STANDARDS ITS TRAINING

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Office of the Assistant Secretary for
Research and Technology

Welcome

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ACTIVITY

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

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

Instructor

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President

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Target Audience

- Traffic management and engineering staff

- Traffic Management Center/operations staff

- Traffic signal maintenance staff

- System developers

- Software developers

- Private and public sector users including manufacturers

- Procurement personnel

Recommended Prerequisites

- 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

- A203: Writing Requirements When ITS Standards Do Not Have SEP Content
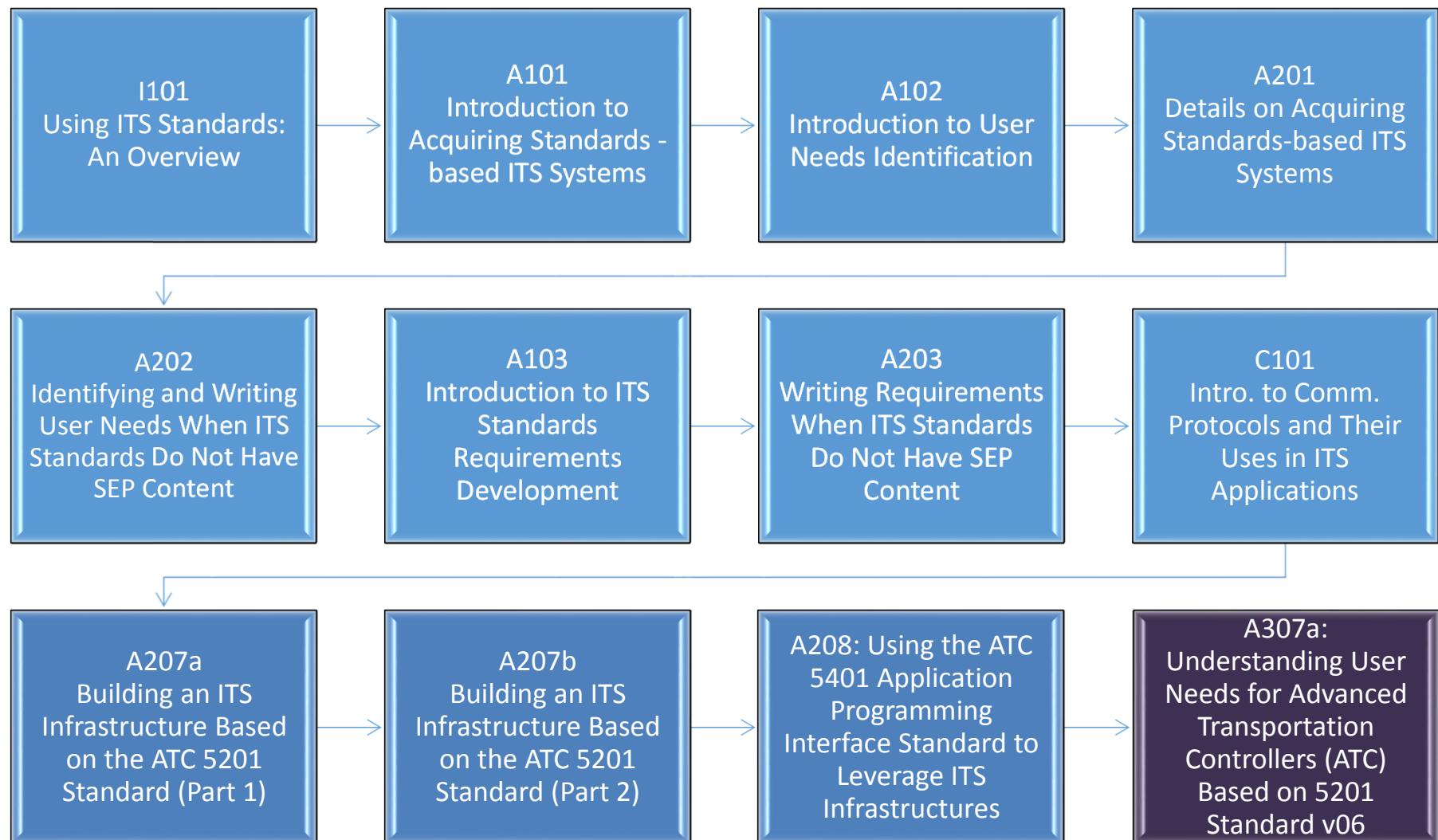
Recommended Prerequisites (cont.)

- 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

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

Curriculum Path


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 → A203 — Writing Requirements When ITS Standards Do Not Have SEP Content → C101 — Intro. to Comm. Protocols and Their Uses in ITS Applications

A207a — Building an ITS Infrastructure Based on the ATC 5201 Standard (Part 1) → A207b — Building an ITS Infrastructure Based on the ATC 5201 Standard (Part 2) → A208: Using the ATC 5401 Application Programming Interface Standard to Leverage ITS Infrastructures → A307a: Understanding User Needs for Advanced Transportation Controllers (ATC) Based on 5201 Standard v06

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Learning Objectives

1. Identify the advantages of transportation controllers based on ATC 5201 Standard v06

2. Describe a systems engineering-based ATC specification development process

3. Identify and write user needs for ATCs

4. Create a concept of operations (ConOps)

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Learning Objective #1: Identify the Advantages of Transportation Controllers Based on ATC 5201 Standard v06

- Discuss the purpose of the ATC 5201 Standard v06

- Identify key elements of the ATC 5201 Standard v06 architecture

- Describe how ATC 5201 Standard v06 works with other ITS standards

Discuss the Purpose of the ATC 5201 Standard v06

- Provide a general purpose field-computing platform for transportation applications that are:

  - Open architecture
    - Any manufacturer can build products conforming to the standards

  - Modular
    - Reduces maintenance costs
    - Increases testability

  - Multi-tasking/multi-application
    - Can do multiple things at the same time
   - May be used for many purposes
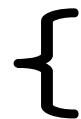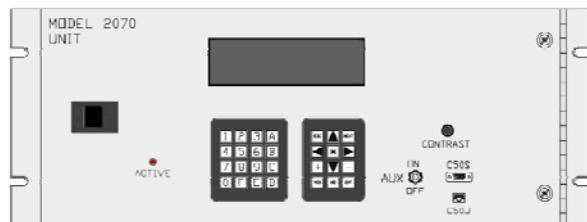
When using ATC Application Programming Interface (API) Software

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Discuss the Purpose of the ATC 5201 Standard v06 (cont.)

- Provide a general purpose field-computing platform for transportation applications that:

  - Can grow with technology
    - Standards allow for evolution within a framework

  - Upgrade for legacy transportation field cabinet systems (TFCSs)
    - Get contemporary performance and capabilities using older cabinet architectures

# Traditional Controllers Run a Single Application Program at a Time
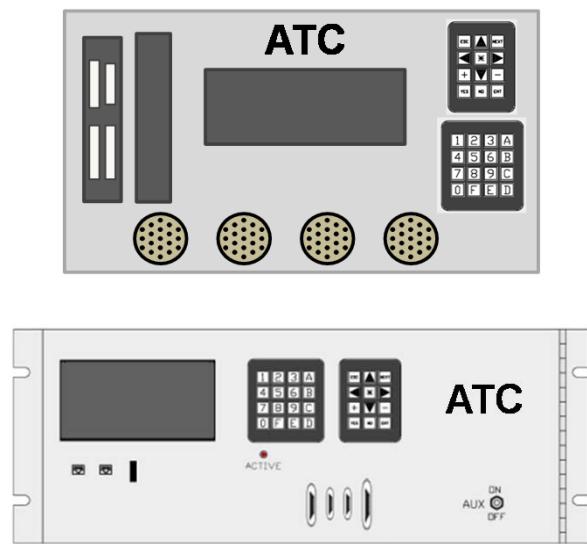
Traditional Applications

