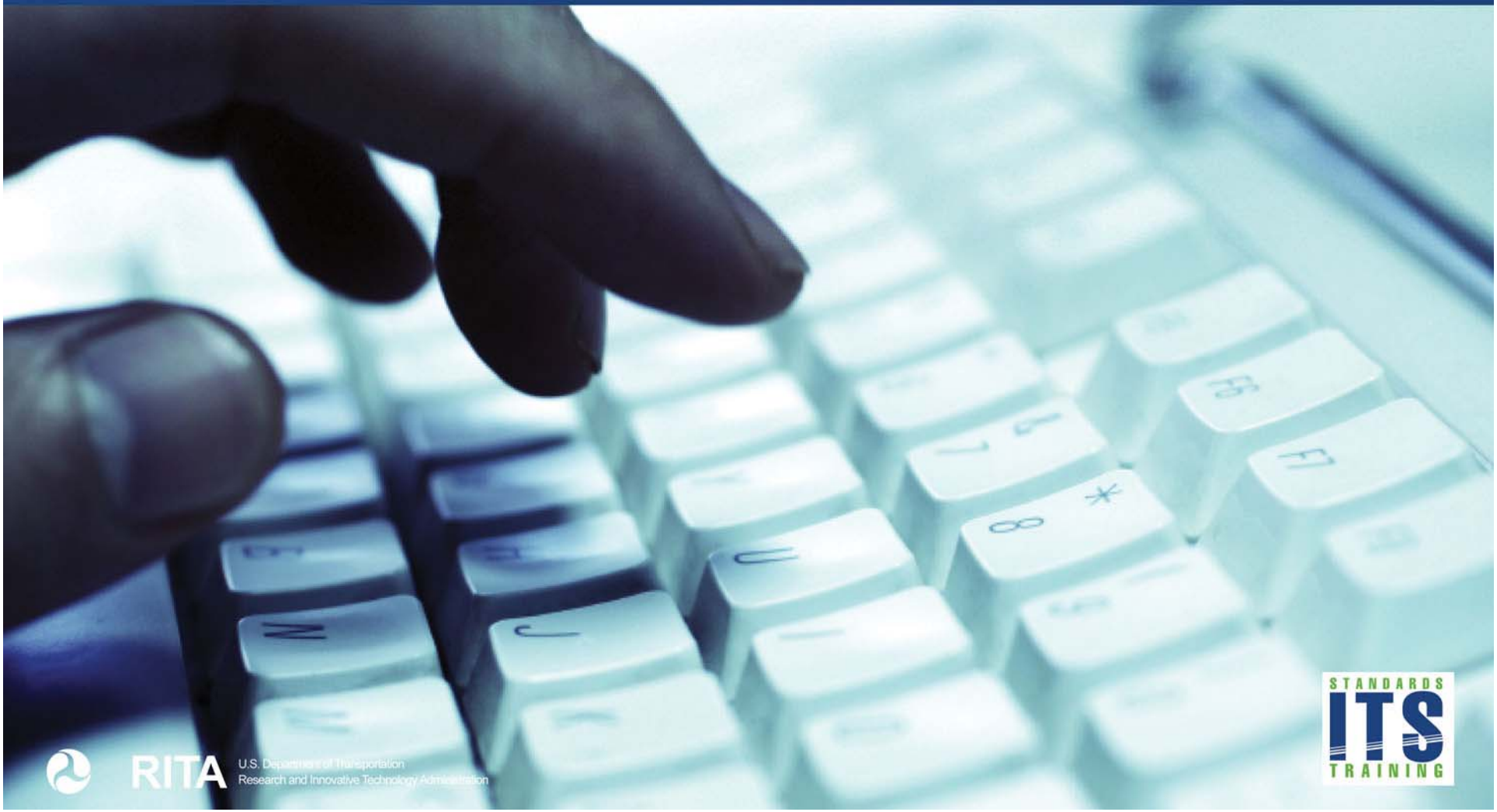

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Which of the following ATC controller resources is NOT shared/managed by the API software?

Answer Choices

a) Real-Time Clock
b) Front Panel
c) Datakey
d) Field Input/Output

Review of answers

a) Real-Time Clock

Incorrect. API software allows multiple programs to set the Real-Time Clock of the controller.

b) Front Panel

Incorrect. The front panel is managed by the API software so that application programs can share the front panel of the controller and users can switch between programs.

c) Datakey

Correct. A Datakey is a memory device controlled by the BSP not the API Software.

d) Field Input/Output

Incorrect. Field Inputs and Outputs are managed by API software, which allows them to be shared across application programs.

