WELCOME

RITA Intelligent Transportation Systems
Joint Program Office

Welcome

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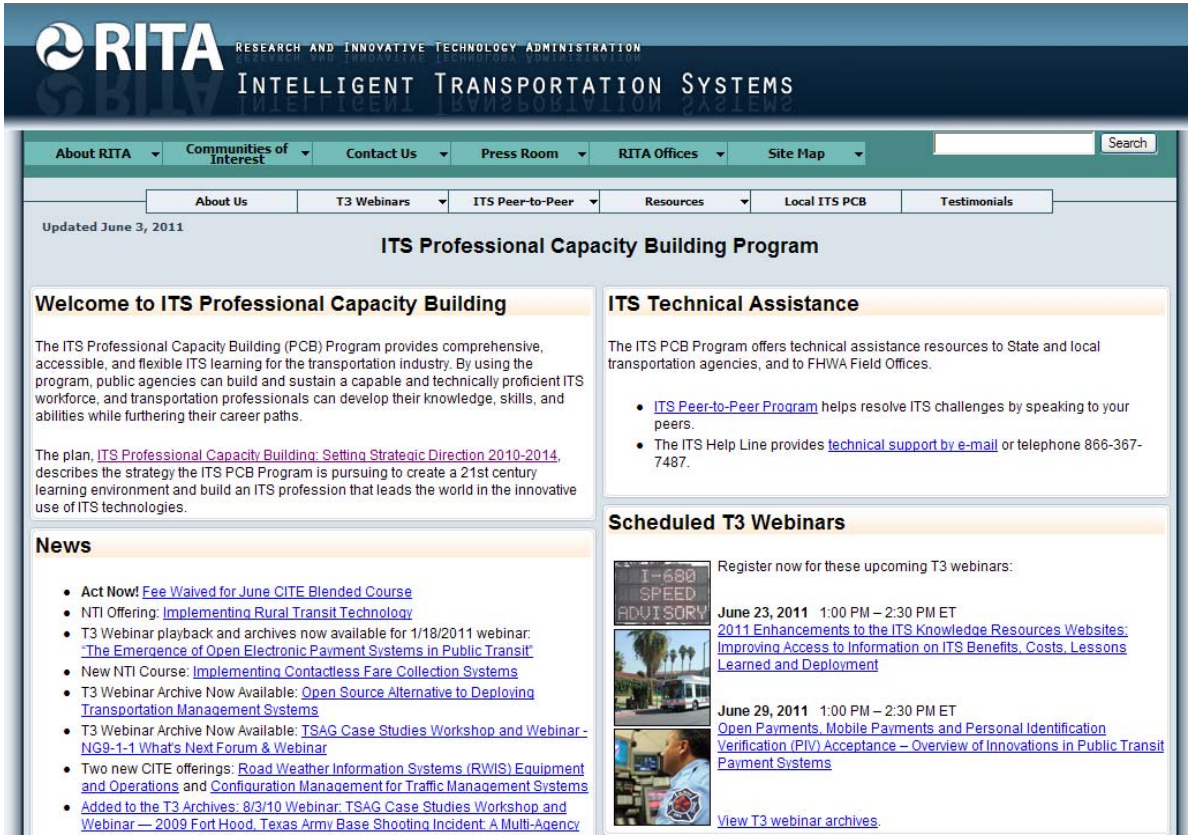

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A103
Introduction to ITS Standards Requirements Development