- Data collection application

  OR

- Traffic signal application

  OR

- Ramp meter application

Graphics: Ralph W. Boaz

Any ATC Can Run Multiple Application Programs Simultaneously

Example Applications for ATCs

- 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

ATC

When using ATC API Software

Graphics: Ralph W. Boaz

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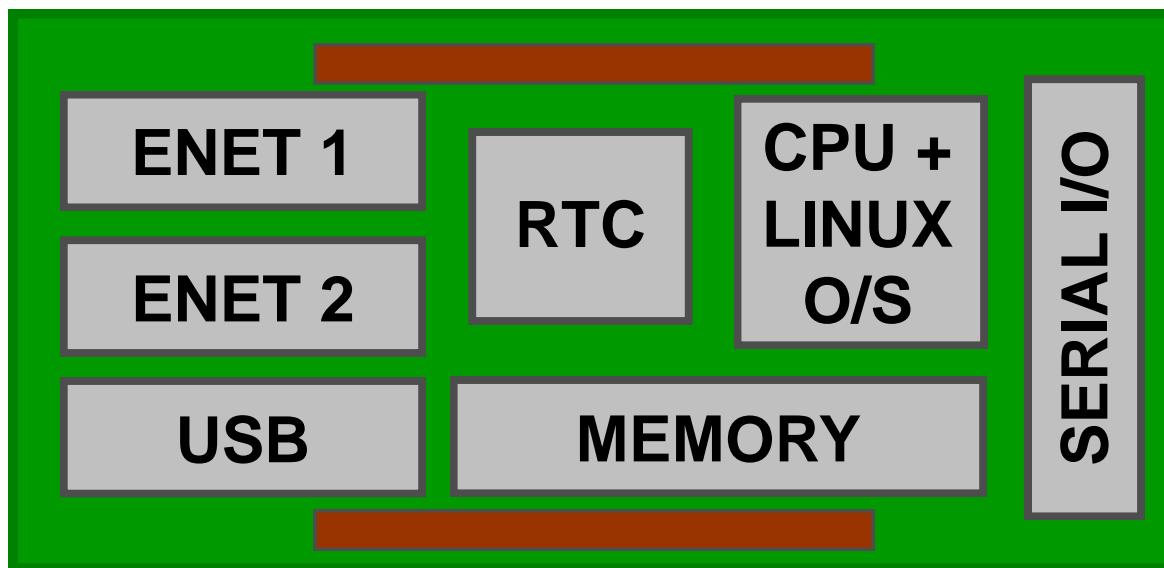
Identify Key Elements of the ATC 5201 Standard v06 Architecture

- Based on an "engine board" concept

- Computational capability can grow with technology

- Uses Linux operating system – open source, multi-process, multi-application

- Mechanical specifications primarily for physical interfaces only

- Works with all major transportation field cabinet system standards and specifications

- Source code portability for application software

- Multiple and concurrent application programs when using application programming interface (API) software

ATC Engine Board Concept

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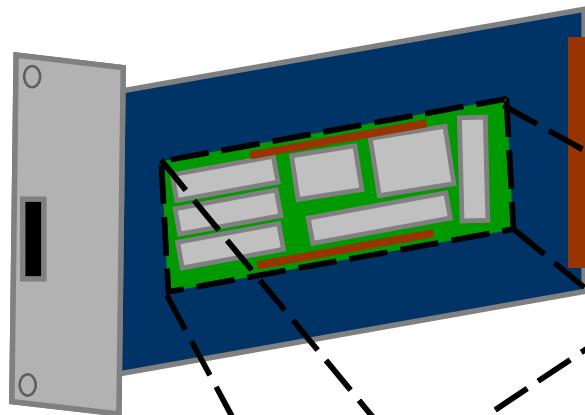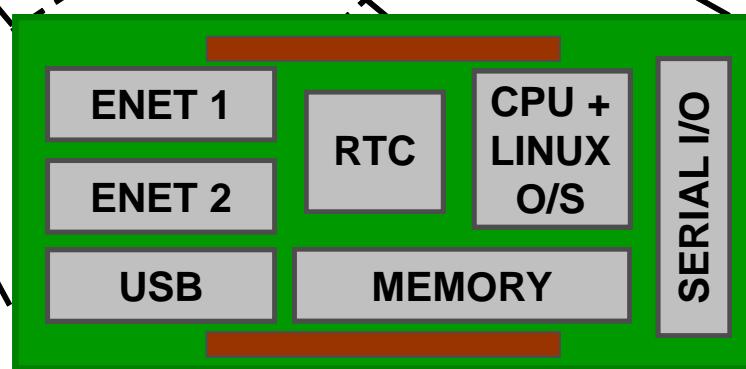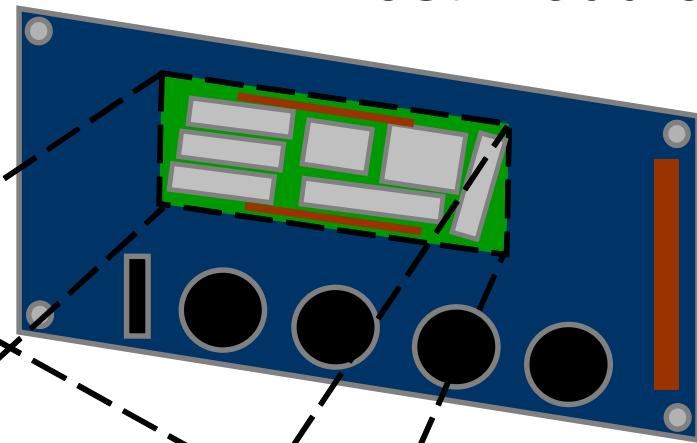
Engine Boards Used to Create Different Types of Transportation Controllers

2070 Host Module

NEMA Host Module

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

Graphics: Ralph W. Boaz

ATC 5401 Standard Defines API Software Which Allows Concurrent Application Programs

- Front panel management

  - Application programs able to use dedicated window(s)

  - Operational users interact with window/application program in "focus"

- Field input/output (I/O) management

  - 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
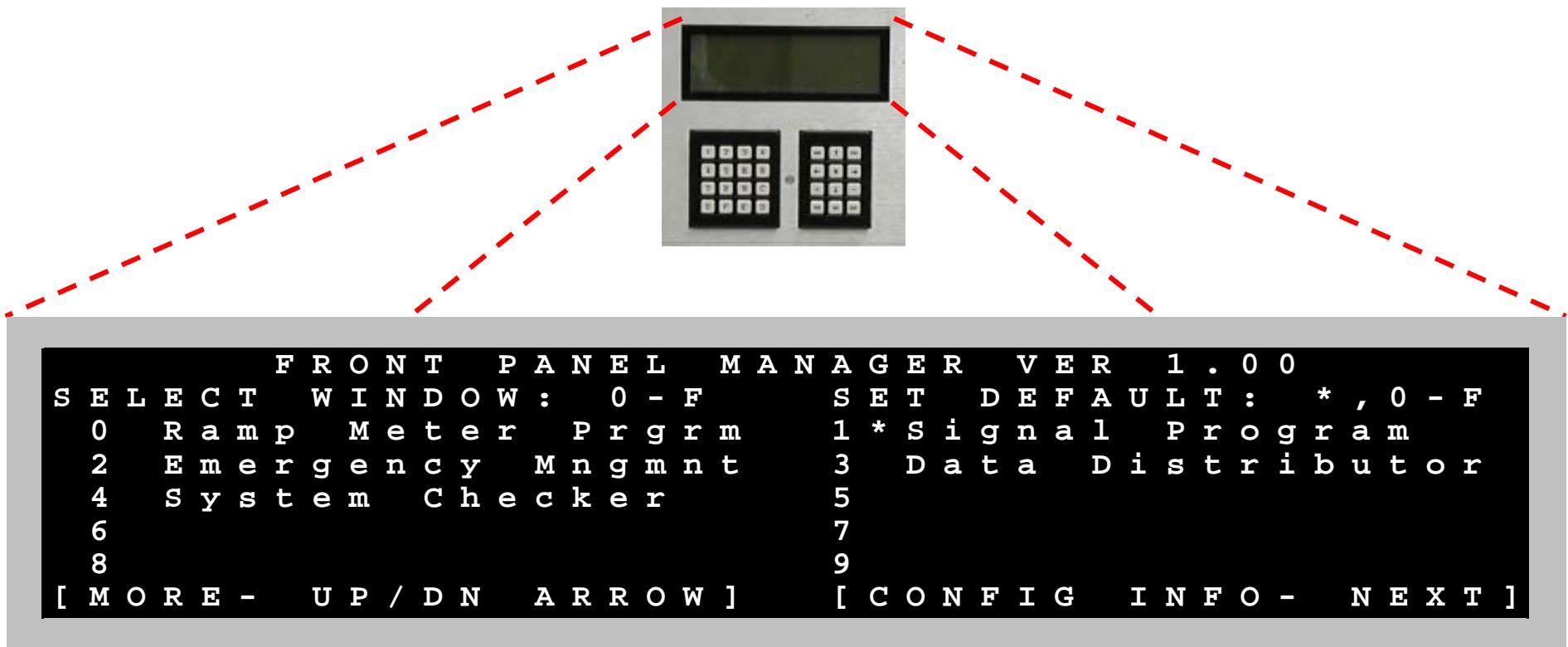
ATC 5401 Standard Defines API Software Which Allows Concurrent Application Programs (cont.)