Summary of Learning Objective #4

Describe the ATC 5201 Architecture

- Key elements of the ATC 5201 architecture
- Describe how the ATC 5201 Standard and ATC 5401 Standard work together
- ATC software portability, compatibility, and interchangeability

Learning Objective #5 – Describe How the ATC 5201 Standard Works With Other ITS Standards

- Transportation Field Cabinet Systems
- ITS Communications Standards

ATC 5201 Standard Works with all of the Major Transportation Field Cabinet Systems

- Provides internal cabinet interfaces for Model 33X Cabinets, NEMA TS 1 and TS 2 Type 2 Cabinets, NEMA TS 2 Type 1 Cabinets, and ITS Cabinets
- Generally, ATC 5201 v06 has more rigorous environmental and testing requirements than the major TFCS standards and specifications

Example ATC Controller Units in a Cabinet Architecture

NEMA TS2 Type 1

Model 332 Cabinet

Photos: Ralph W. Boaz

ATC 5201 Standard Provides Computational Power and Interfaces for ITS Communications

- TFCSs that use 170 controller units require replacement hardware in order to utilize NTCIP Actuated Signal Control (ASC) communications
- ATC 5201 Standard provides the capability to support multiple applications using different (or same) types of NTCIP communications simultaneously
- ATC 5201 Standard provides interfaces and computational power for applications such as Adaptive Control and Connected Vehicle applications

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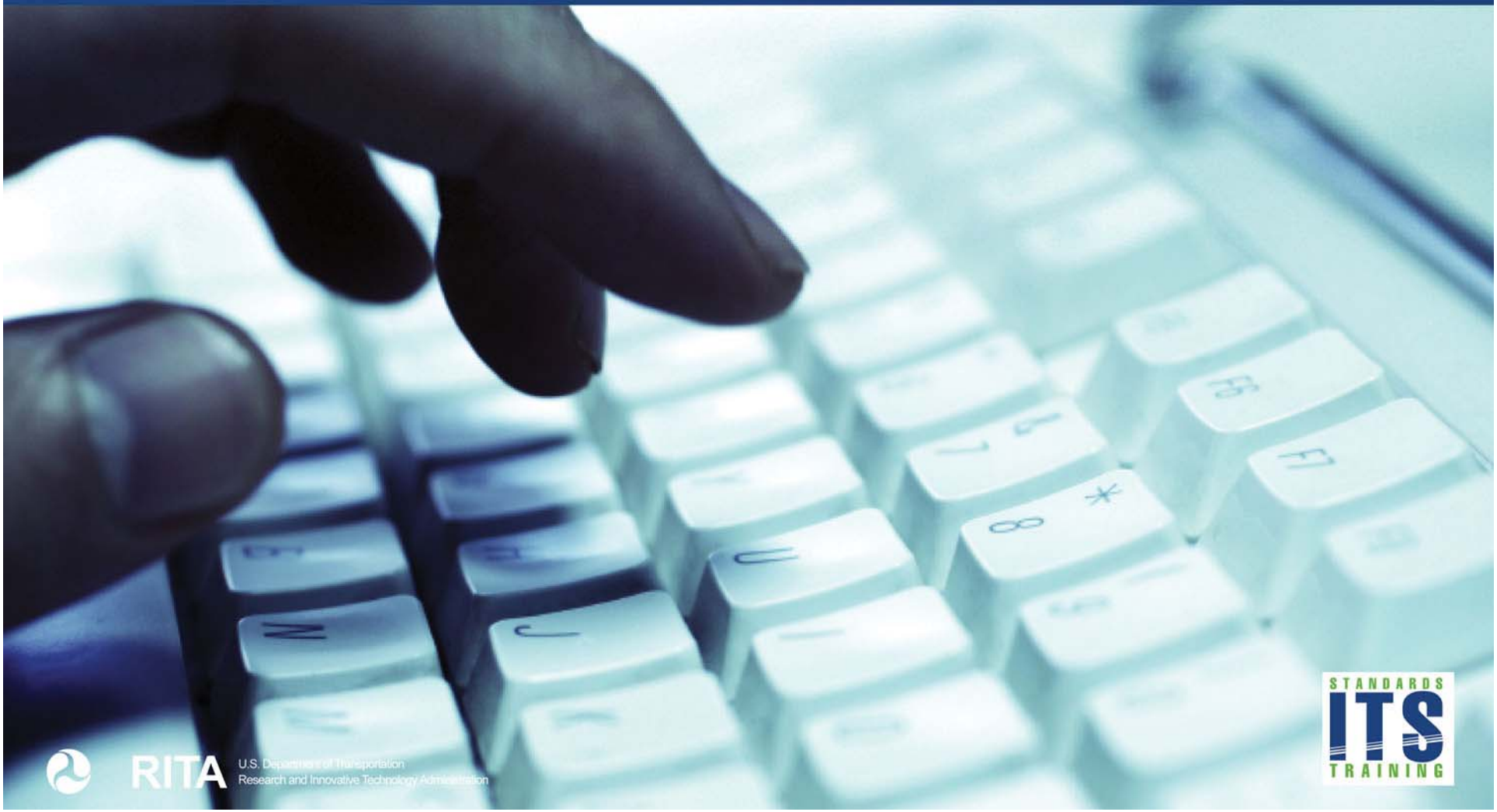

