



W E L C O M E



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

Welcome

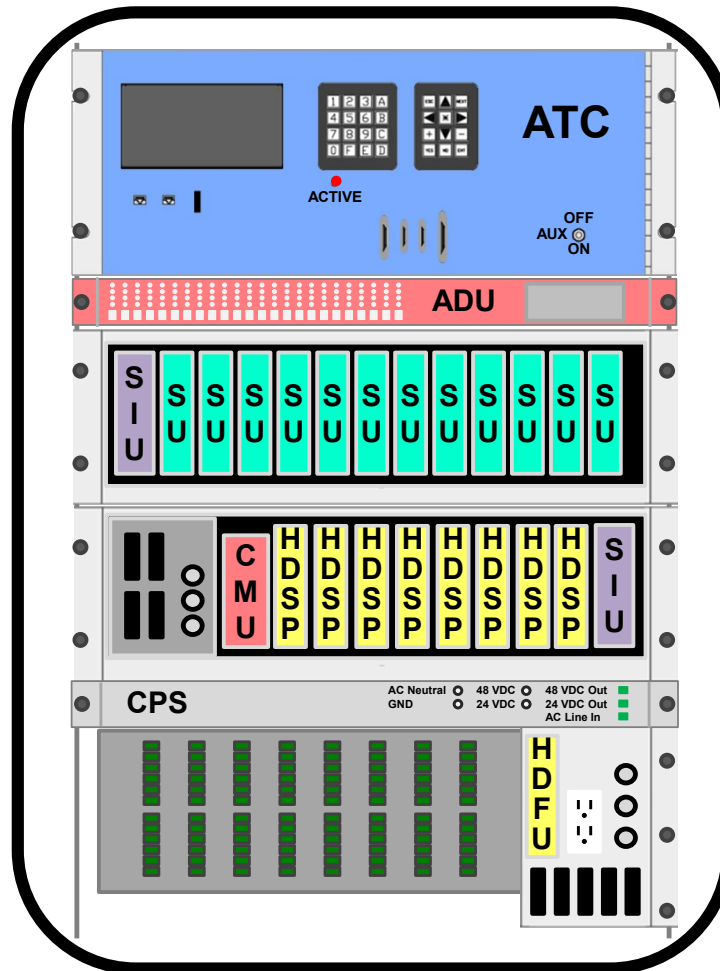


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Module A322a: Understanding User Needs for Transportation Field Cabinet Systems Using ATC 5301 v02



Instructor



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Learning Objectives

Explain the advantages of transportation field cabinet systems based on the ATC 5301 Standard v02

Describe the structure of the ATC 5301 Standard v02

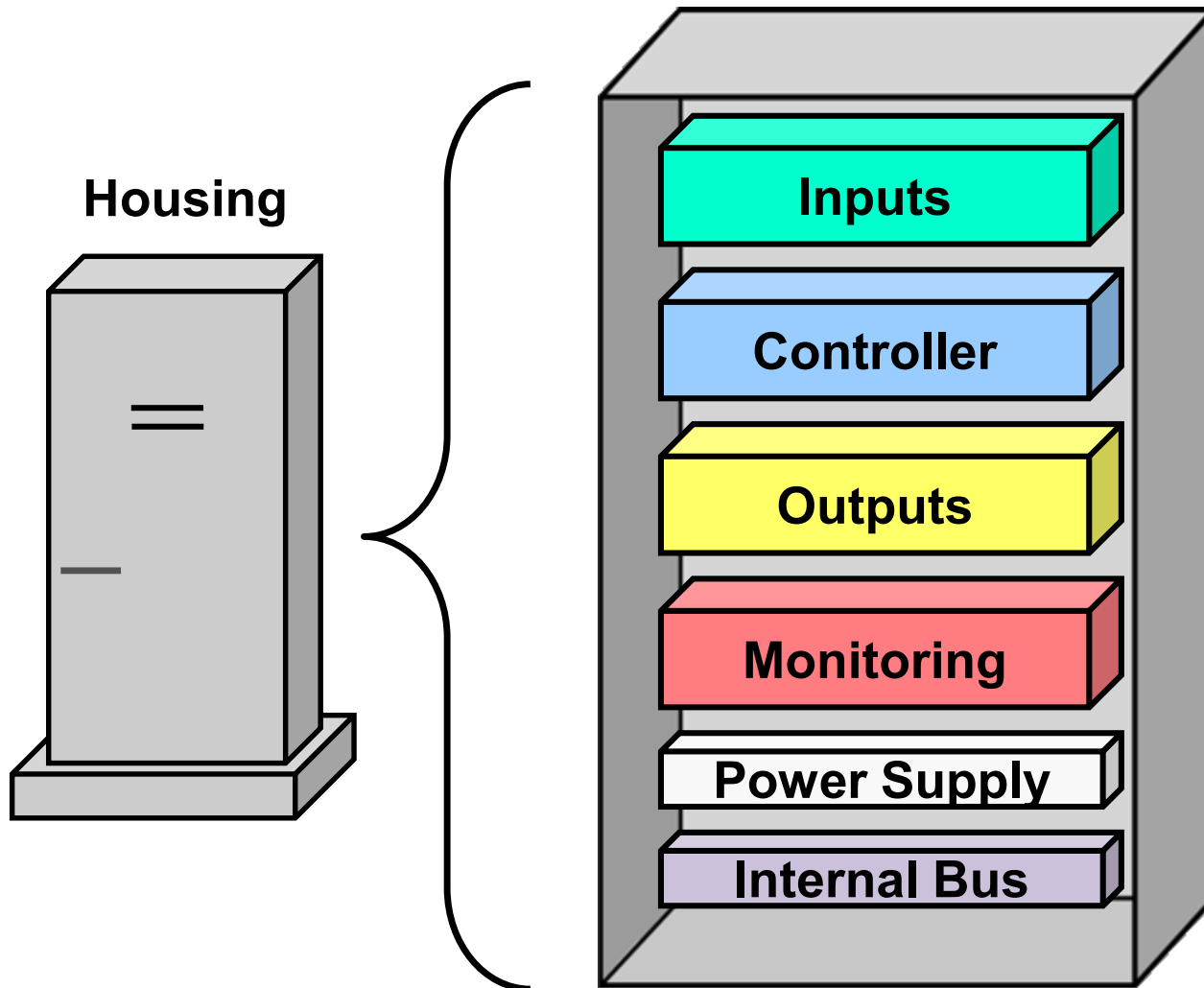
Identify and write user needs for ATC Cabinet systems