- Real-time clock management

  - Set/Get Time Functions

  - Daylight Saving Time (DST) Functions

  - Time Source and Signaling Functions

- API utilities

  - ATC configuration window

  - Standard utilities for setting system time, setting Ethernet ports, selecting system services, getting Linux and API information

  - Extensible so additional utilities may be added

Front Panel Manager Window


```
        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   Ramp  Meter  Prgrm      1 * Signal   Program
  2   Emergency  Mngmnt       3   Data   Distributor
  4   System  Checker         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 ]
```

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

Graphics: Ralph W. Boaz

Examples of ATC Units
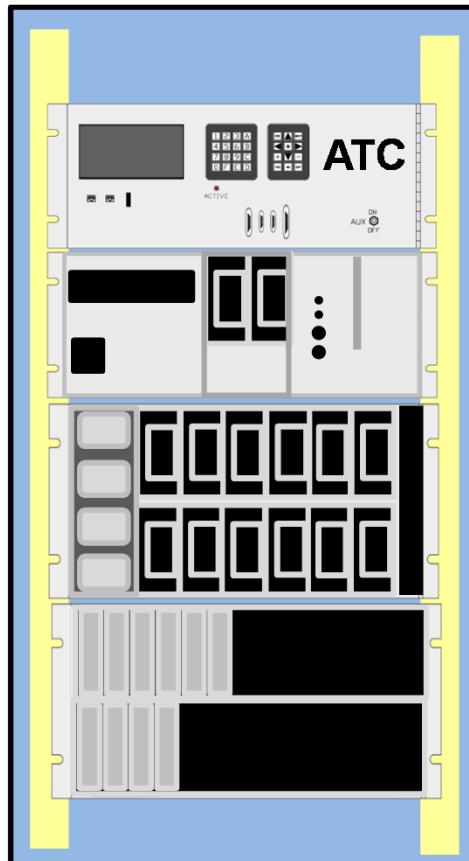
Photos: Econolite, Intelight, McCain, Peek, Siemens, and Trafficware

Describe How ATC 5201 Standard v06 Works With Other ITS Standards
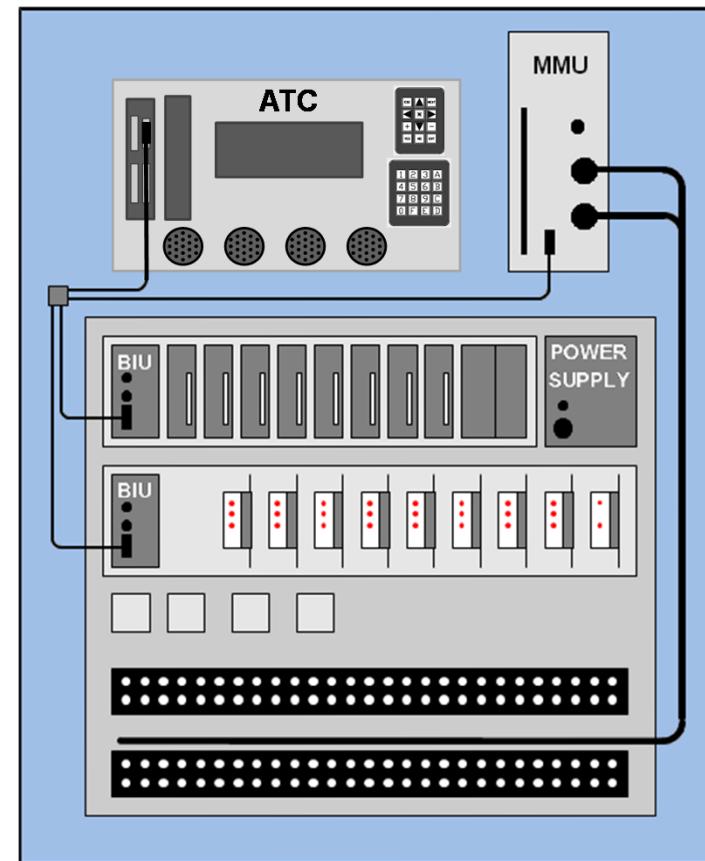
- ATC 5201 Standard provides the capability to support multiple applications using different (or same) types of NTCIP communications simultaneously (when using API Software)

- ATC 5201 Standard provides interfaces and computational power for applications such as Adaptive Control and Connected Vehicle applications

- 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 Standard v06 has more rigorous environmental and testing requirements than the major TFCS standards and specifications