Target Audience

- Decision Makers
- Project Managers
- Operational Stakeholders

Instructor

Ralph W. Boaz

President

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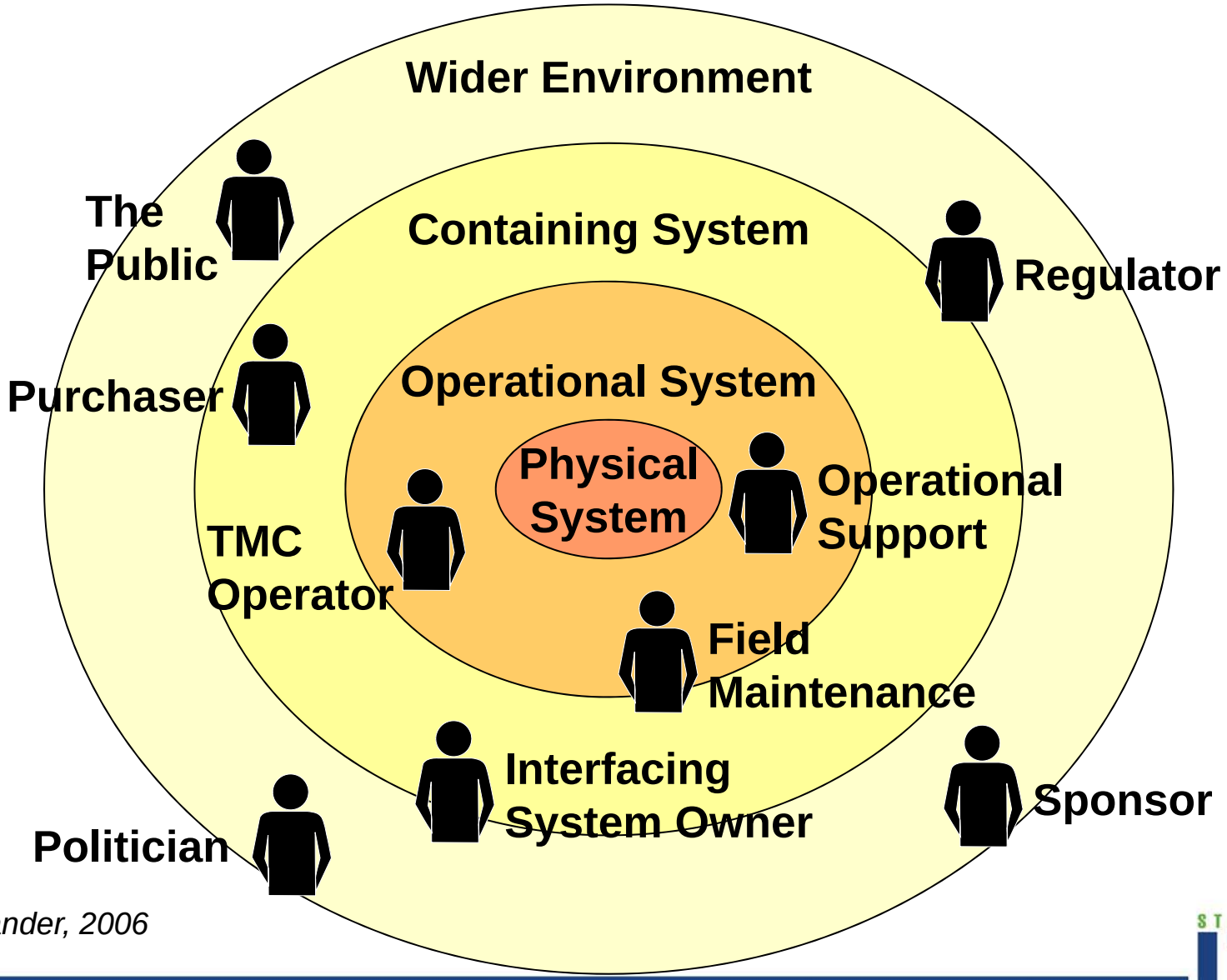
San Diego, CA, USA

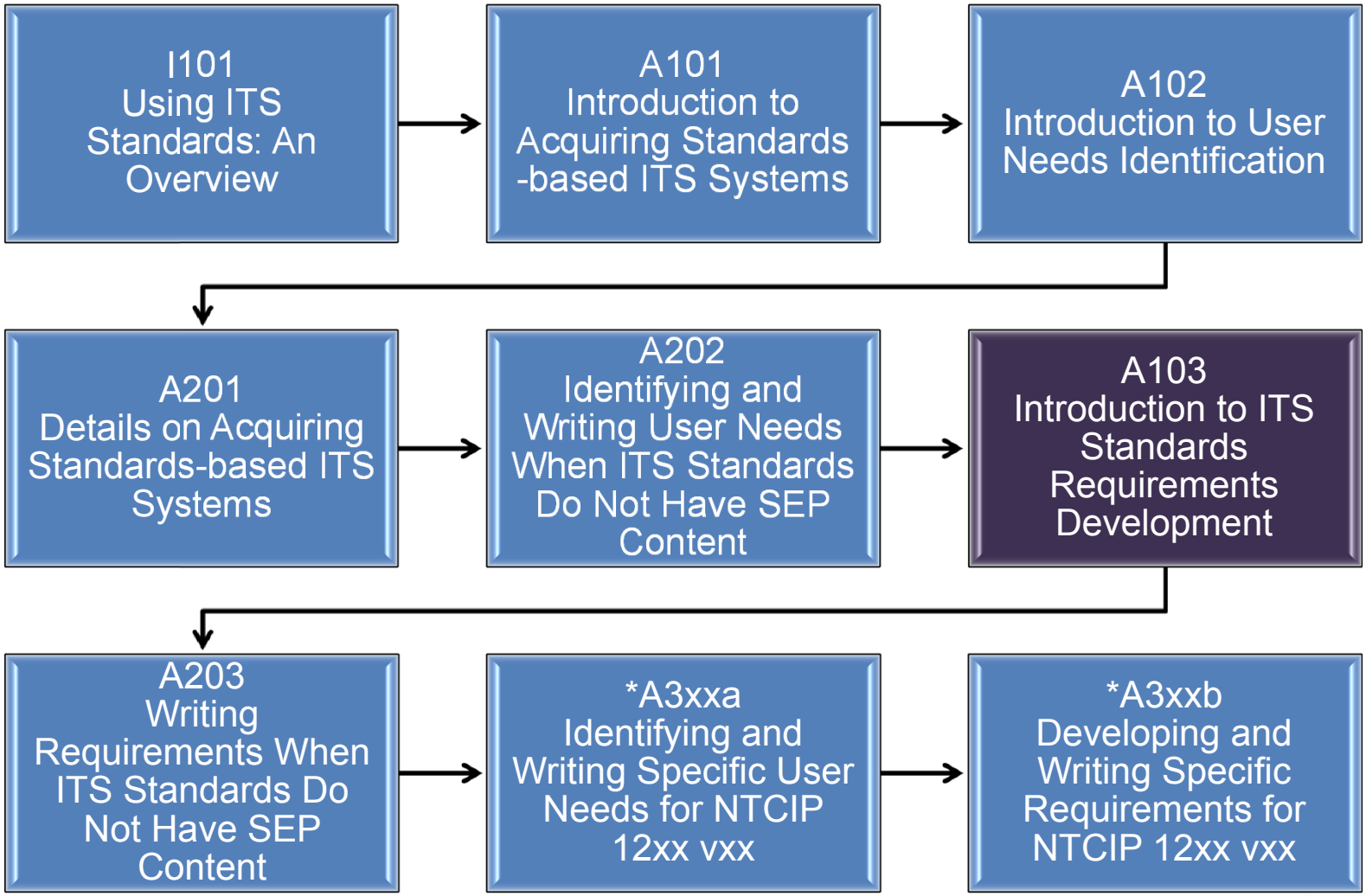
Who Are Stakeholders?