Create a concept of operations for ATC Cabinets

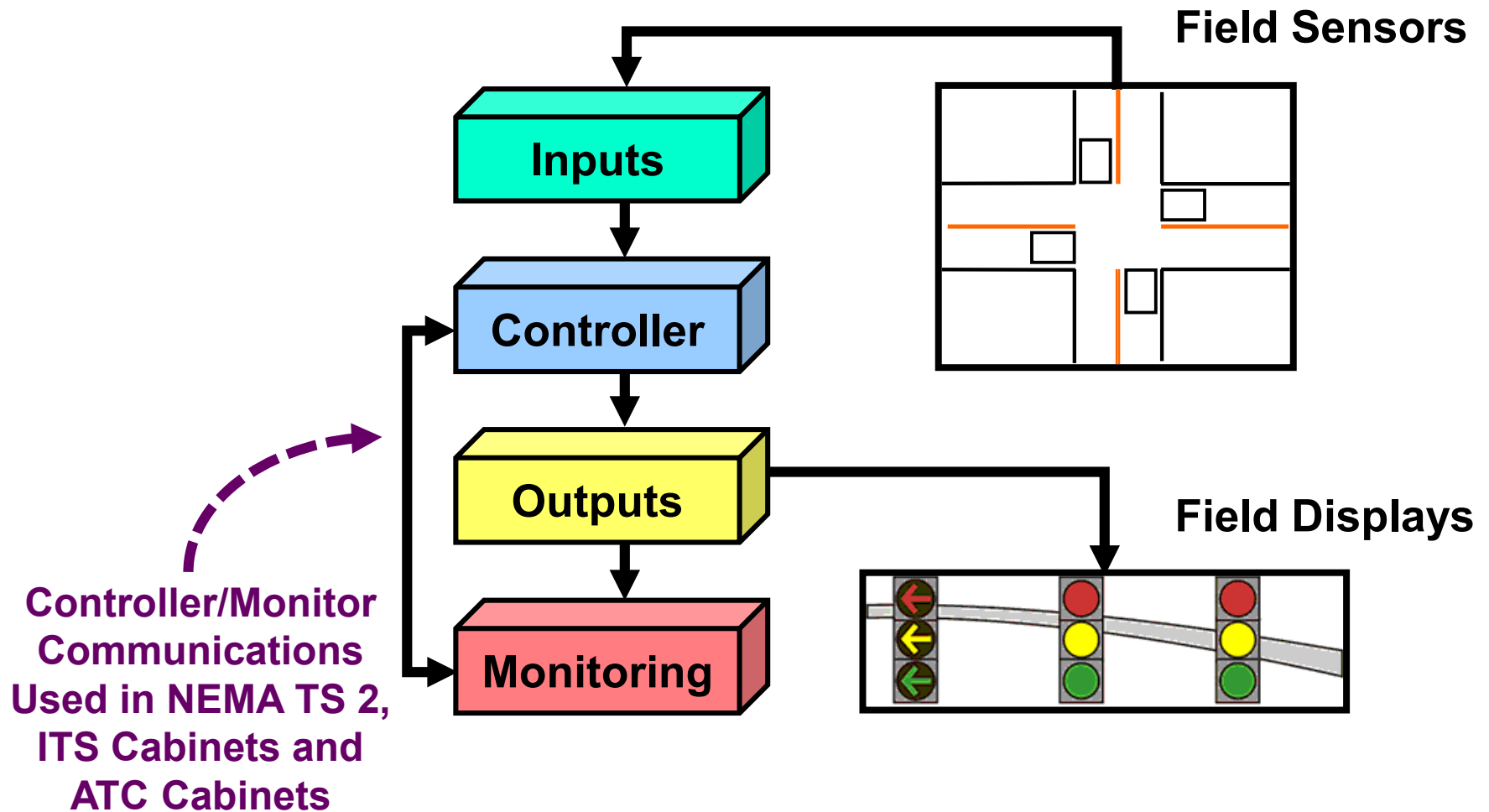
Learning Objective 1

Explain the advantages of transportation field cabinet systems based on the ATC 5301 Standard v02

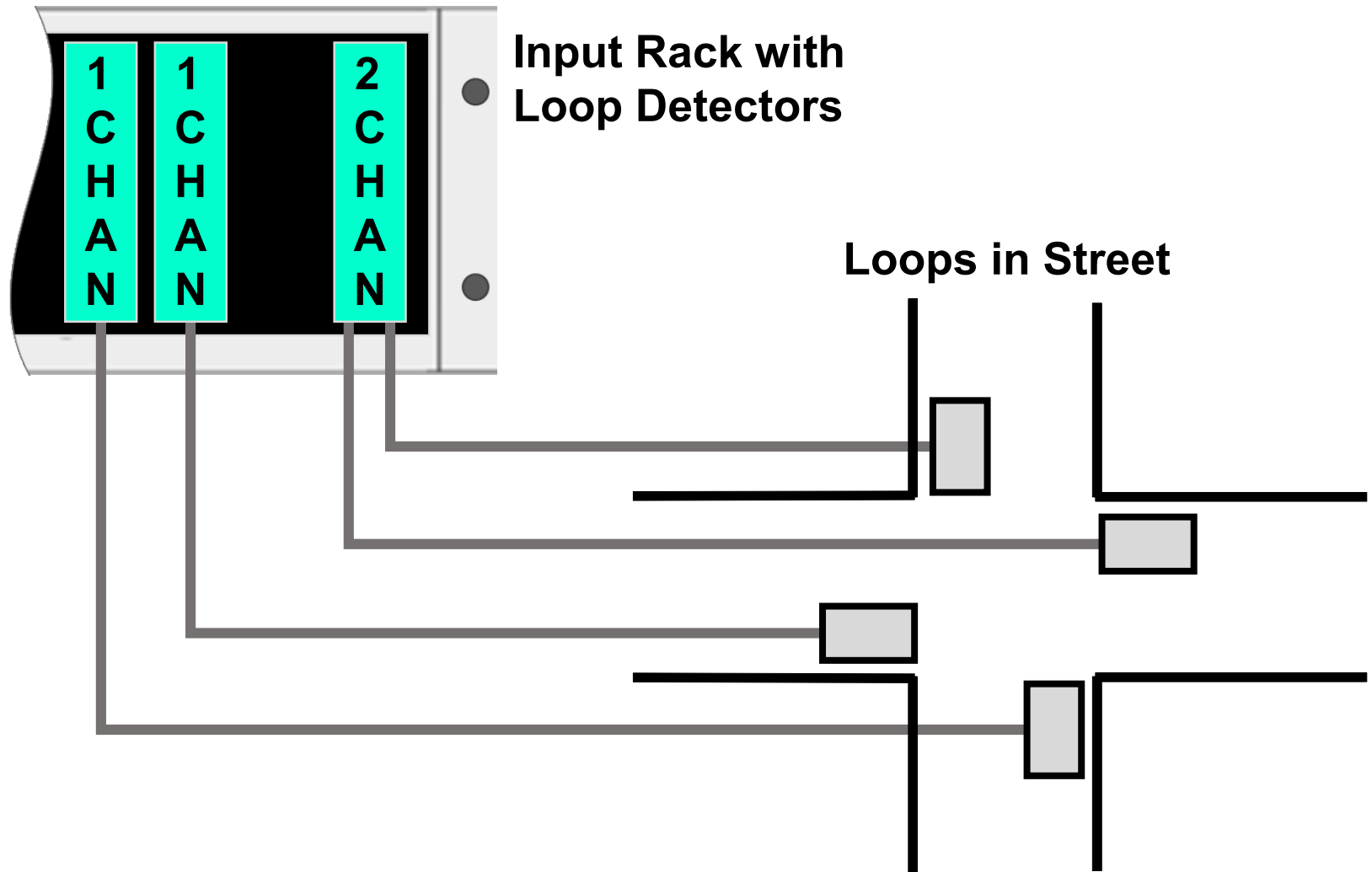
Basic Operation of Transportation Field Cabinet Systems (TFCSSs)