ATC Units in Different TFCSs
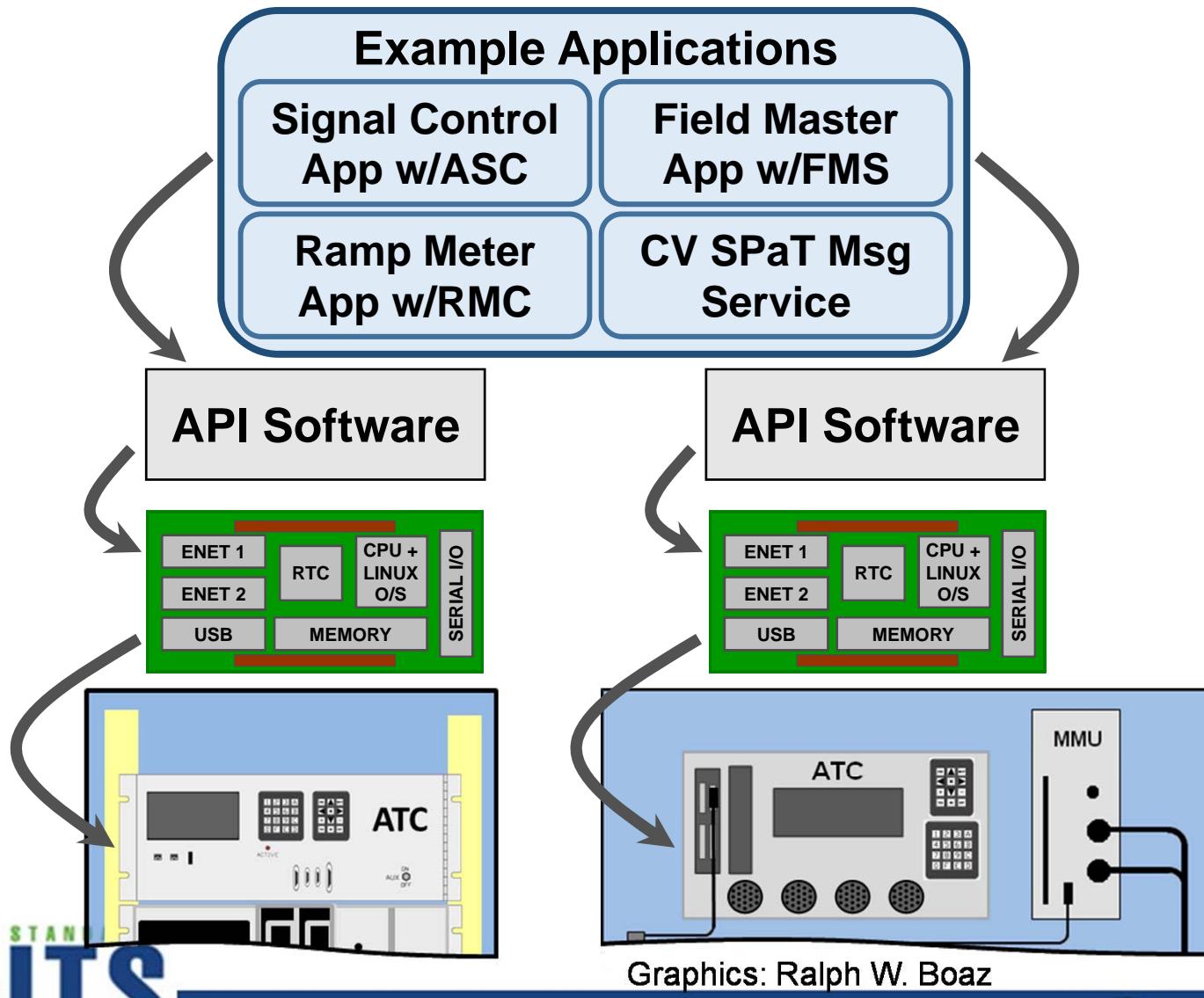
Model 332 Cabinet   **NEMA TS 2 Type 1**

Graphics: Ralph W. Boaz

ATC 5201 Working With Other ITS Standards

Graphics: Ralph W. Boaz

Example Applications
- Signal Control App w/ASC
- Field Master App w/FMS
- Ramp Meter App w/RMC
- CV SPaT Msg Service

NTCIP, Other Standards

API Software

ATC 5401 Standard

ATC 5201 Standard

TFCS Standards & Specifications

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Which of the following features of ATC units allows them to run concurrent application programs?

Answer Choices

a) Has a computational capability that can grow with technology

b) Works with all major transportation field cabinet systems

c) Works with NTCIP standards

d) Runs API software

Review of Answers

a) Has a computational capability that can grow with technology

Incorrect. Being able to grow with technology is a feature of ATCs which mitigates obsolescence.

b) Works with all major transportation field cabinet systems

Incorrect. This feature allows ATC units with contemporary processing power to be used to upgrade older cabinet systems.

c) Works with NTCIP standards

Incorrect. ATC units provide the computing resources for NTCIP communications but the applications determine their use.

d) Runs API software

Correct! The API software, defined by the ATC 5401 Standard, runs on ATC units and allows application programs to share the resources of the controller.

Summary of Learning Objective #1

Identify the Advantages of Transportation Controllers Based on ATC 5201 Standard v06

- Discuss the purpose of the ATC 5201 Standard v06

- Identify key elements of the ATC 5201 Standard v06 architecture

- Describe how ATC 5201 Standard v06 works with other ITS standards

Learning Objective #2: Describe a Systems Engineering-Based ATC Specification Development Process

- Traditional approaches to developing transportation controller procurement specifications

- Systems engineering approach to developing an ATC procurement specification

- Benefits of the specification development process

- Challenges to preparing a good ATC specification

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Traditional Approaches to Developing Transportation Controller Procurement Specification

- Not based on formalized user needs and requirements

  - Agencies often use an existing specification, copy it, and distribute

  - Not connected to other stakeholders who may have user needs that apply to the transportation controller

- Funding problems as policy makers and senior managers see no relationship between their approved strategic or regional plans and the potential solutions offered by ATCs

- Hardware and application procurement are combined for a single purpose use (e.g. signal control, ramp meter, data collection)
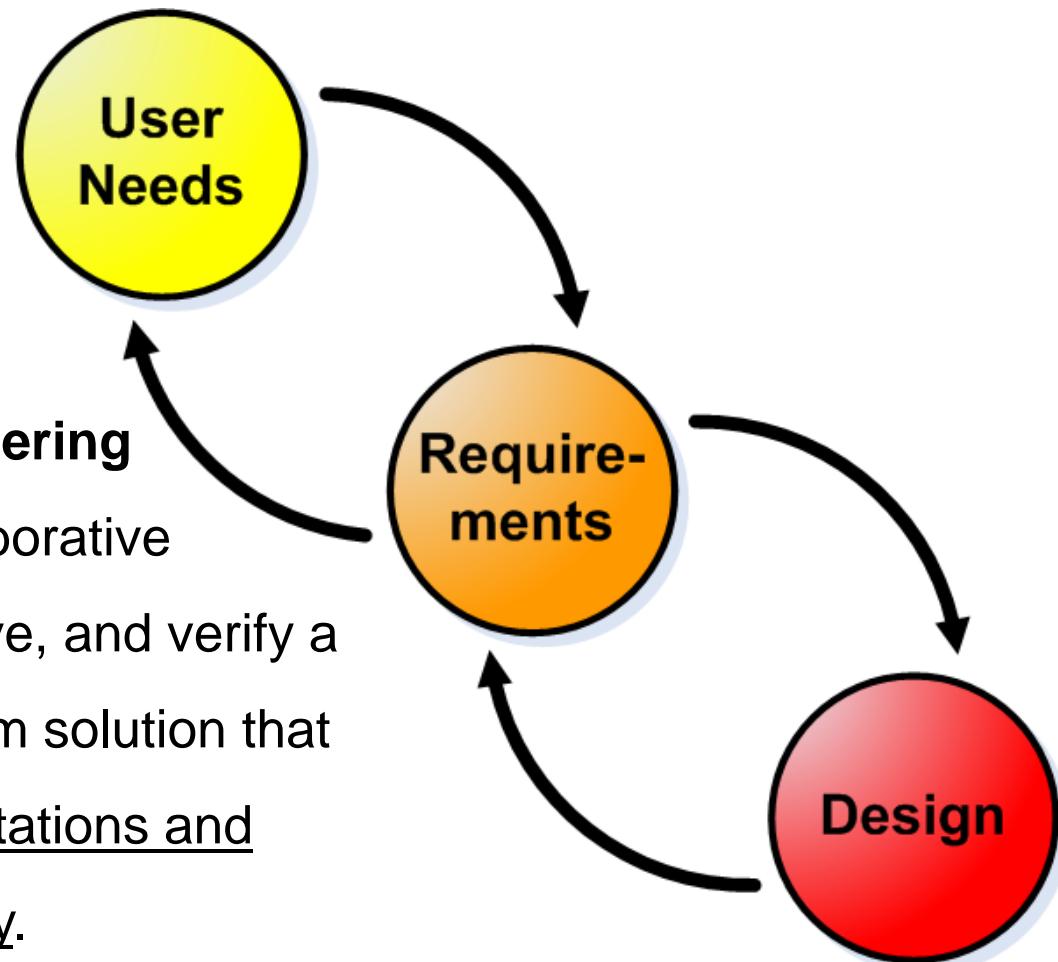
Systems Engineering Approach to Developing an ATC Procurement Specification