- ☑ TMC Operator, Field Maintenance, Operational Support (e.g. IT Dept.)
- ☑ Interfacing System Owner, Purchaser
- ☑ Sponsor of the Project
- ☑ Regulatory Agency (if there is one)
- ☑ Public, Politician

Stakeholders for a System



Curriculum Path (Non-SEP)



Recommended Prerequisites

- I101 Using ITS Standards: An Overview
- A101 Introduction to Acquiring Standards-based ITS Systems
- A102 Introduction to User Need Identification
- A201 Details on Acquiring Standards-based ITS Systems
- A202 Identifying and Writing User Needs When ITS Standards Do Not Have SEP Content

Prerequisites (cont.)

- Basic knowledge of the following areas is helpful:
  - Intelligent Transportation Systems (ITS)
  - Managing ITS deployment projects
  - Government procurement processes
  - Benefits of standards
  - Systems engineering process (SEP)

Learning Objectives

1. Define requirements for overall operation to satisfy user needs
2. Understand the concept of a well-formed requirement
3. Define the system and interfaces as a functional architecture

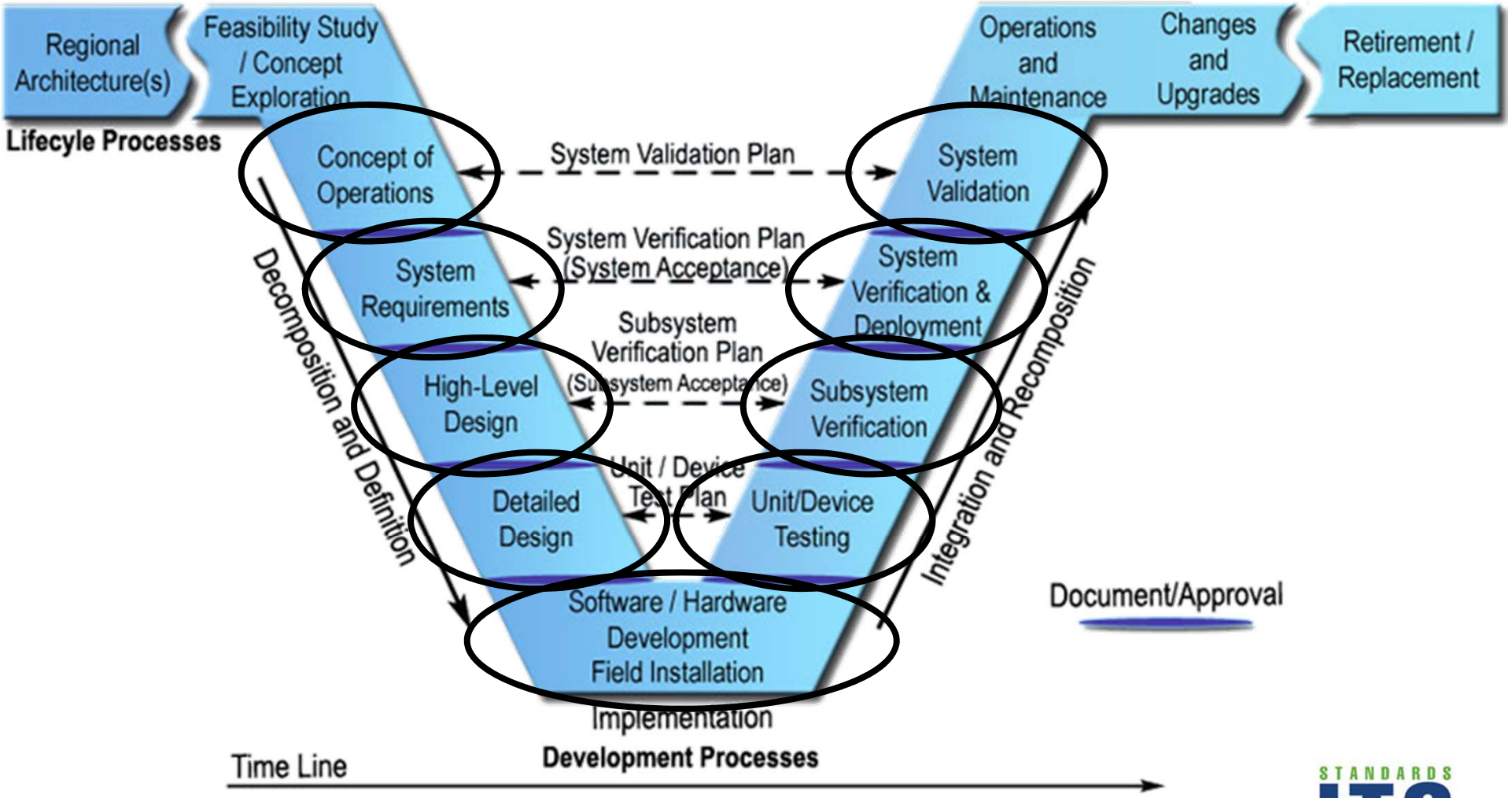
Learning Objectives (cont.)