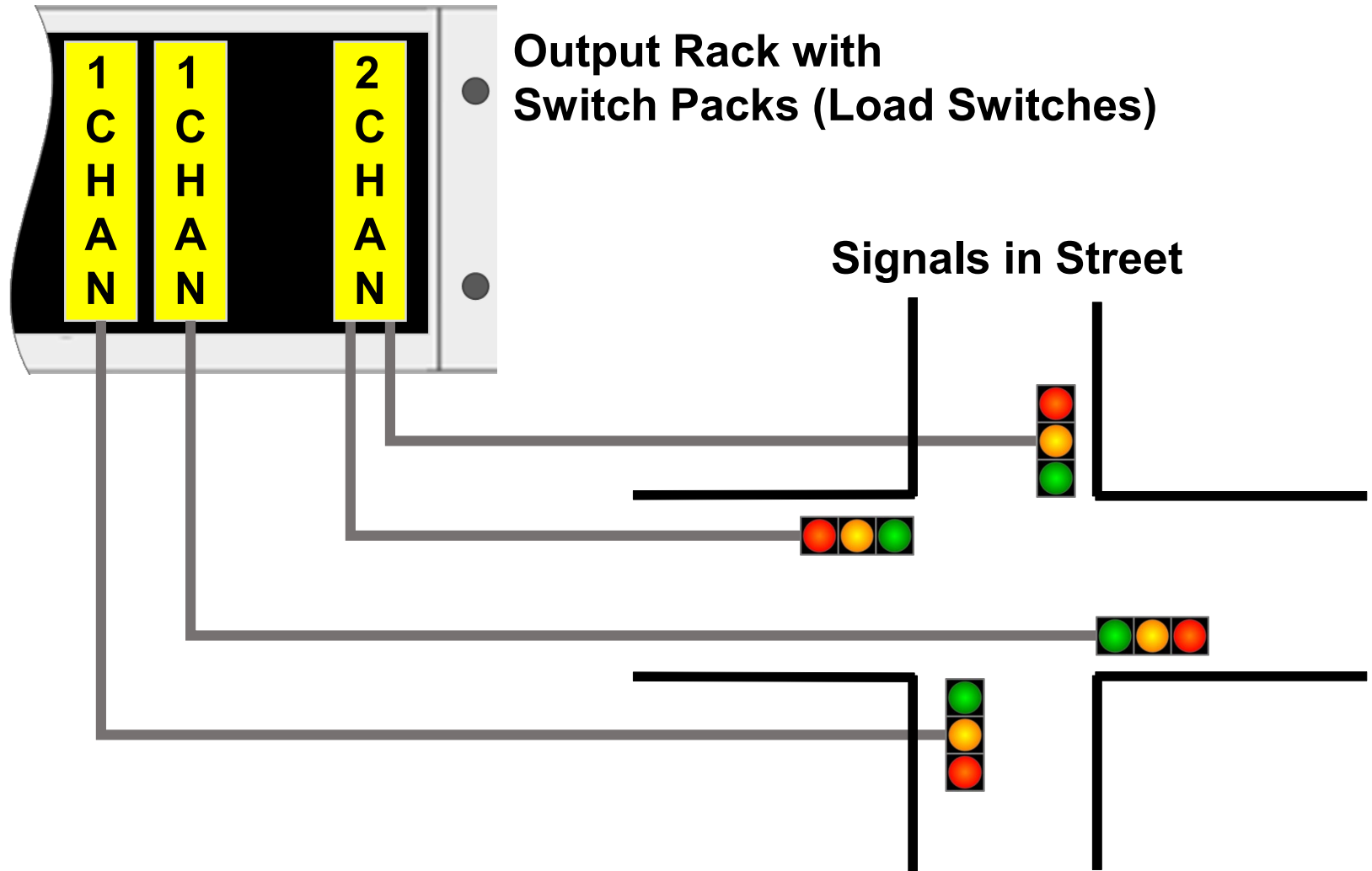
Basic Operation of a Transportation Field Cabinet Systems (TFCSSs)



Basic Operation of TFCs – Input Channels



Basic operation of TFCs – Output Channels



Evolution of Transportation Field Cabinet Systems

**Electro-
mechanical**



1940s

**NEMA
TS 1**



1976

**Model
3XX**



1978

**NEMA
TS 2**



1992

**TS 2 with
NTCIP**



1998

ITS Cabinet v01



2006

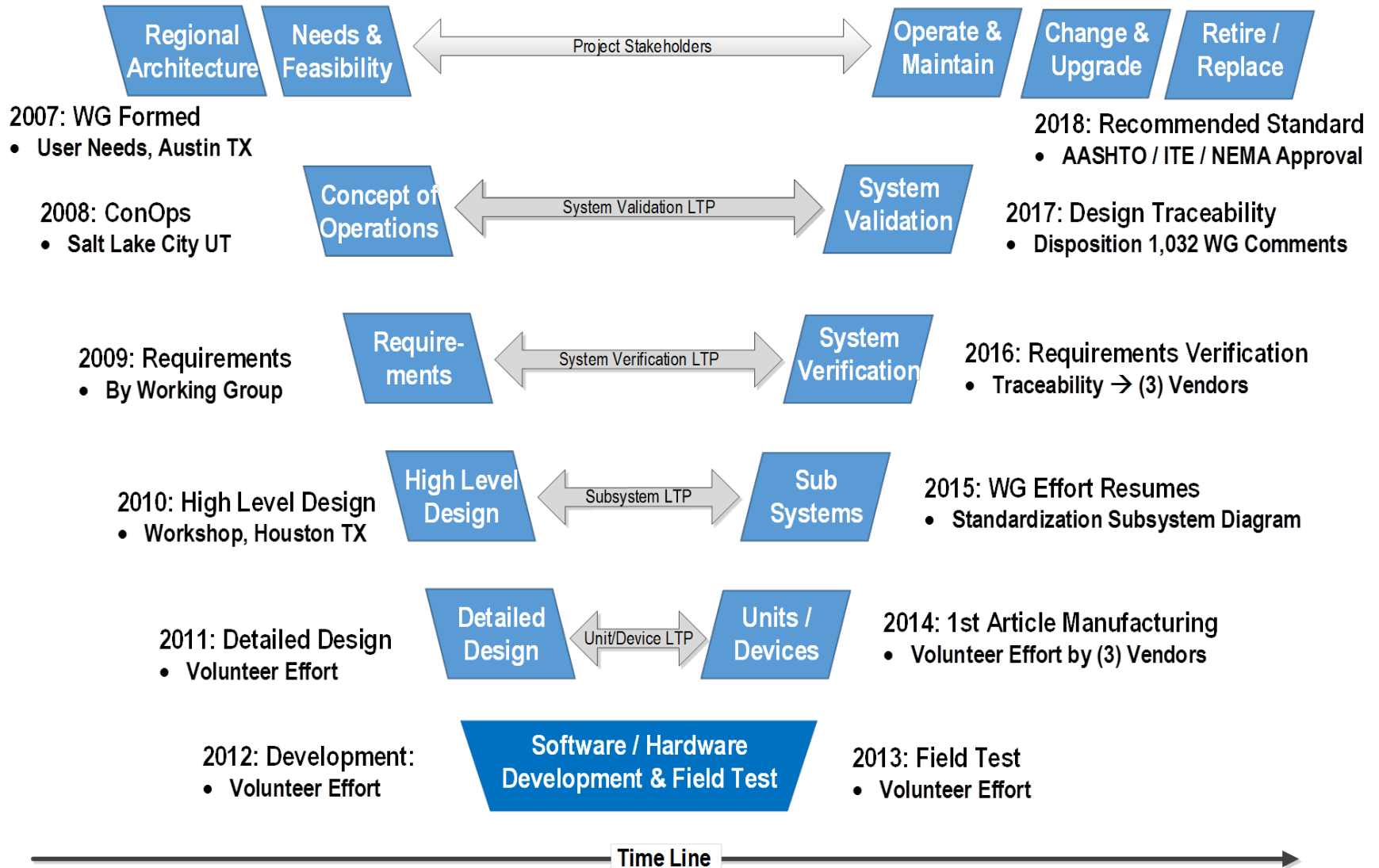
Brief History of the Development

- **ITS Cabinet Standard Version v01** published in November 2006
- **Funded effort on Version 2** of the standard **2008-2010**
 - **Industry needs** required a new version of the standard
 - Ban on incandescent bulbs, EPA mercury regulations, state safety regulations
- **Work continued on a volunteer basis** into 2011
- **ITS Cabinet v02 Standards Requirements Specification** (StdRS) developed
 - **Includes Concept of Operations (ConOps) with user needs** identified and formally stated
 - **Includes high-level requirements**

Brief History of the Development

- **Three manufacturers continued the work** to a detail level design and produced working equipment
- **Project funded** again starting in **late 2015**
- Detailed designs and **lessons learned from manufacturers incorporated into the standard**
- **Name changed to ATC 5301 Cabinet Standard v02**
 - aka ATC Cabinet or ATCC
- Jointly Approved 4th Quarter 2018 and **Published March 2019**
- **Over 1000 ATC Cabinets deployed** across the US produced by five manufacturers

Brief History of the Development



ATC Cabinet v02 Generic Representation – Design Goals

- Focus on **increasing value** to end users
- **Flexibility** within the standard for innovative designs
- **Higher density** – More capability in a smaller space
- Increased **technician safety**
- Increased **public safety**
- **Enhanced monitoring** functionality
- Increased cabinet **power efficiency**
- Provide **LED signal compatibility**