- Develop concept of operations with user needs

- Develop requirements based on user needs

- Show traceability to user needs in an ATC specification
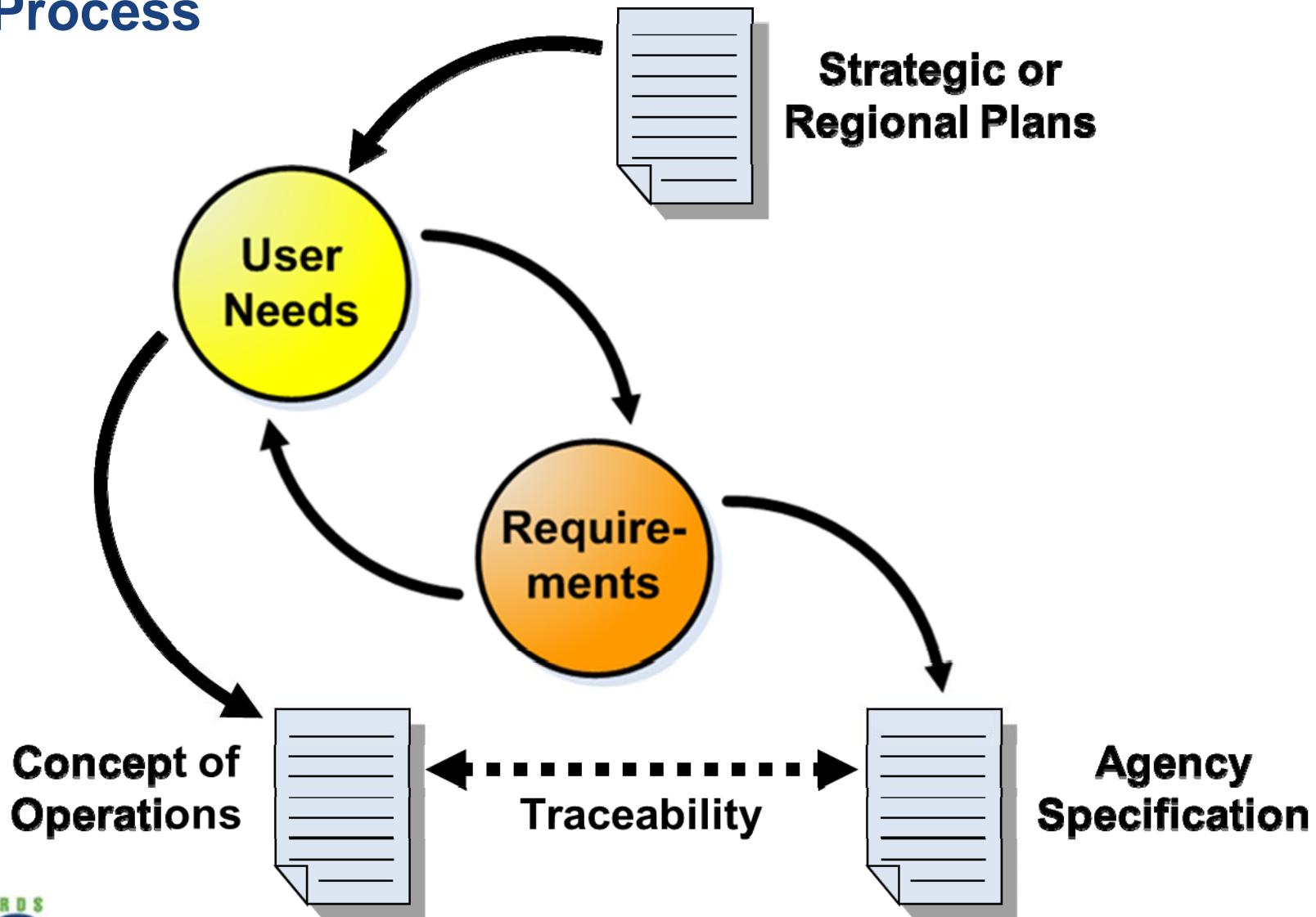
Systems Engineering Processes Used in Standards Development

IEEE – Systems Engineering

An interdisciplinary collaborative approach to derive, evolve, and verify a life cycle balanced system solution that <u>satisfies customer expectations and meets public acceptability</u>.
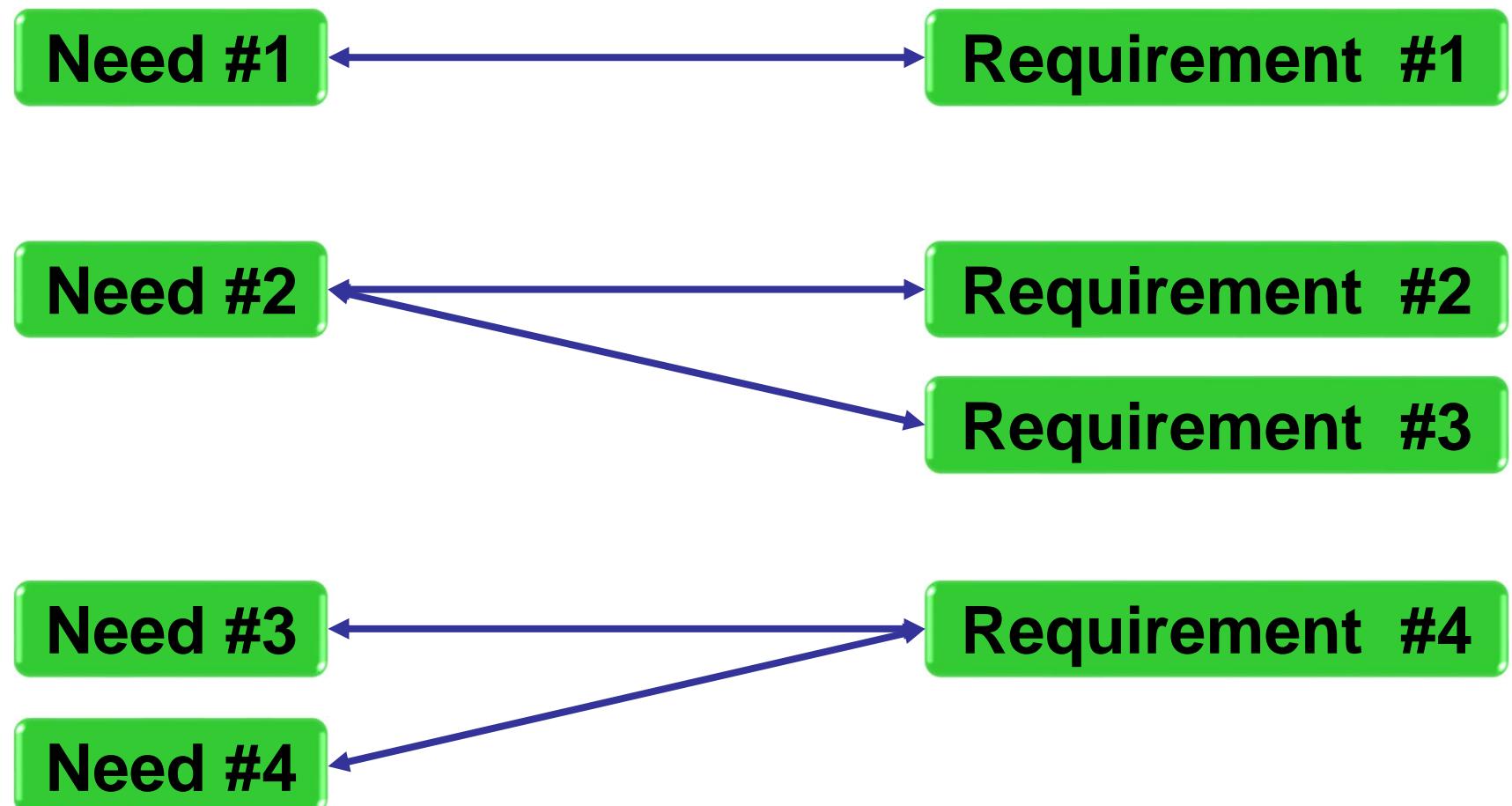
Graphics: Ralph W. Boaz