4. Use decomposition of the architecture and requirements as necessary to properly define the system
5. Verify that requirements are complete and correct
6. Understand how requirements development applies to ITS communication standards

Defining Requirements For Overall Operation To Satisfy User Needs

- Review of the system's life cycle
- Review the concepts of operations and the definition of user needs
- Discuss the relationship of user needs to requirements
- Discuss the role of requirements in the system's life cycle

Review of the Systems Life Cycle



Components of a 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

Components of a Concept of Operations (cont.)

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

Characteristics of Well-Written User Needs

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

An Example User Need

4.3.1.11 Limit Audible Noise

The user needs the TFCS to have limited audible noise. TFCSs will be deployed in areas where residents are sensitive to ambient sound.

It is said that user needs identify the high-level ***WHAT*** of the system?

The Relationship of User Needs to Requirements

A Definition of a Requirement

A translation of needs into a set of individual quantified or descriptive specifications for the characteristics of an entity in order to enable its realization on examination.
[ISO/IEC Guide 25: 1990]

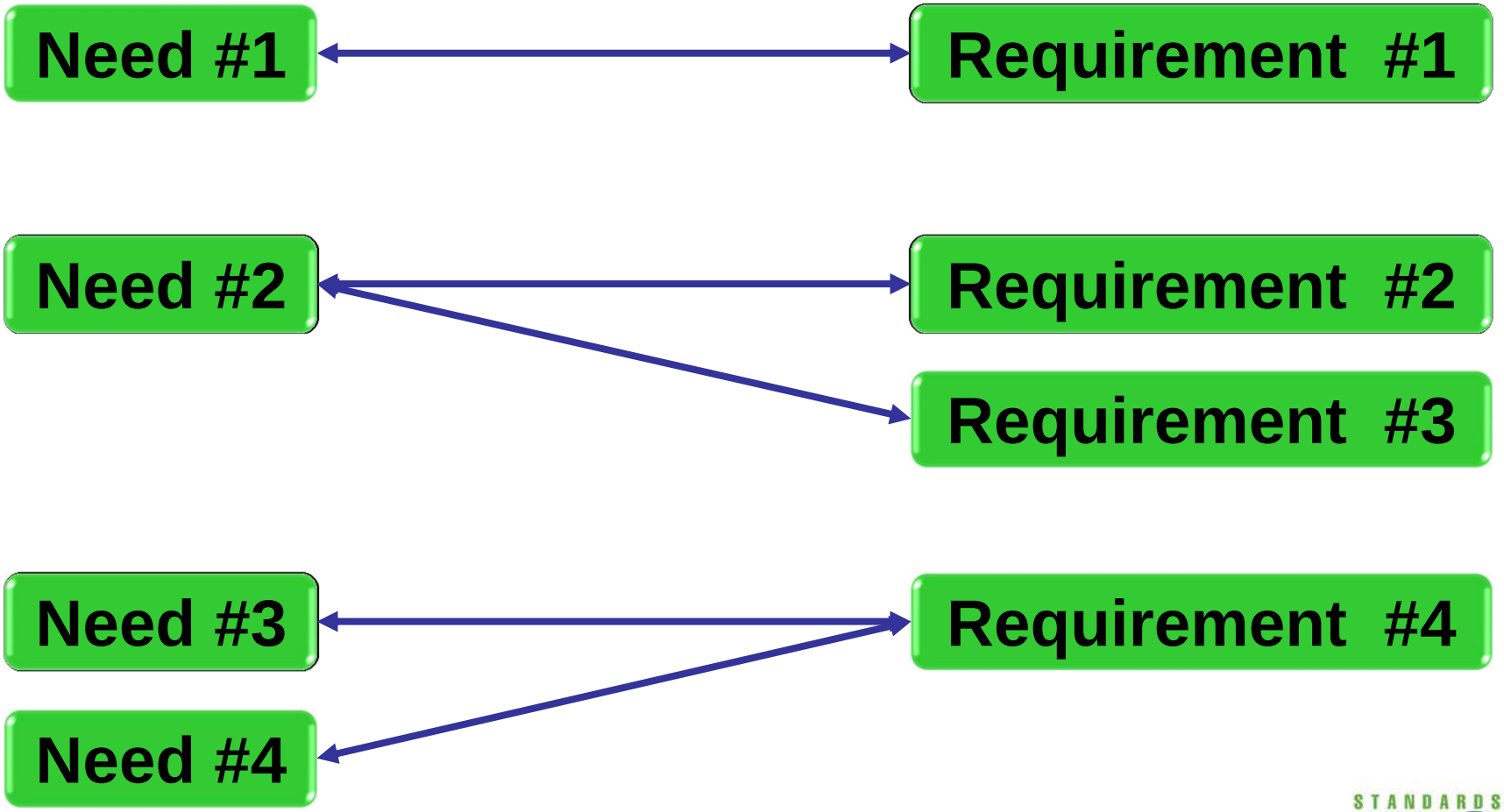
The Relationship of User Needs to Requirements