ATC Cabinet v02 Generic Representation – Major Assemblies

- **Assembly**
 - Any subordinate element to the cabinet system that is made up of multiple parts or components
 - Major and minor Assemblies

- Major assemblies are:
 - **Controller** – Covered by ATC 5201 and ATC 5401 Standards
 - **Input Assembly**
 - **Output Assembly**
 - **Field Termination Assembly**
 - **Service Assembly**

ATC Cabinet v02 Generic Representation – Components

- **Component**

- An electronic assembly with major functional attributes of the TFCS where some level of functional and/or physical interchangeability is desired

- Components are:

- **Serial Interface Unit (SIU)**

- **High-Density Switch Pack / Flasher Unit (HDSP/FU)**

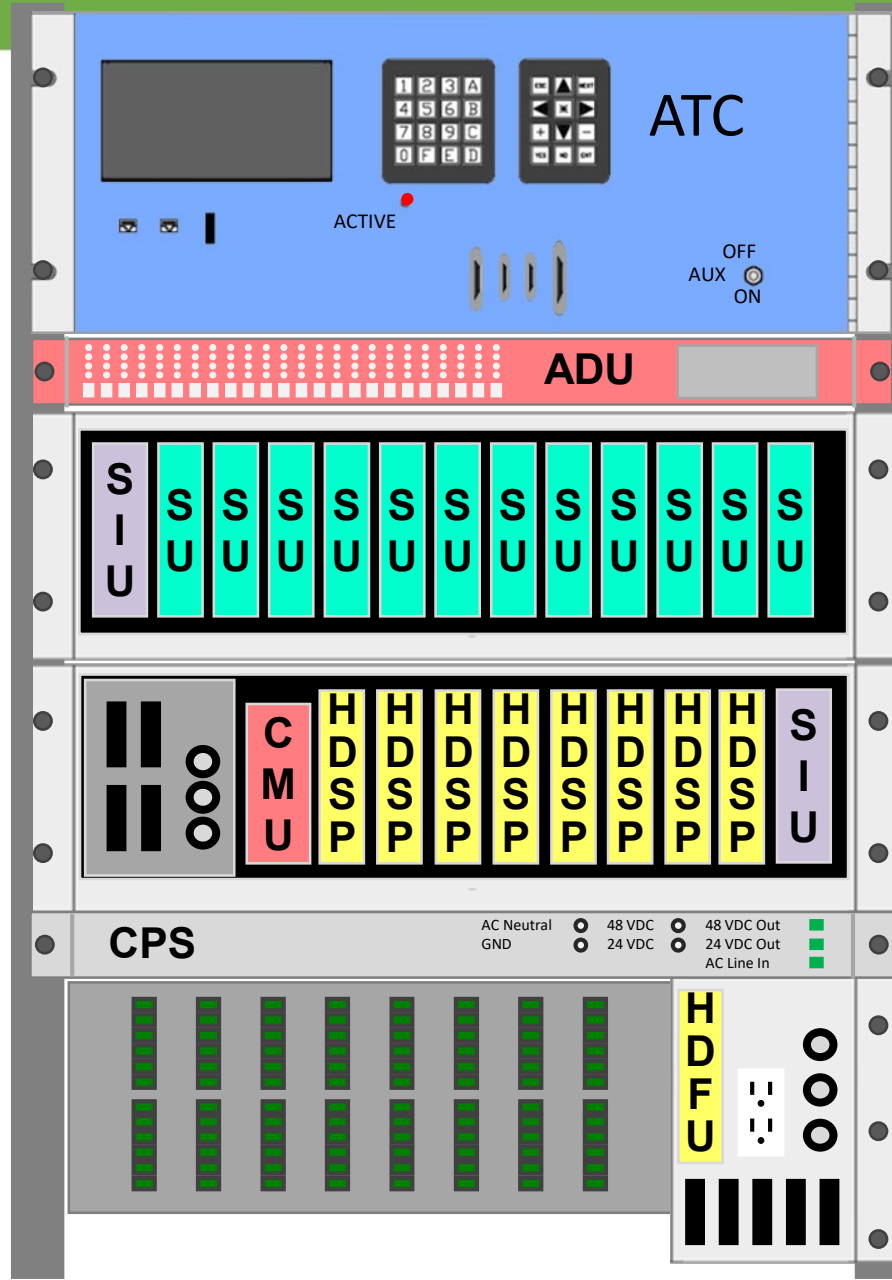
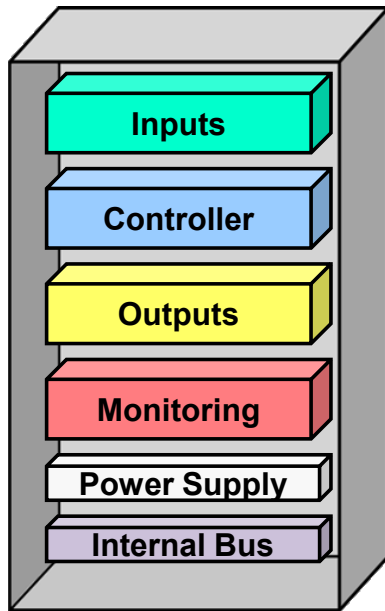
- **Cabinet Monitor Unit (CMU)**

- **Cabinet Power Supply (CPS)**

- **Auxiliary Display Unit (ADU)**

- **Sensor Unit (SU)**

ATC Cabinet v02 Generic Representation



(Option)

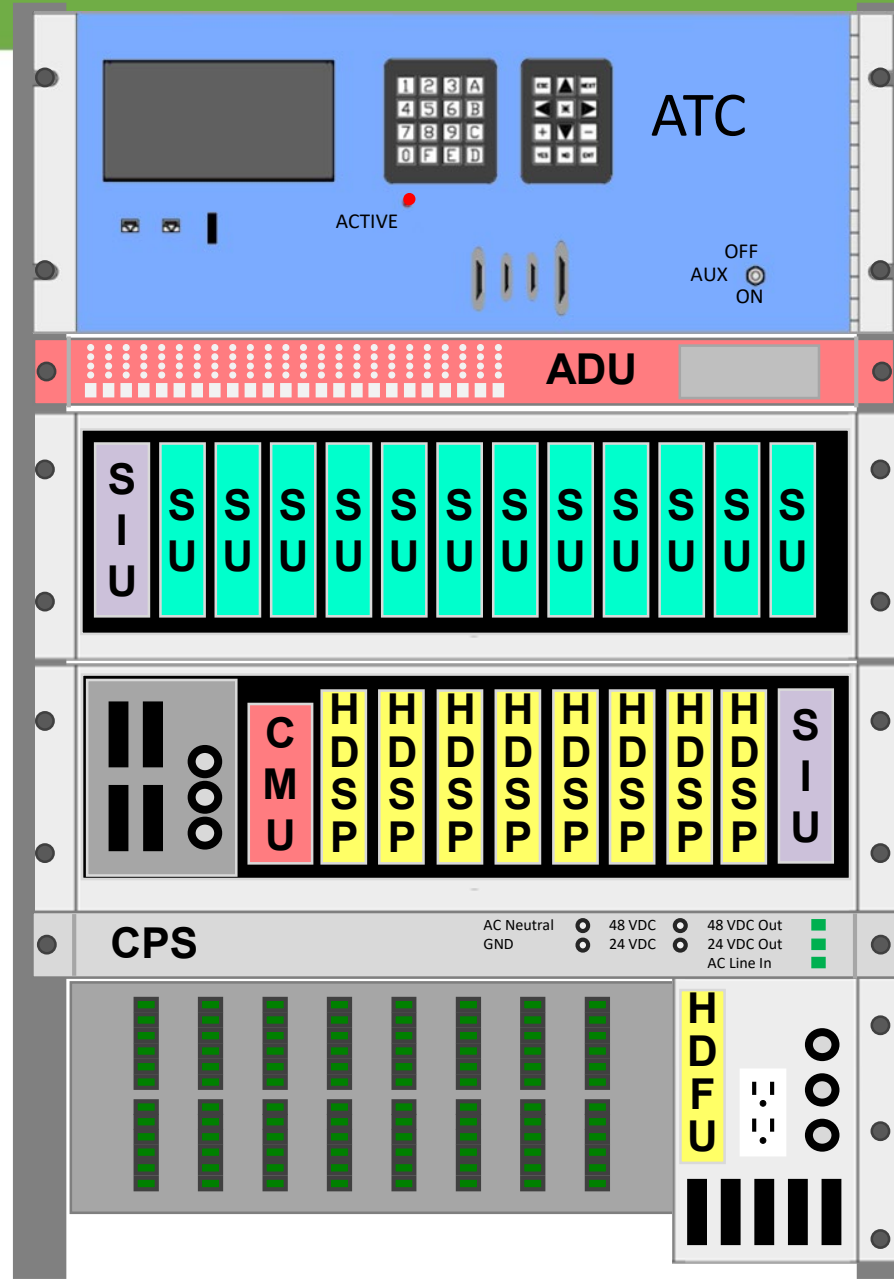
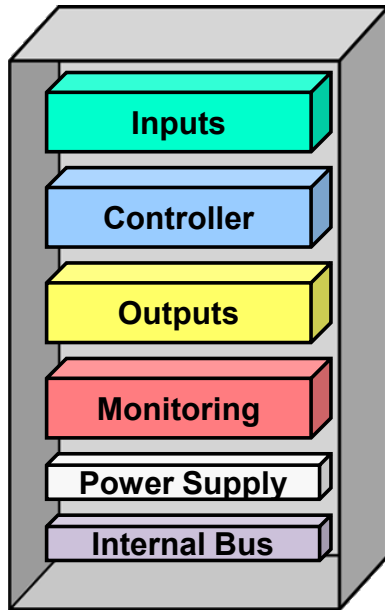
Benefits of ATC 5301 v02