Systems Engineering Specification Development Process

Strategic or Regional Plans

User Needs

Require-ments

Concept of Operations

Traceability

Agency Specification

Graphics: Ralph W. Boaz

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Relationships of User Needs and Requirements

Graphics: Ralph W. Boaz

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Benefits of the Systems Engineering Specification Development Process

- User needs identified by a broad base of stakeholders

- Existing strategic or regional plans already approved by policy makers and higher management are part of user needs development

- Provides justification for investment in ATC units that non-technical people can understand

- Shows accountability to the public

Challenges to Preparing a Good ATC Specification

- Internal resistance to change

- External resistance to change

- Procurement schedules may not allow for the time and effort to go through a rigorous process

- Identifying and getting stakeholders together

- Difficulty getting stakeholders to describe their user needs as opposed to design requirements

- Often, people procuring the equipment are unfamiliar with a systems engineering process

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Which of the following is <u>NOT</u> a good source for discovering user needs?

Answer Choices

a) Regional plans

b) Integration testing

c) Stakeholders

d) Strategic plans

Review of Answers

a) Regional plans

Incorrect. Regional plans provide insight into the future and are a good source for discovering user needs.

b) Integration testing

Correct! It is not a good practice to depend on integration testing to discover user needs.

c) Stakeholders

Incorrect. Stakeholders are a good source (essential source) for discovering user needs.

d) Strategic plans

Incorrect. Strategic plans provide insight into the future and are a good source for discovering user needs.

Summary of Learning Objective #2

Describe a Systems Engineering-Based ATC Specification Development Process

- Traditional approaches to developing transportation controller procurement specifications

- Systems engineering approach to developing an ATC procurement specification

- Benefits of the specification development process

- Challenges to preparing a good ATC specification

Learning Objective #3: Identify and Write User Needs for ATCs

- Sources of needs for ATCs

- Characteristics of well-written user needs

- User needs as a process of discovery
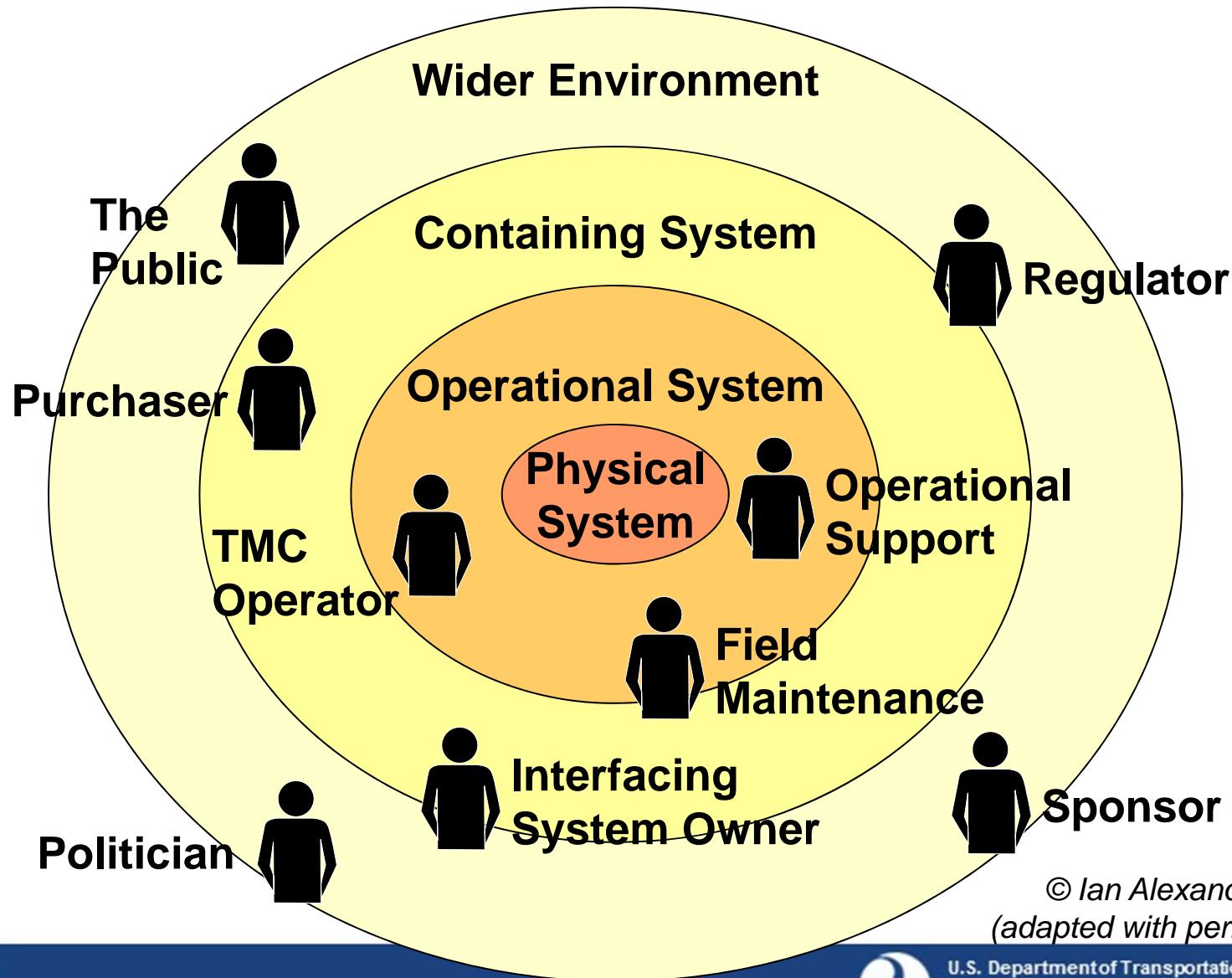
Sources of User Needs for ATCs

- Stakeholders

- Derived user needs from:
  - ❑ Existing strategic or regional plans
  - ❑ Existing or planned operational applications

- Architectural constraints (similar to user needs)
  - ❑ Existing or planned transportation field cabinet systems
  - ❑ Existing or planned communications infrastructure

- Derived user needs from ATC 5201 Standard v06

Sources of User Needs – Stakeholders

Wider Environment

Containing System

Operational System

Physical System

The Public

Regulator

Purchaser

TMC Operator

Operational Support

Field Maintenance

Politician

Interfacing System Owner

Sponsor

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Characteristics of Well-Written User Needs

- Uniquely identifiable

- Major desired capability

- Captures rationale

- Solution-free

An Example User Need

7.8.2.1 Traffic Signal Control

The user needs to safely control the flow of traffic through the city's signalized intersections. *There are over 100 signalized intersections within the city limits. The city uses pre-timed, semi-actuated and fully actuated modes of traffic signal operation. Traffic signals may be operated as a standalone intersection or in coordination with other intersections.*