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Which of the following is a TRUE statement?

Answer Choices

a) API Software provides NTCIP communications software for multiple applications

b) ATC 5201 allows multiple applications to use NTCIP communications simultaneously

c) ATC environmental requirements are generally the same as TFCS standards and specifications

d) Most 170 controllers are suitable for NTCIP ASC communications

Review of answers

a) API Software provides NTCIP communications for multiple applications

Incorrect. API software does not provide NTCIP communications directly.

b) ATC 5201 allows multiple applications on an ATC controller to use NTCIP communications simultaneously

Correct. The Linux O/S supports multiple network addressing allowing multiple applications to use NTCIP at the same time.

c) ATC environmental requirements are generally the same as TFCS standards and specifications

Incorrect. ATC environmental requirements are generally greater than TFCS standards and specifications.

d) Most 170 controllers are suitable for NTCIP ASC communications

Incorrect. Most TFCSs that use 170 controllers will require replacement controllers to perform full functioning NTCIP ASC communications.

Summary of Learning Objective #5

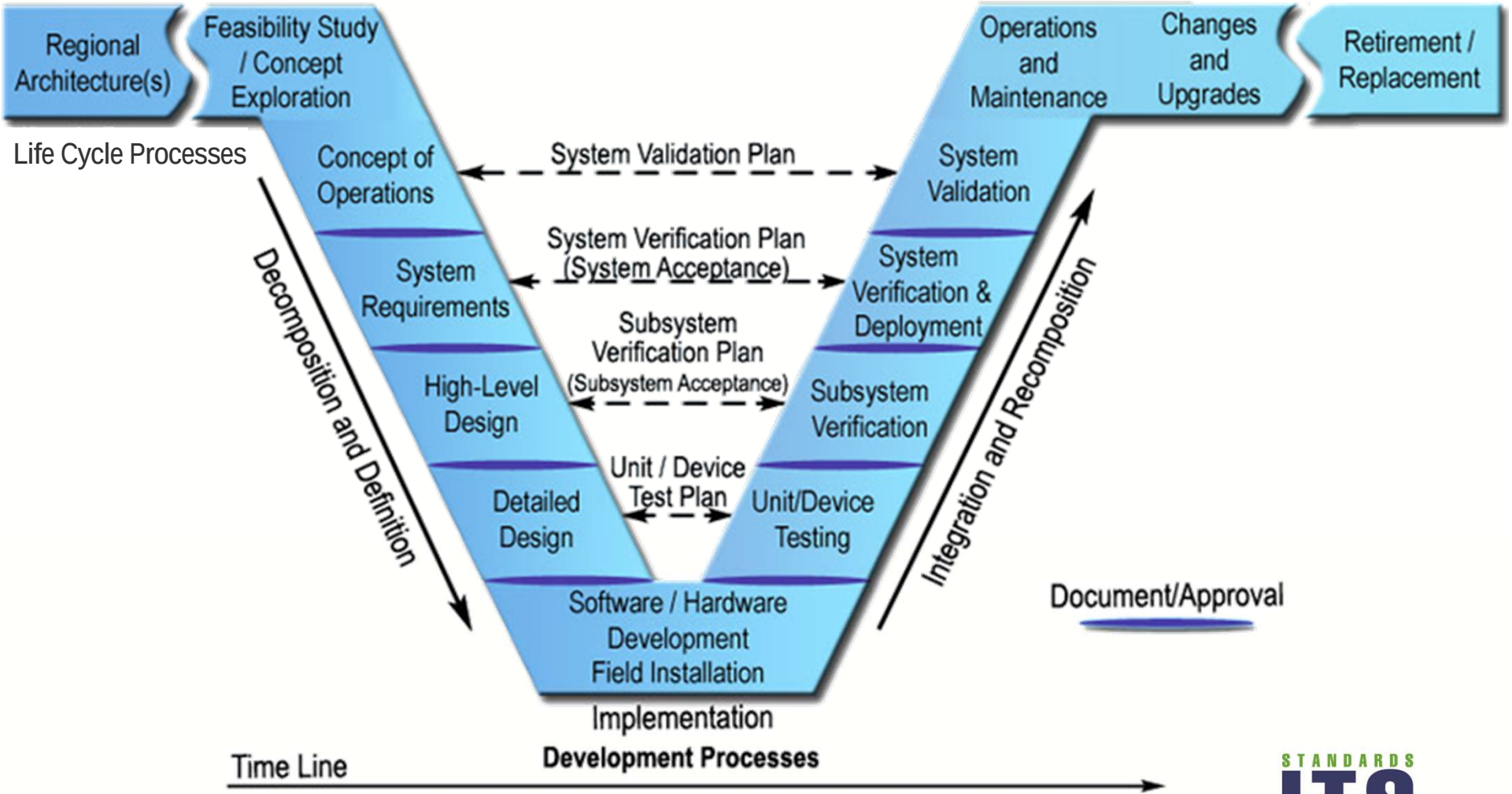
Describe How the ATC 5201 Standard Works With Other ITS Standards