- **Functional standard** except where component interchangeability is desired
- **Double** the number of **detector channels** in the same space
- **Double** the number of **channels per switch pack** and the switch pack is **physically smaller**
- **Eliminate arc flash hazard** per NFPA 70E
- **Touch safe** design
- **Low voltage option for 48 Vdc** on field wires
 - Electrically safe for humans

Benefits of ATC 5301 v02

- Most **assemblies replaceable** while intersection **in flash**
- Load **current monitoring** for **detecting dark approaches**
- Better **LED compatibility** issue – **potential power conservation** and alternative power sources

Benefits of ATC 5301 v02 - Major Assemblies Removable while in Flash



(Option)

Benefits of ATC 5301 v02 – Many Designs



Photos: Center cabinet photo courtesy of Econolite, others by Ralph W. Boaz.

Benefits of ATC 5301 v02 – Many Designs



Photos: Ralph W. Boaz

Benefits of ATC 5301 v02 – Number of I/O Channels

TFCS	Physical Mounting	Internal Bus	Signal Monitor	Input Channels	Monitored Output Channels
ATC Cabinet v02	Rack and Shelf	Serial 614.4 kbps	Cabinet Monitor Unit	120	32
ITS Cabinet v01	Rack	Serial 614.4 kbps	Cabinet Monitor Unit	120	28
NEMA TS 2	Shelf	Serial 153.6 kbps	Malfunction Management Unit	64	16
Caltrans Model 33X	Rack	Parallel / Discrete Wiring	Conflict Monitor	44	16/18
NEMA TS 1	Shelf	Parallel / Discrete Wiring	Conflict Monitor	8	3/6/12/18

ACTIVITY



Question

Which of the following is NOT a benefit of using the ATC Cabinet Standard?

Answer Choices

- a) Low voltage option for 48 VDC on field wires
- b) Touch Safe Design
- c) Functional standard except where interchangeability desired
- d) Same # of channels per switch pack as ITS Cabinet v01

Review of Answers



a) Low voltage option for 48 VDC on field wires

Incorrect. ATC Cabinet has a low voltage option. That would help protect the public in the case of knock downs.



b) Touch Safe Design

Incorrect. A touch safe design protects technicians from high voltage exposed wiring.



c) Functional standard except where interchangeability desired

Incorrect. ATC Cabinet Standard allows for innovation in cabinet designs while maintaining component interchangeability.



d) Same number of channels per switch pack as ITS Cabinet v01

ATC Cabinet has DOUBLE the number of channels per switch pack than the ITS Cabinet Standard v01.

Learning Objective 2

Describe the structure of the ATC 5301 Standard v02

Sections of ATC 5301 Standard v02

- 1 Purpose of the Document
- 2 Scope of Project
- 3 Referenced Documents
- 4 Conventions Used in This Document
- 5 High Level Block Diagram**
- 6 Components
- 7 Slots
- 8 Interfaces

Sections of ATC 5301 Standard v02

9 Protocols

10 Product Safety and Reliability

11 Environmental and Testing Requirements

12 Wire Requirements

13 Acronyms

14 Needs to Requirements to Design Traceability

15 Non Functional Requirements

16 ATCC Power Signal Naming Conventions

High Level Functional Block Diagrams

- Standard contains **two High Level Functional Block Diagrams**
 - High Voltage Operation 120 VAC
 - Low Voltage Operation 48 VDC
- **Central to understanding the detailed design of standard**
- Diagram **identifies the relationship of design elements and interfaces** within the standard
- Each of the element and interfaces shown are described in a corresponding section of the standard
- **All design elements** (except sheet metal) and interfaces **have electrical requirements**
- Only **some design elements** and interfaces **have mechanical requirements**

High Level Functional Block Diagrams

- Oval hatched symbol with dashed border indicates an interface defined by the standard electrically but it may require an adapter for interchangeability among manufacturers.



- Oval symbol with solid line indicates interface used to connect physical cabinet elements