Uniquely Identifiable?   ✓
Major Desired Capability?   ✓
Captures Rationale?   ✓
Solution-Free?   ✓
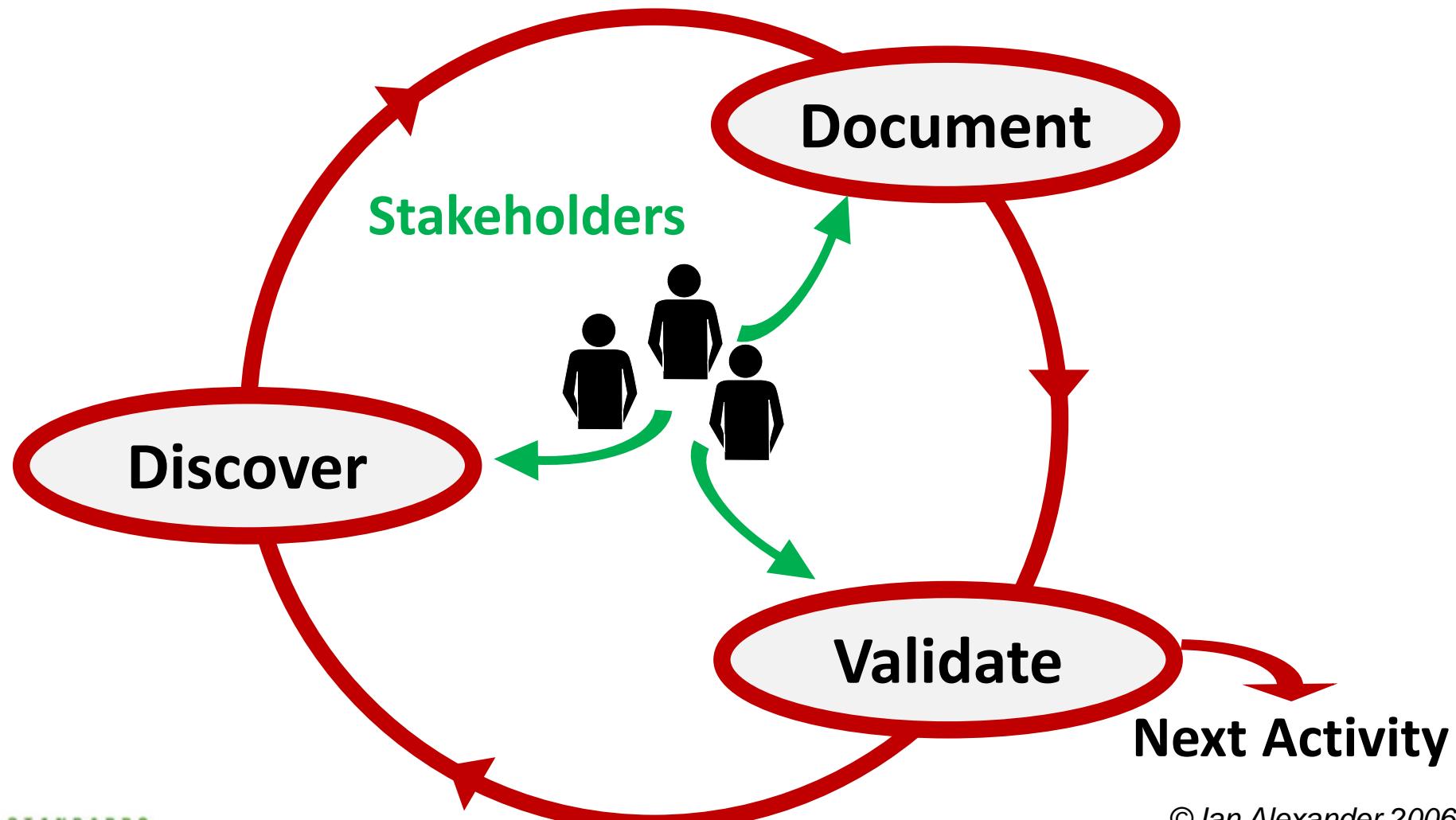
An Example User Need

7.3.5 Keypads

The user needs the controller to have keypads as described in Section 9.4.2 of the Caltrans TEES 2009. *The city has had no maintenance issues with these types of keypads on their existing controllers. The keypads work well with the city's existing signal control software.*

Uniquely Identifiable?   ✓
Major Desired Capability?   ✗
Captures Rationale?   ✗
Solution-Free?   ✗

User Needs as a Process of Discovery

Document

Stakeholders

Discover

Validate

Next Activity

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User Needs from Strategic and Regional Plans
Case Study

This section uses examples from the "Orange County Intelligent Transportation Systems (ITS) Strategic Deployment Plan (SDP) – Update 2013." This SDP was developed by the Orange County Transportation Authority (OCTA), a Metropolitan Planning Organization (MPO) for Orange County, CA.

The SDP uses ITS "strategies" to provide context for the agencies and the private sector who are deploying technology today and for the following ten years. Strategies are organized as follows: Transit management and multi-modal (MM); traffic management (TM), incident management and emergency response (IM), traveler information (TI), performance monitoring (PM), communications and connectivity (CC), safety (SF), and institutional (IN).

Other strategic or regional plans may have different names and different methods of expressing desired capabilities.

Example "Strategies" from Orange County ITS Strategic Deployment Plan

MM2 – Bus Rapid Transit (BRT): Roll out BRT service in a two-step implementation process. Technology applications could include transit signal priority (TSP), real-time bus arrival information, and automated fare collection.

MM5 – Support for Pedestrian and Bicycle Travel: Local deployments of pedestrian and bicycle safety, bike-sharing, and information technologies.

Example User Needs Derived from Orange County ITS SDP "Strategies"

7.8.3.3 Increase Public Use of Transit Buses

The city needs transportation controllers that can be used to help increase ridership of transit buses. The city needs to improve customer service and ridership experience through the use of field applications that may include *TSP (transit signal priority), real-time bus arrival information, automated fare collection, and others.*

7.8.6.1 Non-Vehicle Modes of Transportation

The city needs transportation controllers that provide for pedestrian and bicycle applications. *This is to reduce vehicle congestion, improve safety, and promote non-motorized travel.*

Example "Strategies" from Orange County ITS Strategic Deployment Plan

CC1 – Countywide Communications Master Plan: Physical and logical connectivity to support multi-modal and multi-agency operations and data sharing needs.

CC3 – Provide a Connected Vehicles Platform: Allow for the future possibility of connected vehicles in order to capitalize on the robust local operational environment and further enhance the existing foundation.

Example User Needs Derived from Orange County ITS SDP "Strategies"

7.4.3.1 Multi-Network Ready

The city needs transportation controllers equipped with communications capabilities to accommodate connectivity with multiple systems and communications networks. *The city has legacy center-to-field (C2F) communications to some arterials. The majority of the arterials are supported by Ethernet communications through fiber or high speed radios. It is expected that some applications will share a physical network while others will require separate networks.*

Example User Needs Derived from Orange County ITS SDP "Strategies" (cont.)

7.5.1 Connected Vehicle V2I Communications

The city needs transportation controllers that have the processing power to perform connected vehicle vehicle-to-infrastructure (V2I) communications. *Connected vehicle applications have the potential for a major advancement in integrated traveler information, safety, transportation management, and eco driving.*

Example Architectural Constraint

6.5.1 Transportation Field Cabinet Systems

The city needs transportation controllers equipped for existing transportation field cabinet systems. *The city has 70% of its TFCSs that are NEMA TS 2 Type 1 and 30% of its TFCSs are NEMA TS 2 Type 2. The transportation controllers should be suitable for these cabinet systems.*

Deriving User Needs From ATC 5201 Standard v06

- ATC 5201 v06 did not go through a formal systems engineering process

- ATC 5201 v06 contains a section called "representative usage" where user needs are expressed as "features"

- Features are organized into three major categories
  - Manage/configure applications
  - Manage external devices
  - Facilitate ease of maintenance and future hardware/software updates

Features From ATC 5201 Standard v06

2.3.1 Manage/Configure Applications

2.3.1.1 Install/Update Applications Software Quickly and Efficiently

2.3.1.2 Install/Upgrade 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

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

Features From ATC 5201 Standard v06

2.3.1 Manage/Configure Applications (cont.)

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

Features From ATC 5201 Standard v06

2.3.2 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

2.3.3 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

Converting ATC Standard v06 Features Into User Needs

Feature

2.3.1.1   Install/Update Applications Software Quickly and Efficiently
This feature allows the local operator or a remote computer to install or update the application software resident on the ATC.