- Transportation Field Cabinet Systems
- ITS Communications Standards

Learning Objective #6 – Specify ATC Equipment for System and Equipment Procurements

- Discuss How ATC 5201 Fits in the Systems Life Cycle
- Develop Migration Strategies and Mitigate Deployment Issues
- Creating a Specification Based on the ATC 5201 Standard

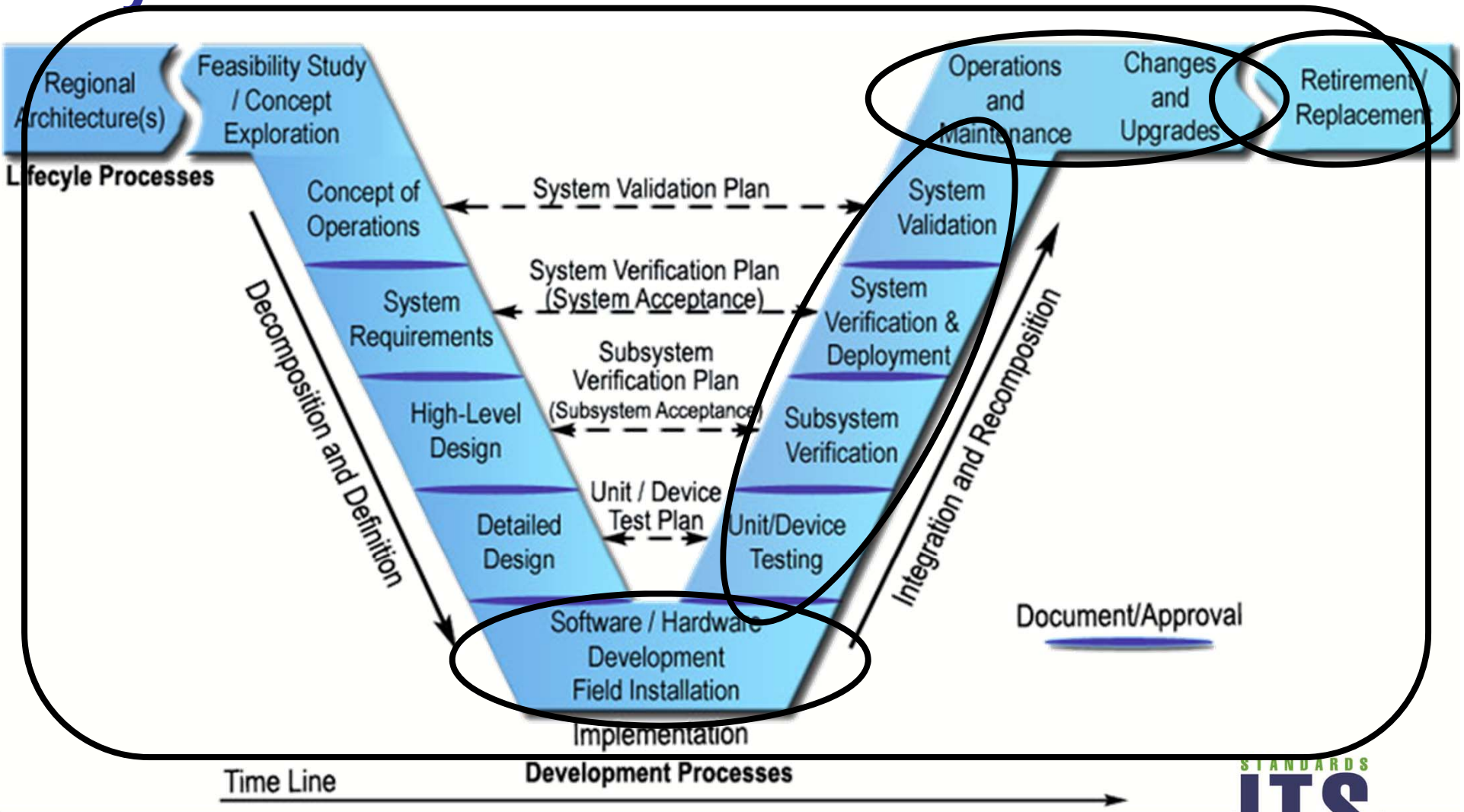
How ATC 5201 Fits into the Systems Life Cycle