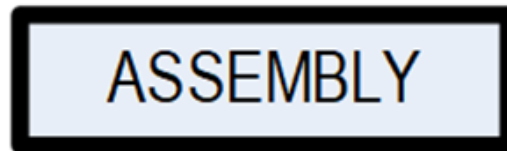


High Level Functional Block Diagrams

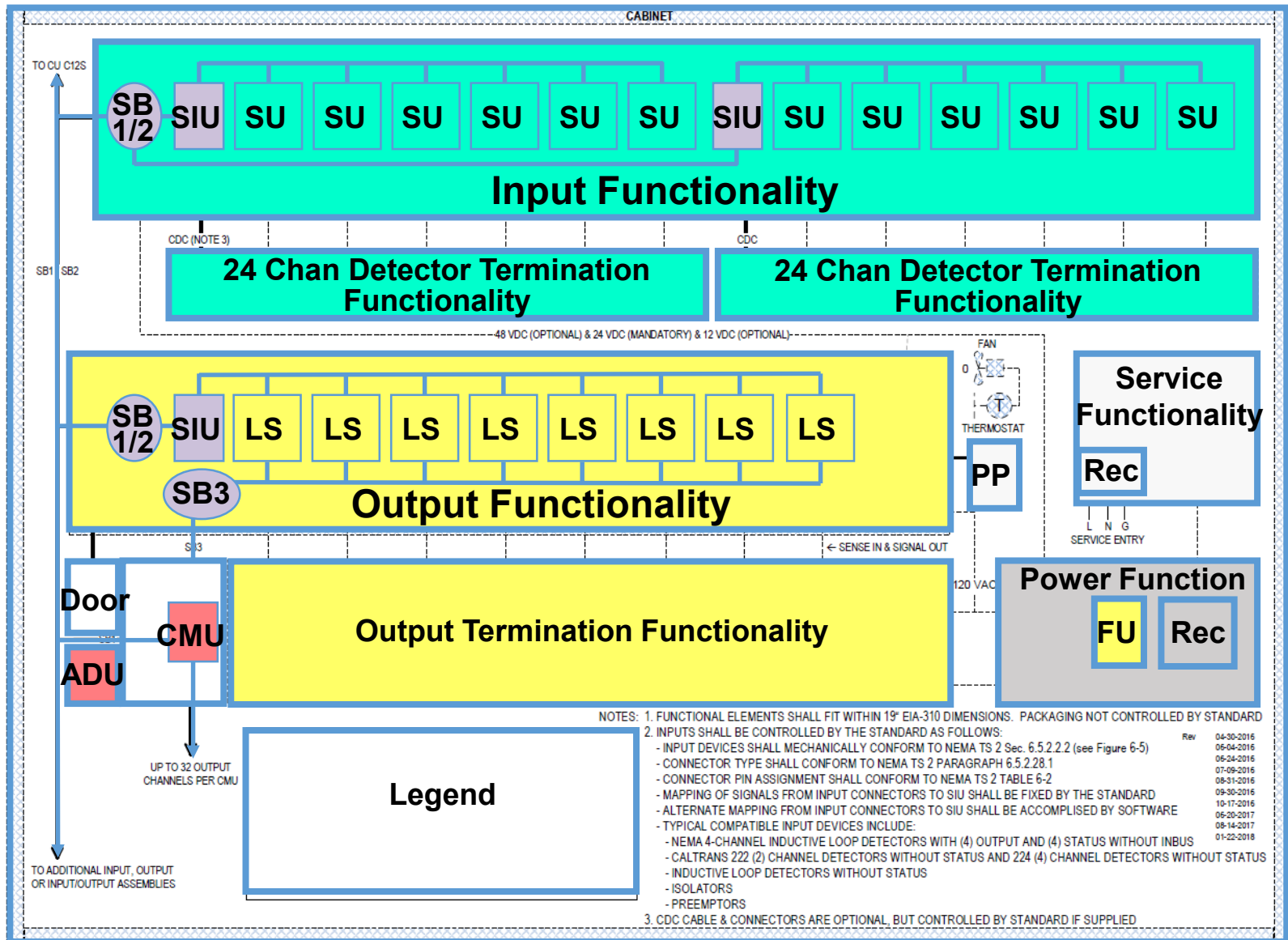
- Hatched symbol with dashed border indicates a functionality in the standard but the standard does not control mechanical dimensions



- Rectangular symbol with solid line indicates physical cabinet element



High Level Functional Block Diagrams – High Voltage



Traceability in ATC 5301 v02

- Traceability found in Section 14 of the ATC 5301 Standard
 - User needs are traced to requirements and requirements are traced to design elements
 - **Reference** is to the **user needs found in Section 4 of the ITS Cabinet v02 Requirements Specification**
- Provides for verification of a standard as part of its development
- Provides for validation of a product when a product is built to the standard

Traceability in ATC 5301 v02

Verify the Requirement

Requirement ID	Requirement Title
5.13.1	Diagnostic Display Local Display

Requirement Text

The TFCS shall contain a Diagnostic Display Unit (DDU) which supports local display of both historical and current cabinet status and log data collected by the monitoring subsystem.

Justification for the Requirement:

1. The user needs the TFCS to be of a design that reduces the time required for maintenance personnel to perform maintenance actions in the field.

Source for Justification:

1. UN ID 4.3.1.20

Related Design Elements

1. 6.5 Model 2220 Auxiliary Display Unit

Traceability in ATC 5301 v02

Verify the Requirement

Requirement ID	Requirement Title
5.4.4	Low Voltage Switch Pack Modules

Requirement Text

The following power limitations shall apply to the Low Power / Low Voltage cabinet option:

- Less than 30 Volts RMS
- Less than 42 Volts Peak
- Less than 60 Volts DC

Justification for the Requirement:

1. The user needs the TFCS to provide for field wiring that is at voltage and current levels below those dangerous to humans.

Source for Justification:

1. UN ID 4.3.4.2

Related Design Elements

1. 6.2.2.2 Field Signal Voltage Sense Inputs
2. 6.2.4.1 Field Signal Outputs

[Many others]

Traceability in ATC 5301 v02

Verify the Requirement

Requirement ID	Requirement Title
5.4.3.1	Two Output Channels per HDSP120

Requirement Text

The HDSP120 shall have two output channels

Justification for the Requirement:

1. The user needs the TFCS to support the use of output devices that have higher channel density than the commonly deployed field output devices

Source for Justification:

1. UN ID 4.3.4.1

Related Design Elements

1. 6.2 Model 2202 High Density Switch Pack / Flasher Unit (HDSP/FU)

ACTIVITY



Question

True or False?

The High Level Functional Block Diagram identifies how the ATC Cabinet functions perform actuated signal control.

Answer Choices

- a) True
- b) False

Review of Answers



a) True

Incorrect. Actuated signal control is described in the NEMA TS 2 standard.



b) False

Correct! The High Level Functional Block Diagram identifies the relationship of design elements and interfaces within the standard.