Requirement…

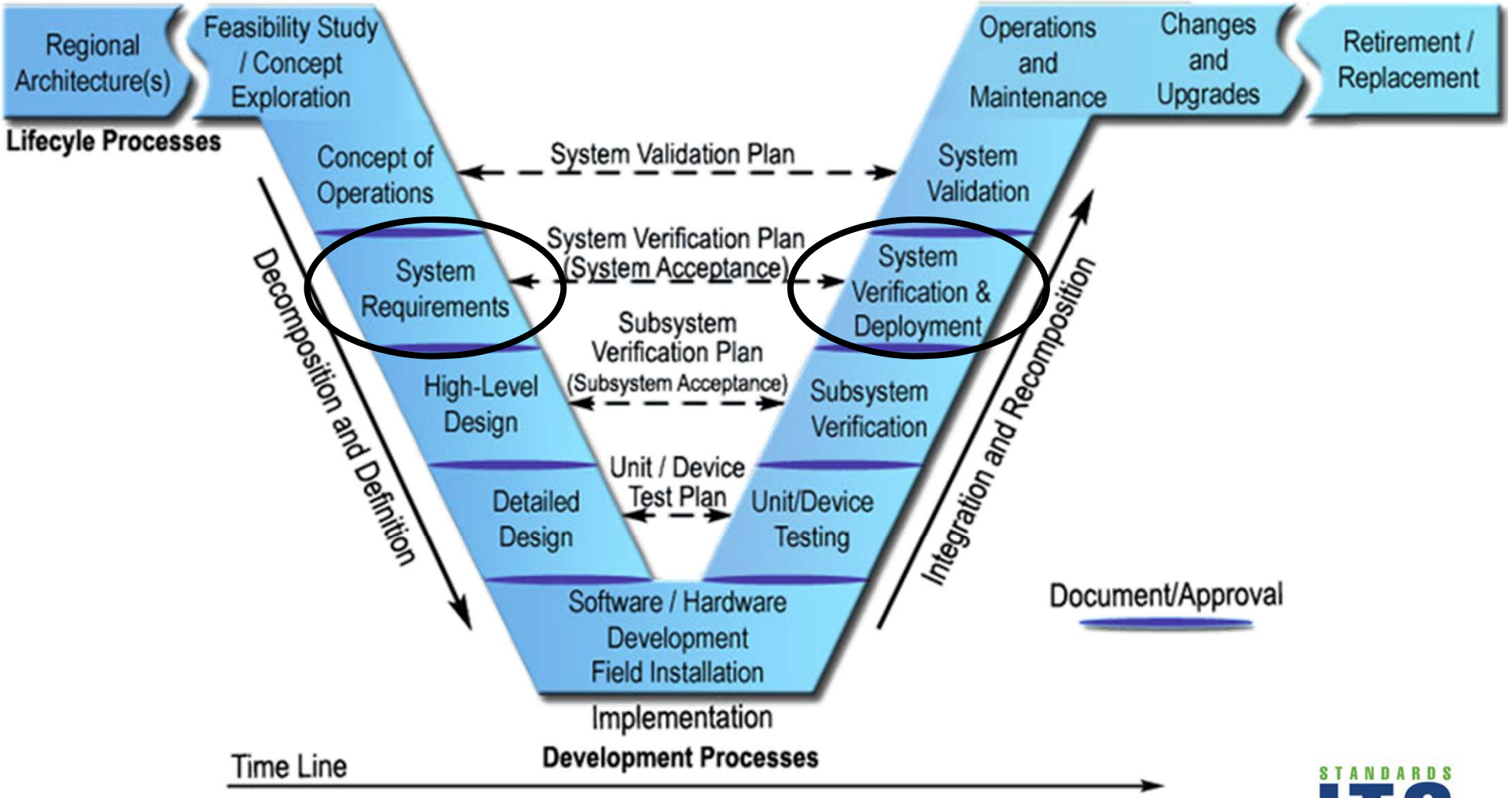
5.1.20 Audible Noise Level

The TFCS shall have no component that emits an audible noise level exceeding a peak level of 55 dBA when measured at a distance of one meter away from its surface.