How ATC 5201 Fits in the Systems Life Cycle

- ATC 5201 Standard defines a general purpose computing platform for TFCSs
- ATC controller units can be deployed as part of a Center-to-Field (C2F) system project
- ATC controller units may be used for multiple C2F systems and for generations of C2F systems
- ATC controller units may extend the life of a system
- Procurements **may** be made in relation to a system deployment but it is more of a strategic decision to use the ATC standards

How ATC 5201 Fits in the Systems Life Cycle



Develop Migration Strategies

- Have a written plan and policy for deploying ATC equipment as part of a strategic plan
- Factors that may influence the plan:
  - Working with Existing TFCS
  - Moving to new TFCS architectures
  - New Projects
  - Scheduled Maintenance
  - Upgrading to ATC hardware while using an agency's current application software
  - Upgrading to new operational software

Develop Migration Strategies (cont.)

- Factors that may influence the plan: (cont.)
  - Compatibility with existing or planned system software
  - Training operational staff

ATC Standards Update

- ATC 5201 v06 is currently being developed with publication projected second quarter 2014
- Although the API 5401 v02 has been published, complete API software meeting the standard is not yet available
- USDOT starting a project to create a reference implementation of API software (APIRI) for public use (2014/2015)
- APIRI project includes a validation suite that can be used to test API software on an Engine Board

Mitigating Deployment Issues

- Reference User Comment Draft ATC 5201 v06.10 or later in specifications
- Establish a contractual commitment from Engine Board suppliers to provide operational API software for their Engine Boards once the API RI is available
- Establish a contractual commitment from application software providers to supply software compatible with the API once the API RI is available
- Identify the tool chain (compiler and C libraries) used to create application programs for the Engine Board

Mitigating Deployment Issues (cont.)

- Determine access to source code for the Linux environment (Board Support Package) used on the Engine Board
- Require a test program from manufacturers demonstrating that each of the interfaces is operational
- Have a certification from manufacturer that the ATC being purchased passed testing “under load”
- Prior to purchase, have application providers demonstrate their software on the agency’s current ATC units
- Buy support services with software in the case that the software becomes inoperable due to changes in the configuration of the Controller