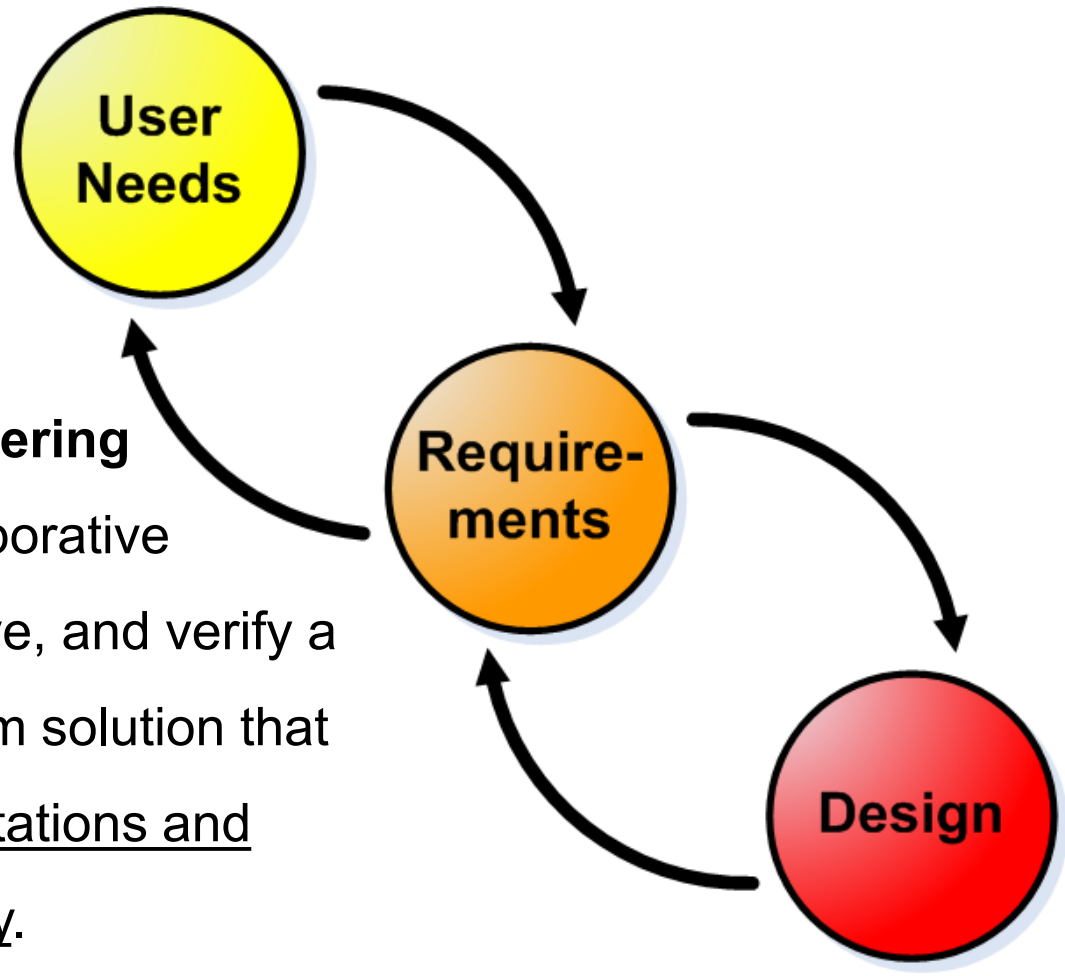
Learning Objective 3

Identify and write user needs for ATC Cabinet systems

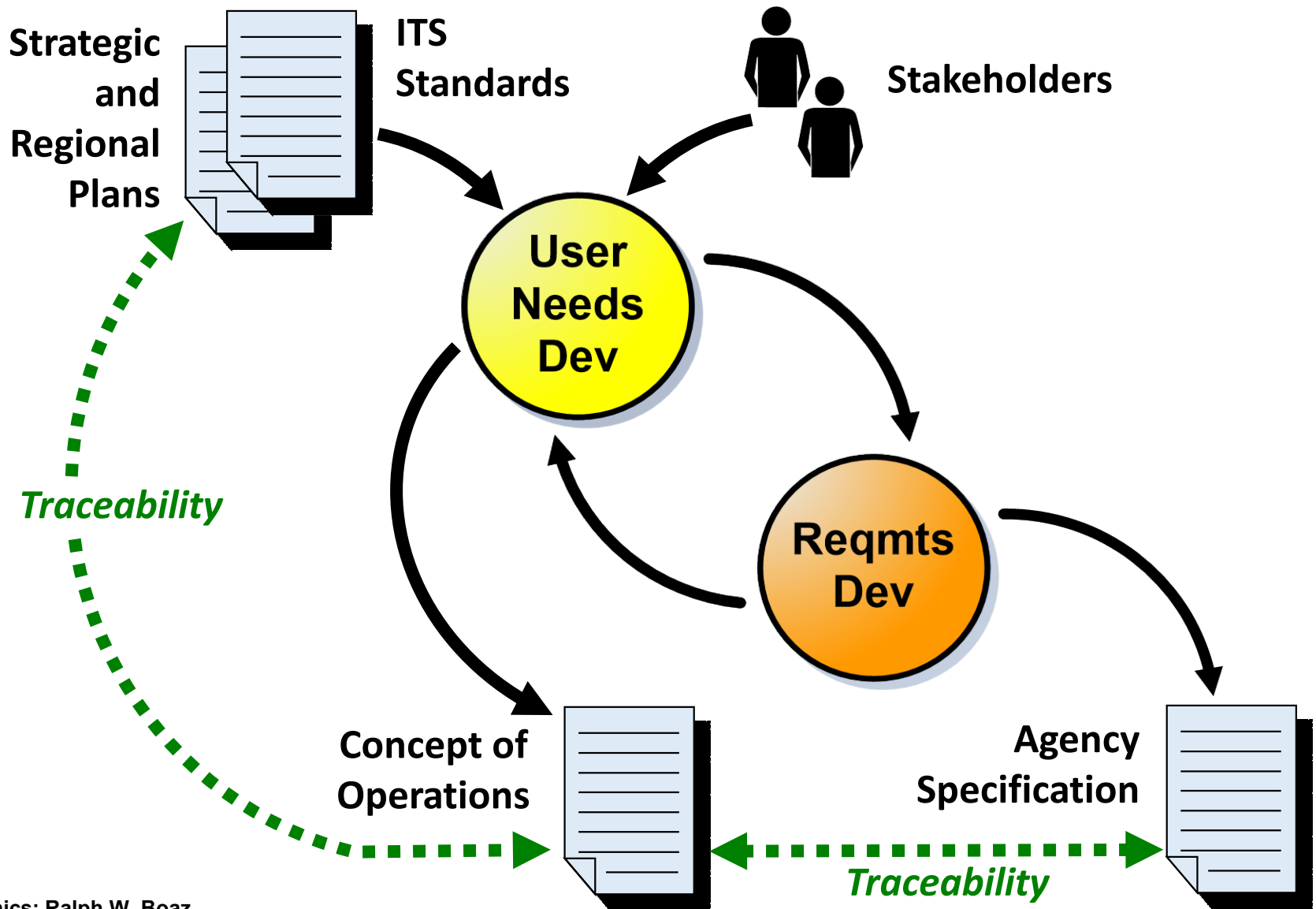
Systems Engineering Approach to Developing an ATC Cabinet Procurement Specification

IEEE – Systems Engineering

An interdisciplinary collaborative approach to derive, evolve, and verify a life cycle balanced system solution that satisfies customer expectations and meets public acceptability.

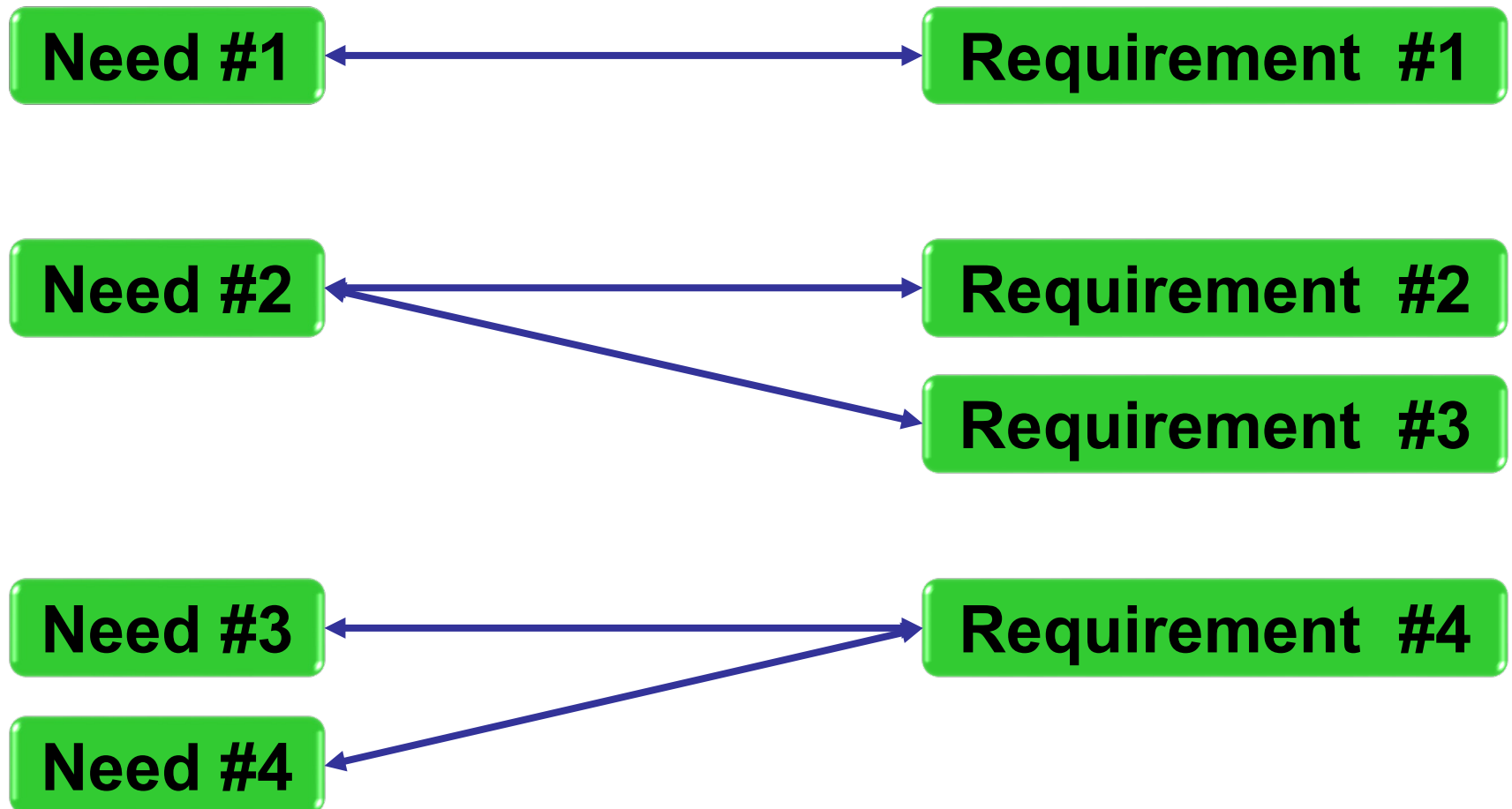


Systems Engineering Approach to Developing an ATC Cabinet Procurement Specification