User Need

7.3.8 Install/Update Applications Software Quickly and Efficiently
The user needs to be able to install or update the application software resident on the controller unit. *Users may or may not use application programs from the original manufacturer. All application programs need maintenance over time. Depending on the user's organization, application updates may be performed directly on the controller unit, from computer connection, or remotely through a network.*

Converting ATC Standard v06 Features Into User Needs

User Need

7.3.8 Install/Update Applications Software Quickly and Efficiently
The user needs to have the ability to install or update the application software resident on the ATC unit. *Users may or may not use application programs from the original manufacturer. All application programs need maintenance over time. Depending on the user's organization they may desire the option to perform these actions directly on the ATC unit or remotely through a computer or computer network.*

Uniquely Identifiable?   ✓
Major Desired Capability?   ✓
Captures Rationale?   ✓
Solution Free?   ✓

Converting ATC Standard v06 Features Into User Needs

Feature

2.3.3.1 Maintain/Update Controller Hardware

This feature addresses the need for controller unit hardware to be maintained and updated as technology changes and additional functional and performance capabilities are needed.

User Need

7.7.2 Maintain/Update Controller Hardware

The user needs the controller unit to be upgradeable. *Controller units are commonly in the field for seven years or more. This leads to obsolescence. The user needs to be able to upgrade the controller unit as technology changes and additional functional and performance capabilities are needed.*

Converting ATC Standard v06 Features Into User Needs

User Need

7.7.2 Maintain/Update Controller Hardware
The user needs the controller unit to be upgradeable. *Controller units are commonly in the field for seven years or more. This leads to obsolescence. The user needs to be able to upgrade the controller unit as technology changes and additional functional and performance capabilities are needed.*

Uniquely Identifiable?   ✔
Major Desired Capability?   ✔
Captures Rationale?   ✔
Solution Free?   ✔

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Which of the following is <u>NOT</u> a source of user needs for the specification development process?

Answer Choices

a) Brand of controller equipment currently used by the agency

b) Existing type of transportation field cabinet systems

c) Existing strategic or regional plans

d) Stakeholders

Review of Answers

a) Brand of controller equipment currently used by the agency

Correct! The fact that an agency is using a particular brand of equipment should not become a user need. With ATCs software applications will be portable across vendors.

b) Existing type of transportation field cabinet systems

Incorrect. The types of TFCSs being or planned to be used by the agency becomes a constraint user need for the controller equipment.

c) Existing strategic or regional plans

Incorrect. These higher level types of documents help provide the "vision" for the agency and are a source from which user needs can be derived.

d) Stakeholders

Incorrect. Stakeholders are the primary source of user needs for the transportation controller equipment (especially operational stakeholders).

Summary of Learning Objective #3

Identify and Write User Needs for ATCs

- Sources of needs for ATCs

- Characteristics of well-written user needs

- User needs as a process of discovery

Learning Objective #4: Develop a Concept of Operations (ConOps)

- Structure of a ConOps

- Organizing user needs

- Traceability of user needs to sources

Structure of a ConOps

- Example from the FHWA Systems Engineering Guidebook V3 - Modified

  - Purpose of document

  - Scope of the project

  - Referenced documents

  - Background

  - Concept for the proposed procurement

  - User-oriented operational description

  - User needs

  - Appendices

Content of the ConOps

- Purpose of document

  - Brief statement 1-2 paragraphs

  - Expected operations of the system to be procured

  - Instrument for stakeholder discussion and consensus

  - Briefly describe contents, intention, and audience

Content of the ConOps (cont.)

- Scope of the project

  - Brief statement 1-2 paragraphs

  - Brief overview of the system to be procured

  - The departments involved and other agencies involved directly or indirectly

- Referenced documents

  - List supporting documentation used and other resources that are useful in understanding the operation of the system

  - List documentation of any operational documents, strategic, or regional plans that drive the goal of the procurement

Content of the ConOps (cont.)

- Background

  - Brief description of the current equipment, how it is used currently, and its drawbacks

  - Reasons for the proposed procurement and the general approach to improvements

- Concept for the proposed procurement

  - Discuss alternative concepts and why they are not optimal

  - High-level description of an ATC

  - Justification for the approach

Content of the ConOps (cont.)

- User-oriented operational description

    - Section focuses on how the goals and objectives are accomplished currently

    - Describes strategies, tactics, policies, and constraints

    - Describes stakeholders including the users and what the users do

    - Describes personnel capabilities, organizational structures, personnel & inter-agency interactions, and types of activities

Content of the ConOps (cont.)

- User Needs

  - Here is a description of the vision, goals & objectives, and personnel needs that drive the requirements for the system

  - User needs are well-written as discussed in Learning Objective #3

  - It is recommended that user needs are organized in a fashion similar to the that of the requirements in the specification

- Appendices

  - Traceability matrix

  - Glossary

  - Backup or background material for the sections

  - Notes

Organizing User Needs

- Quality and construction user needs

- TFCS user needs

- User interface user needs

- Communications user needs

- Application user needs

- Environmental and testing user needs

- Warranty user needs

- Other user needs

Traceability of User Needs to Sources

- Include a table in the ConOps that maps each user need to source documents if they exist

UN ID	User Need	Source(s)
7.7.2	Maintain/Update Controller Hardware	ATC5201(Sec4)
7.8.2.1	Traffic Signal Control	Stakeholders
7.8.3.3	Increase Public Use of Transit Buses	SDP(MM2)
7.8.6.1	Non-Vehicle Modes of Transportation	SDP(MM5)

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ACTIVITY

Which of the following is a <u>TRUE</u> statement?

Answer Choices

a) There is only one way to organize user needs in a ConOps

b) A ConOps for an ATC is written from a vendor's point of view

c) Consider your specification when organizing your user needs

d) A ConOps is just "busy work"

Review of Answers

a) There is only one way to organize user needs in a ConOps

Incorrect. There are various ways to organize user needs in a ConOps. The method used in this module is a suggestion.

b) A ConOps for an ATC is written from a vendor's point of view

Incorrect. A ConOps should be written from the user's point of view.

c) Consider your specification when organizing your user needs

Correct! Organizing the user needs in a ConOps, in a similar fashion to the way you will organize requirements in your specification, facilitates traceability and understanding.

d) A ConOps is just "busy work"

Incorrect. A ConOps focuses users to think of what they <u>need</u> and express it in terms they <u>understand</u>.

Summary of Learning Objective #4

Develop a Concept of Operations (ConOps)

- Structure of a ConOps

- Organizing user needs

- Traceability of user needs to sources

What We Have Learned

1) ATC 5201 Standard v06 and the ATC 5401 __application__ __programming__ __interface__ work together so that ATC units can run multiple application programs simultaneously.

2) A systems engineering specification development process provides traceability from __user__ __needs__ in a ConOps to __requirements__ in the Agency Specification.

3) Well-written user needs are uniquely identifiable, a major desired capability, captures the rationale, and are __solution__ __free__.

4) Showing the __sources__ of user needs in the ConOps can demonstrate the __connection__ of the user needs to the agency's regional and strategic plans.

Resources

- United States Department of Transportation. Systems Engineering Guidebook for Intelligent Transportation Systems Version 3.0. USDOT, November 2009. http://www.fhwa.dot.gov/cadiv/segb/

- Caltrans Transportation Electrical Equipment Specifications (TEES), 12 March 2009

- 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/

- Orange County Strategic Deployment Plan 2013 Update http://www.scag.ca.gov/Documents/OrangeCounty_Aug2013Update_Final.pdf

Next Course Module

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

Concepts taught in Module (Learning Objectives):

1) Describe a systems engineering based ATC specification development process

2) Write requirements for ATCs based on user needs

3) Describe a specification based on ATC 5201 Standard v06

4) Verify an ATC procurement specification

QUESTIONS?

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