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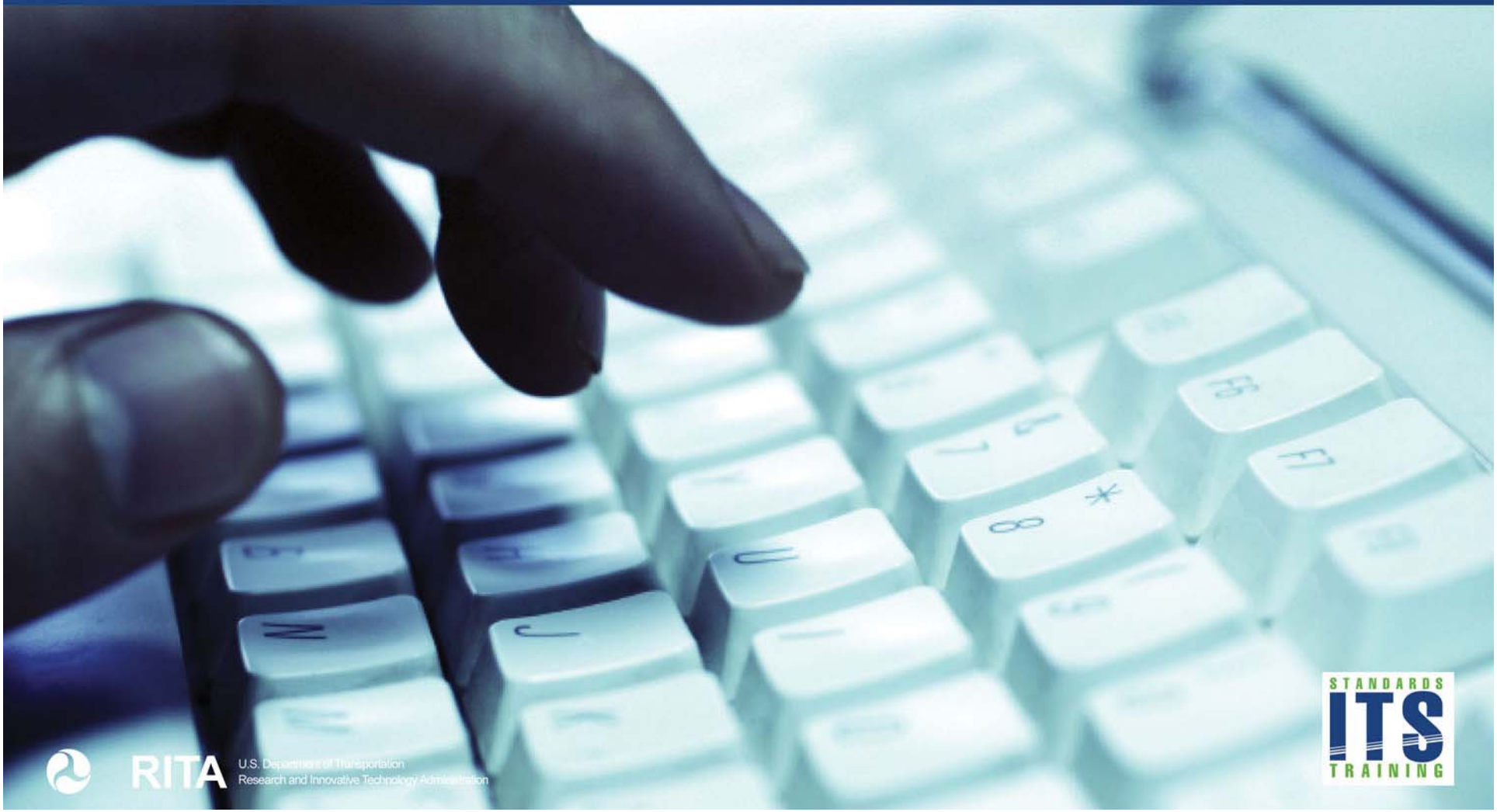

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What is the best way to migrate to ATC equipment?

Answer Choices

a) Use existing TFCSs and replace older controllers with ATC controller units

b) Use existing operational software that has a version suitable for ATC controller units

c) Replace controller units as part of regular scheduled maintenance

d) All equally good and it depends on the needs of the agency

Review of answers

a) Use existing TFCSs and replace older controllers with ATC controller units

Incorrect. This is a good option for migrating to ATC equipment but agencies must define their needs and goals to assess what is best.

b) Use existing operational software that has a version suitable for ATC controller units

Incorrect. This is a good option for migrating to ATC equipment but agencies must define their needs and goals to assess what is best.

c) Replace controller units as part of regular scheduled maintenance

Incorrect. This is a good option for migrating to ATC equipment but agencies must define their needs and goals to assess what is best.

d) All equally good and it depends on the needs of the agency

Correct. All of the items listed can be part of a migration strategy. Agency must define their needs and goals to assess what is best.

Creating a Specification Based on the ATC 5201 Standard

- Agency specifications written based on how the agency will be purchasing equipment
- Agencies create standing specifications to insure consistency and expediency in procuring equipment
- Agencies may have a prequalified vendors list or a single vendor selected through a bid process
- Recommended that agencies separate specifications for ATC 5201 equipment from that of any application programs

Creating a Specification Based on the ATC 5201 Standard

- Develop a Concept of Operations (ConOps) for the TFCS based on your strategic plan
  - Describe characteristics of the TFCS equipment from the user's perspective
  - Cover the operational scenarios in which the equipment will be used
  - ConOps may or may not be part of the specification

Concept of Operations

- Example from the FHWA Systems Engineering Guidebook V3
  - Purpose of Document
  - Scope of Project
  - Referenced Documents
  - Background
  - Concept for the Proposed System
  - User-Oriented Operational Description

Concept of Operations (con't)

- Example from the FHWA Systems Engineering Guidebook V3 (cont.)
  - Operational Needs
  - System Overview
  - Operational Environment
  - Support Environment
  - Operational Scenarios
  - Summary of Impacts

Requirements for specifications that use ATC 5201 v06

- ATC 5201 Standard generally describes a minimum level of capability for conformant ATC controller units
- ATC 5201 specifications are a composite of standards and/or other specifications (referenced documents)
- This composite may consist of:
  - Explicit requirements developed by the agency
  - Explicit requirements gleaned from referenced documents
  - Referenced requirements (or sections) in the referenced documents
  - Inherited requirements from referenced documents with an established document precedence