Systems Engineering Approach to Developing an ATC Cabinet Procurement Specification

Relationship of User Needs to Requirements



Systems Engineering Approach - Benefits

- 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

Characteristics of Well-Written User Needs

- Uniquely Identifiable
- Major Desired Capability
- Captures Rationale
- Solution Free

Example User Needs for an ATC Cabinet System

7.1.1 Modern ITS Standards and Specifications

The city needs the transportation infrastructure to be based on modern ITS standards and specifications. *Much of the city's ITS infrastructure is based on 25-40 year old technology. Infrastructure based on modern ITS standards provides choices for ITS solutions today and in the future. It also offers the best opportunity to leverage new technologies for mobility and safety.*

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

Example User Needs for an ATC Cabinet System

7.2.1 Existing Foundations

The city needs TFCS to use existing cabinet foundations at signalized intersections. *Intersections outside the downtown area have Caltrans 332 cabinet foundations. The downtown area has both Caltrans 332 cabinet foundations and pedestal mounts for Caltrans 336 cabinets. The city wants to avoid the cost of having to replace foundations when installing a new cabinet system.*

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

Example User Needs for an ATC Cabinet System

7.4.1 120 VAC Service Power

The city needs the TFCS to operate using existing 120 VAC service power. *Numerous on street devices require 120 VAC including traffic signal displays and the city's Changeable Lane Assignment System (CLAS) and lighted cross walks.*

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

Example User Needs for an ATC Cabinet System

7.8.1 Standard Cabinet Configuration

The city needs a TFCS configuration that is suitable for intersections that are outside the downtown area. *The number of inputs and outputs need to support 80% or more of the intersections in this configuration. The city has plans to include a UPS in the cabinet and network equipment. Room is required for Connected Vehicle Roadside Equipment once the city chooses to deploy it. The city is identifying this configuration for ease of procurement.*

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

Example User Needs for an ATC Cabinet System

7.8.2 Downtown Cabinet Configuration

The city needs a configuration TFCS that is suitable for intersections that are in the downtown area. *The number of inputs and outputs need to support 80% or more of the intersections in this configuration. The city has plans to include a UPS in the cabinet and network equipment. Room is required for Connected Vehicle Roadside Equipment once the city chooses to deploy it. The city is identifying this configuration for ease of procurement.*

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

Example User Needs for an ATC Cabinet System

7.4.2 Multiple Applications

The city needs the TFCS to be used for multiple and concurrently running applications. *The city wishes to operate multiple concurrent applications on a single controller unit as part of the TFCS. The city may have a single TFCS operate multiple intersections simultaneously, adjacent ramp meters, and smart city applications not yet identified.*

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

Example User Needs for an ATC Cabinet System (cont.)

7.2.3 Physical Security

The city needs TFCS enclosure that inhibits unauthorized entry into the cabinet. *The enclosure should be tamper resistant and use technology to restrict access to unauthorized users. Use of the common #2 key in some areas of the city has resulted in unauthorized access and vandalism.*

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

ACTIVITY



Question

Which of the following is a correct statement?

Answer Choices

- a) Rationales of user needs have proposed solutions
- b) User needs must be testable
- c) A user need is a major desired capability
- d) Only needs in ATC 5301 v02 are valid for a spec

Review of Answers



- a) Rationales of user needs have proposed solutions

Incorrect. A rationale helps to understand what is intended by the major desired capability. A user need is solution free.



- b) User needs must be testable

Incorrect. Requirements must be verifiable. One method is by testing. In SE, user needs by are not directly testable.



- c) A user need is a major desired capability

Correct! User needs are expressed at a high level. Think of them as goals.



- d) Only needs in ATC 5301 v02 are valid for a spec

Incorrect. Agencies will have user needs that are based on their particular policies, area, existing equipment, etc.

Learning Objective 4

Create a concept of operations for ATC Cabinets

Structure of a ConOps

- Example from the FHWA Systems Engineering Guidebook V3 - Modified
 1. Purpose of Document
 2. Scope of the Project
 3. Referenced Documents
 4. Background
 5. Concept for the Proposed Procurement
 6. User-Oriented Operational Description
 7. User Needs
 8. Appendices

Content of the ConOps

1. 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

2. Scope of the **Project/Specification**

- **Brief Statement 1-2 paragraphs**
- Brief overview of the system to be procured
- The **departments involved** and other **agencies involved** directly or indirectly

3. Referenced Documents

- **Documentation and other resources** useful in understanding the **operation of the system**
- **Strategic or regional plans** that create or influence the user needs for the procurement

Content of the ConOps

4. 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

5. Concept for the Proposed Procurement

- Discuss alternative concepts and why they are not optimal
- **High-level description** of an ATC Cabinet and its use
- **Justification for the approach**

Content of the ConOps

6. 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 operational users and what the users do
- Describes personnel capabilities, organizational structures, personnel & inter-agency interactions, and types of activities

Content of the ConOps

7. 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

8. Appendices

- **Traceability Matrix**
- Glossary
- Backup or background material for the sections
- Notes

Organizing User Needs

- 7.1 Quality and Construction Needs
- 7.2 Housing and Mounting Needs
- 7.3 Communication Needs
- 7.4 Application Needs
- 7.5 Maintenance Needs
- 7.6 Environmental and Testing Needs
- 7.7 Warranty Needs
- 7.8 Procurement Needs
- 7.9 Other Needs

Traceability of User Needs to Sources

UN ID	User Need	Source(s)
7.1.1	Modern ITS Standards and Specifications	ITS Strategic Deployment Plan (4.1.1)
7.2.1	Existing Foundations	Stakeholders (Public Works)
7.2.2	Physical Security	Stakeholders (IT, Operations)
7.4.1	120 VAC Service Power	Stakeholders
7.4.2	Multiple Applications	Livable Community Plan (5.2.1)
7.8.1	Standard Cabinet Configuration	Stakeholders (Procurement Office)
7.8.2	Downtown Cabinet Configuration	Stakeholders (Procurement Office)

ACTIVITY



Question

Which of the following is a benefit of building a ConOps for an ATC Cabinet?

Answer Choices

- a) Provides justification for investment in ATC Cabinets
- b) Only technical stakeholders are necessary to produce it
- c) Strategic or regional plans are unnecessary
- d) Organization of user needs is the same for all agencies

Review of Answers



a) Provides justification for investment in ATC Cabinets

Correct! ConOps is written from user perspective, there is traceability to existing plans and user needs are identified.



b) Only technical stakeholders are necessary to produce it

Incorrect. User needs for the ConOps come from a broad base of technical and non-technical stakeholders at various levels.



c) Strategic or regional plans are unnecessary

Incorrect. Existing plans become a source of user needs that justify the investment in ATC Cabinets.



d) Organization of user needs is the same for all agencies

Incorrect. Agencies should have user needs organized in a manner that is most effective for their agency.

Module Summary

Explain the advantages of transportation field cabinet systems based on the ATC 5301 Standard v02

Describe the structure of the ATC 5301 Standard v02

Identify and write user needs for ATC Cabinet systems

Create a concept of operations for ATC Cabinets

Next Course Module

Module A322b

Understanding Requirements for Transportation Field Cabinet Systems Using ATC 5301 v02

The second module on ATC 5301 v02 will describe the assemblies, components and options for ATC Cabinets. It will demonstrate how to develop requirements for ATC Cabinets based on user needs identified in Module A322a. Module A322b will show how to create an agency ATC Cabinet specification and how to verify that it is complete.

Thank you for completing this module.

Feedback

Please use the Feedback link below to provide us with your thoughts and comments about the value of the training.

Thank you!