The Relationship of User Needs to Requirements



Requirements in the Systems Life Cycle



Different Types of Requirements

- Functional Requirements
- Performance Requirements
- Non-Functional Requirements
- Architectural Constraints (or Constraints)

The Concept of a Well-Formed Requirement

- The structure of well-formed requirements
- The characteristics of a well-formed requirement

Structure of Well Formed Requirements

[Actor] [Action] [Target] [Constraint] [Localization]

Actor	Identifies who or what that does the action
Action	Identifies what is to happen
Target	Identifies who or what receives the action
Constraint	Identifies how to measure success or failure of the requirement
Localization	Identifies the circumstances under which the requirement applies

Localization and constraint portions are important but not all requirements will have both

Structure of Well-Formed Requirements

[Actor] [Action] [Target] [Constraint] [Localization]

Example:

The system [Actor] shall generate [Action] event reports [Target] containing the following information [Constraint] on a scheduled interval [localization]

If a requirement can't be stated in this simple format, you probably need to define the functionality using multiple requirements.

Characteristics of a Well-Formed Requirement

- Necessary
  - Must be useful and traceable to needs
- Concise
  - Minimal, understandable and expressed in a declarative language (e.g. “shall statements”)
- Attainable
  - Realistic to achieve within available resources and time

Characteristics of a Well-Formed Requirement (cont.)

- Standalone
  - Stated completely in one place
- Consistent
  - Does not contradict itself, nor any other stated requirement
- Unambiguous
  - Susceptible to only one interpretation

Characteristics of a Well-Formed Requirement (cont.)

- Verifiable
  - Requirement can be met through inspection, analysis, demonstration, or test

An Example Requirement

5.1.20 Audible Noise Level

The TFCS shall have no component that emits an audible noise level exceeding a peak level of 55 dBA when measured at a distance of one meter away from its surface.

It is said that requirements define the *detailed* ***WHAT*** of the system.

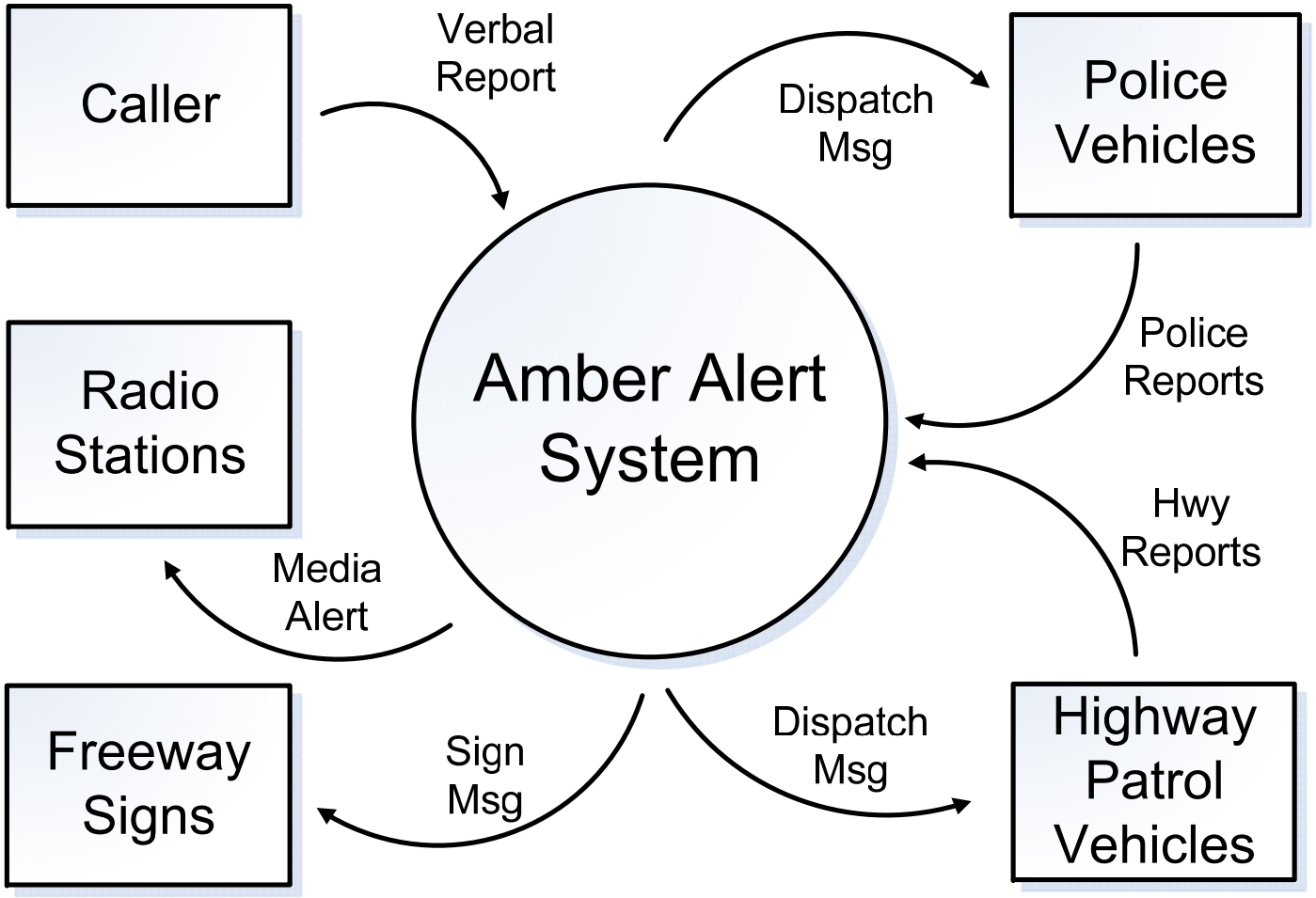
Defining the System and Interfaces as a Functional Architecture