Proposed Organization of Requirements

- Referenced Documents and Precedence
- General Requirements
- TFCS Requirements
- User Interface Requirements
- Serial and Parallel I/O Requirements
- Engine Board CPU and Memory Requirements
- Environmental and Testing Requirements
- Warranty Requirements
- Other Requirements

Referenced Documents and Precedence

- Establish precedence between other standards documents and specifications referenced to resolve conflicts. Example:

  In the case there is a conflict between the requirements in referenced documents that is not directly addressed by a stated requirement, the precedence of the referenced documents shall be as follows:

  1) *Agency Specific Requirements*
  2) *ATC 5201 Standard v06 Requirements*
  3) *TFCS Requirements (e.g. NEMA TS 2, Model 33X, ITS Cabinet v01)*

General Requirements

- Apply to the overall unit. Examples:
  - Material Requirements
  - Electronic Requirements
  - Mechanical Requirements
  - Quality Requirements

TFCS Requirements

- Identify the type(s) of TFCS architectures for the ATC controller unit
- TFCS configuration requirements that may influence the controller specification
  - User Interface
  - Serial and parallel interfaces
  - Operational Voltages

User Interface Requirements – ATC Minimum

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

- EIA-574, 9-pin “D” serial connector for console

OR

- RJ45, serial connector for console

- EIA-574, 9-pin “D” connector for an external front panel

OR

- Keyboard, LCD, Bell

Graphics: Ralph W. Boaz

User Interface Requirements – ATC Options

- User Interface Optional Features
  - Datakey
  - AUX Switch
    (only available for Keyboard/LCD/Bell configuration)
- Power Supply Optional Features
  - Power Switch
  - Power LEDs

User Interface Requirements

- ATC controller user interfaces may have some restrictions based on the TFCS architecture selected
- ATC 5201 allows expansion of user interface requirements to include high-resolution graphics and additional front panel keys

Agencies are cautioned to verify that these types of interfaces will also operate in a mode that supports the basic ATC 5201 and ATC 5401 Standards

Serial and Parallel I/O Requirements

- TFCS architectures may have serial and parallel I/O requirements already defined
- ATC 5201 Standard offers numerous additional general purpose ports
- Agencies should include requirements for extra ports based on their concept of operations

Agencies are cautioned to not unnecessarily require communications ports as it can drive up costs and limit choices of vendors

Engine Board CPU and Memory Requirements

- CPU – 60 MIPS Minimum
- DRAM – 64 MB Minimum
- SRAM –1 MB Minimum
- Flash Memory – 16 MB Minimum

Agencies are cautioned not to arbitrarily require the highest number of MIPS and memory available as it can drive up costs and limit choices of vendors

Environmental and Testing Requirements

- Requirements vary between TFCS documents
- Environmental requirements within ATC 5201 v06 are generally more robust than TFCS documents
- Operational Voltages for the ATC controller unit must be specified to be consistent with the TFCS architecture used

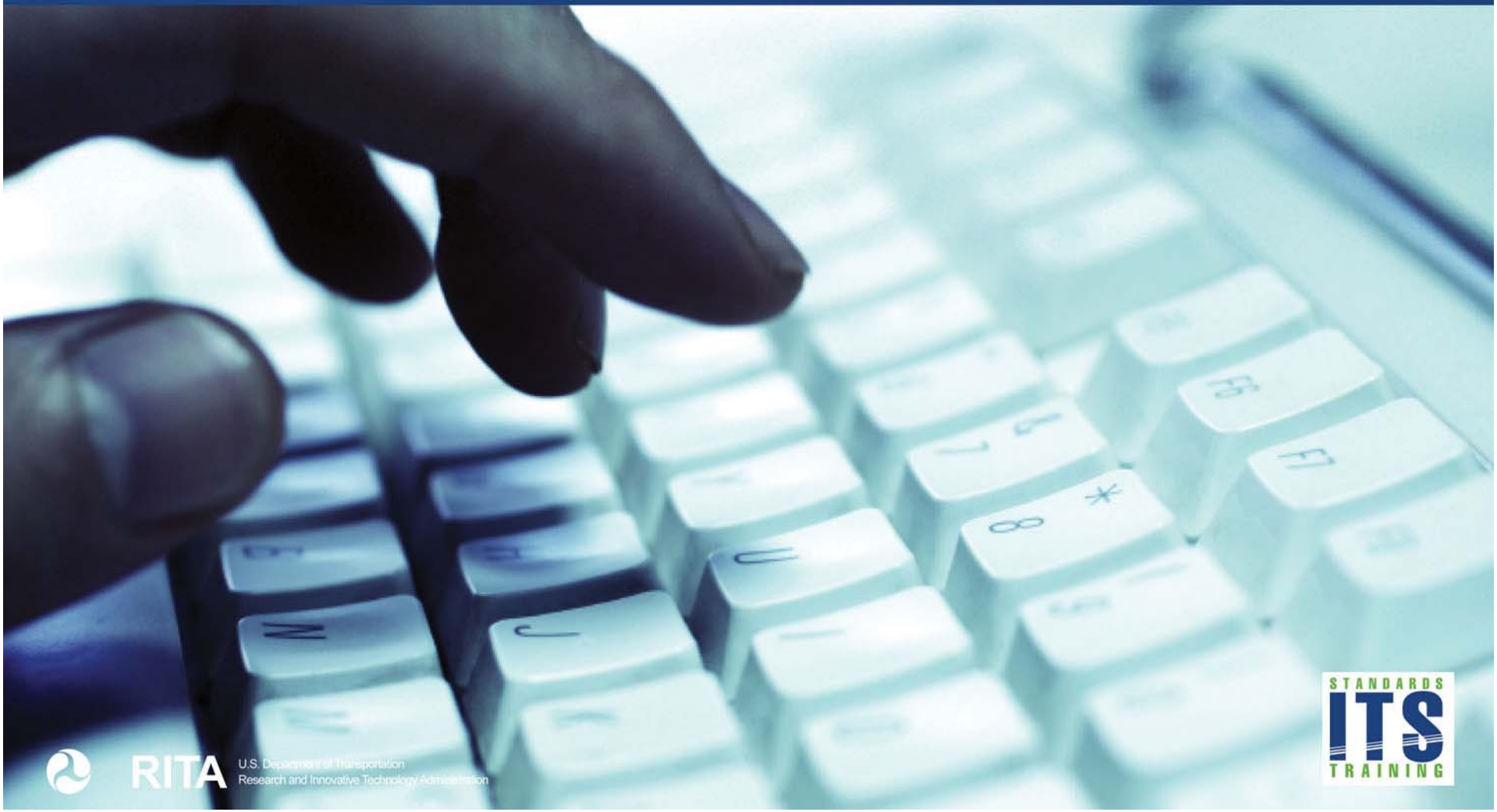
Warranty Requirements

- Long-term investment – Get as much warranty as possible
- Get software support for Linux environment

Other Requirements

- Identification of the tool chain (compiler and C libraries) used to create application programs for the Engine Board
- Access to the tool chain and source code used to produce the Linux environment for the Engine Board (requires special arrangement)
- Engine Board suppliers to provide operational API software for their Engine Boards once the API RI is available
- Packaging
- Delivery
- Manuals

ACTIVITY



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Which of the following is a good practice when preparing a specification using ATC 5201 v06?

Answer Choices

a) Establish a precedence of referenced standards and specifications

b) Always specify the fastest CPU available

c) Always specify several extra serial ports than you need

d) Never exceed the minimum user interface requirements of the ATC 5201 Standard

Review of Answers

a) Establish a precedence of referenced standards and specifications

Correct. This is important since an ATC 5201 based specification is a composite of other documents.

b) Always specify the fastest CPU available

Incorrect. Agencies should consider leaving themselves options and assess the entire unit proposed by vendors.

c) Always specify several more serial ports than you need

Incorrect. This may limit choices of controller units and may increase costs.

d) Never exceed the minimum user interface requirements

Incorrect. User interfaces may exceed those of ATC 5201 as long as the basic operation is still achievable.

Summary of Learning Objective #6

Specify ATC Equipment for System and Equipment Procurements

- Discuss how ATC 5201 fits in the Systems Life Cycle
- Develop migration strategies and mitigate deployment issues
- Creating a specification based on the ATC 5201 Standard

What We Have Learned

1. The ATC 5201 Standard provides for controller units that can ***grow*** with technology using an ***Engine Board*** concept.

2. The ATC 5201 Standard can be used to specify ATC controller units that can operate in ***any*** major TFCS architecture.

3. The ATC 5201 Standard works with the ATC 5401 Standard to provide for ***portable***, ***compatible*** and ***interchangeable*** application programs.

4. Agencies will reference ***other*** ITS standards or specifications in preparing an ATC 5201 specification.

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/
- *ITS PCB Training* http://www.pcb.its.dot.gov/

QUESTIONS?

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Next Course Module

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

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