- Context Diagrams
- Functional Architecture

Context Diagrams

- Show the system specified with a boundary that defines the external interfaces
- Often the most difficult and critical task for a project
  - Requires skill and creativity to explore alternative possibilities
  - All later work on the project is affected by the choice

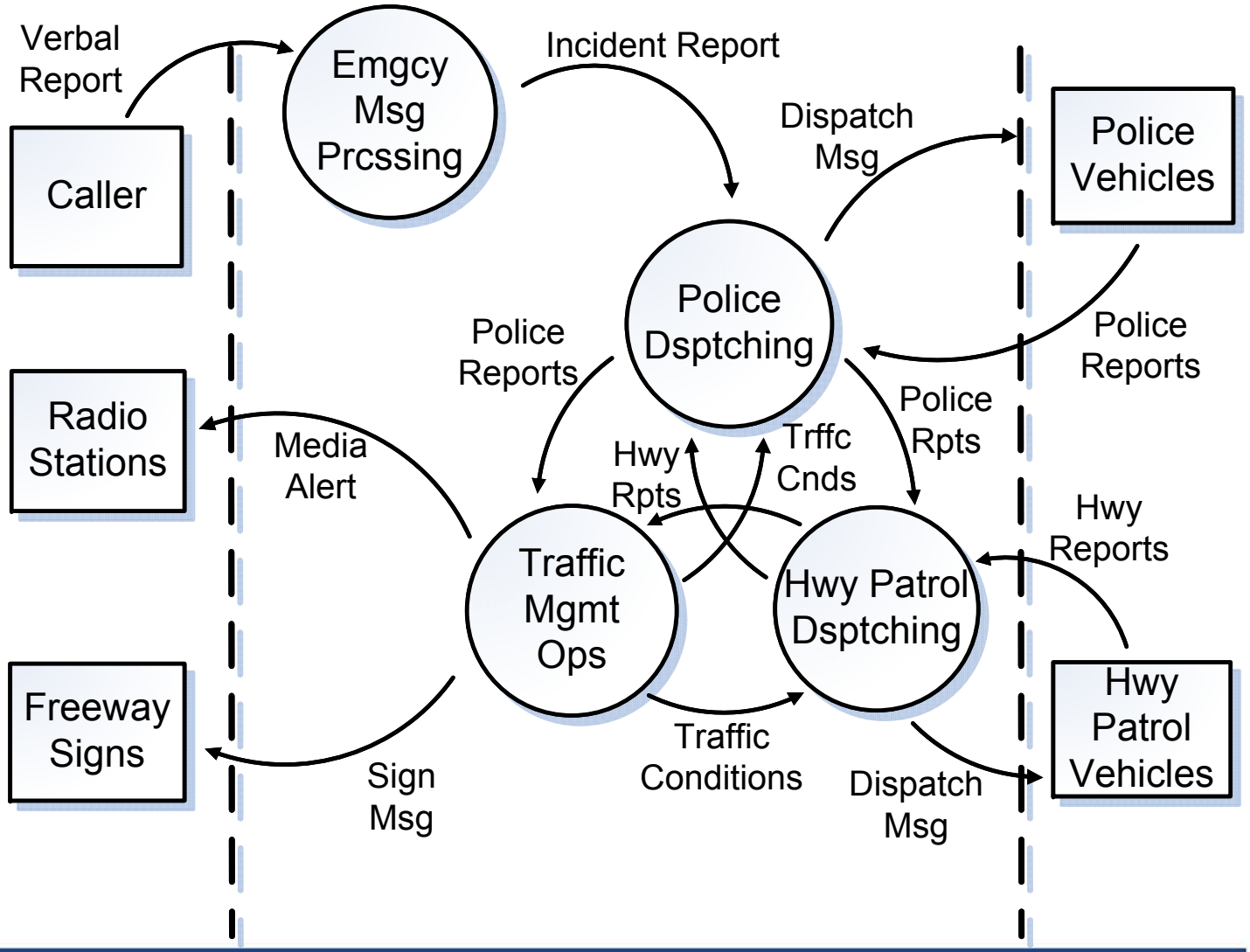
Amber Alert System Context Diagram



Functional Architecture

- Describes functions within a system and the data into and out of the functions
  - Parts are sometimes called “functional elements”
  - Not a design drawing
  - Describes the lines of communication and kinds of information to be conveyed (high-level only)
  - Structure for describing operations in terms of where the operations will be carried out

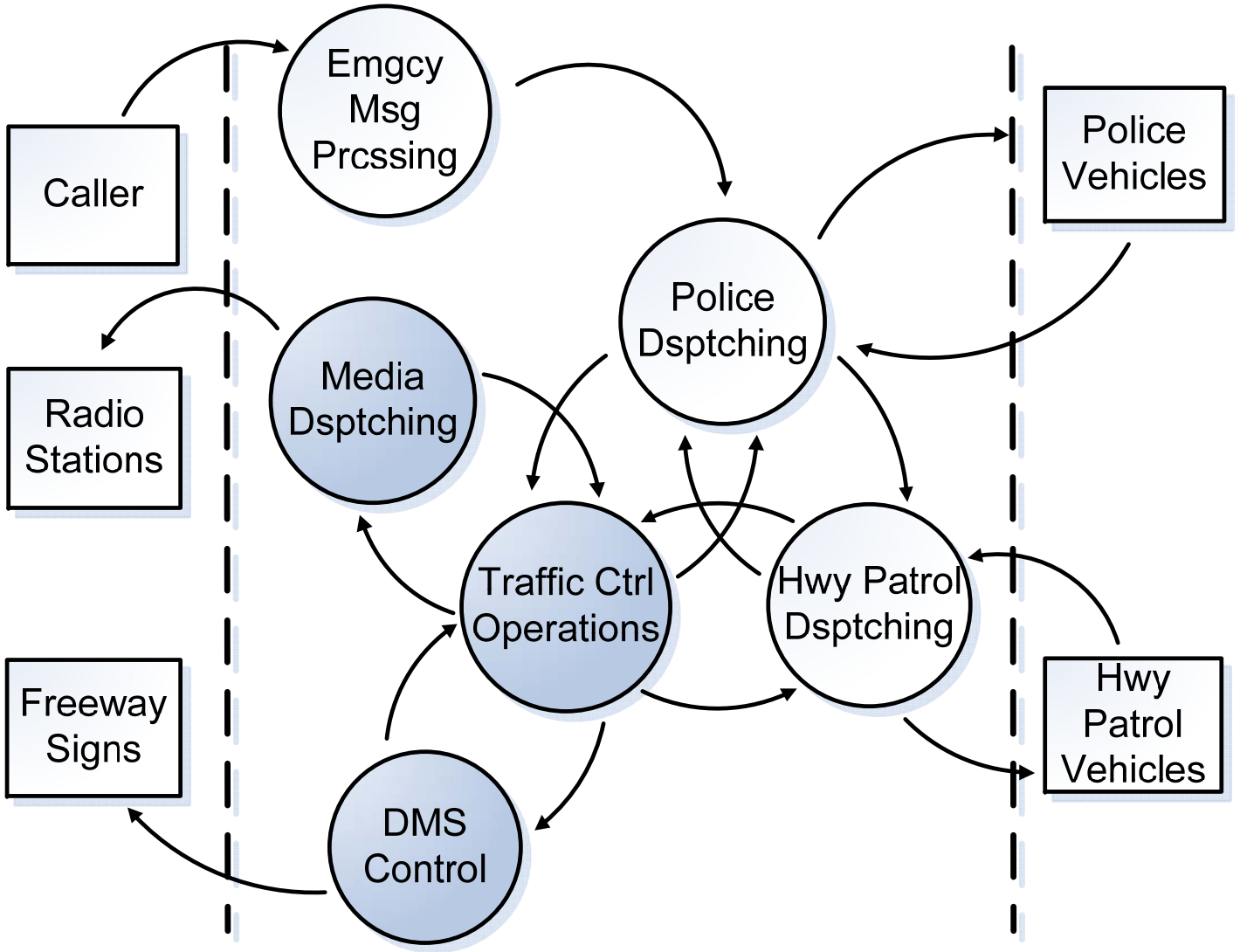
Amber Alert System Functional Architecture



Using Decomposition of Architecture and Requirements to Define the System

- Decomposition of the Architecture
- Decomposition of the Requirements

Decomposition of the Architecture



Decomposition of Requirements

A System Requirement for the Traffic Management Operations Functional Element

5.1.20 Public Notice of Amber Alerts
Traffic Management Operations shall notify the public of an Amber Alert.

Decomposition of Requirements

Requirements for the Subsystems of the Traffic Management Operations Functional Element

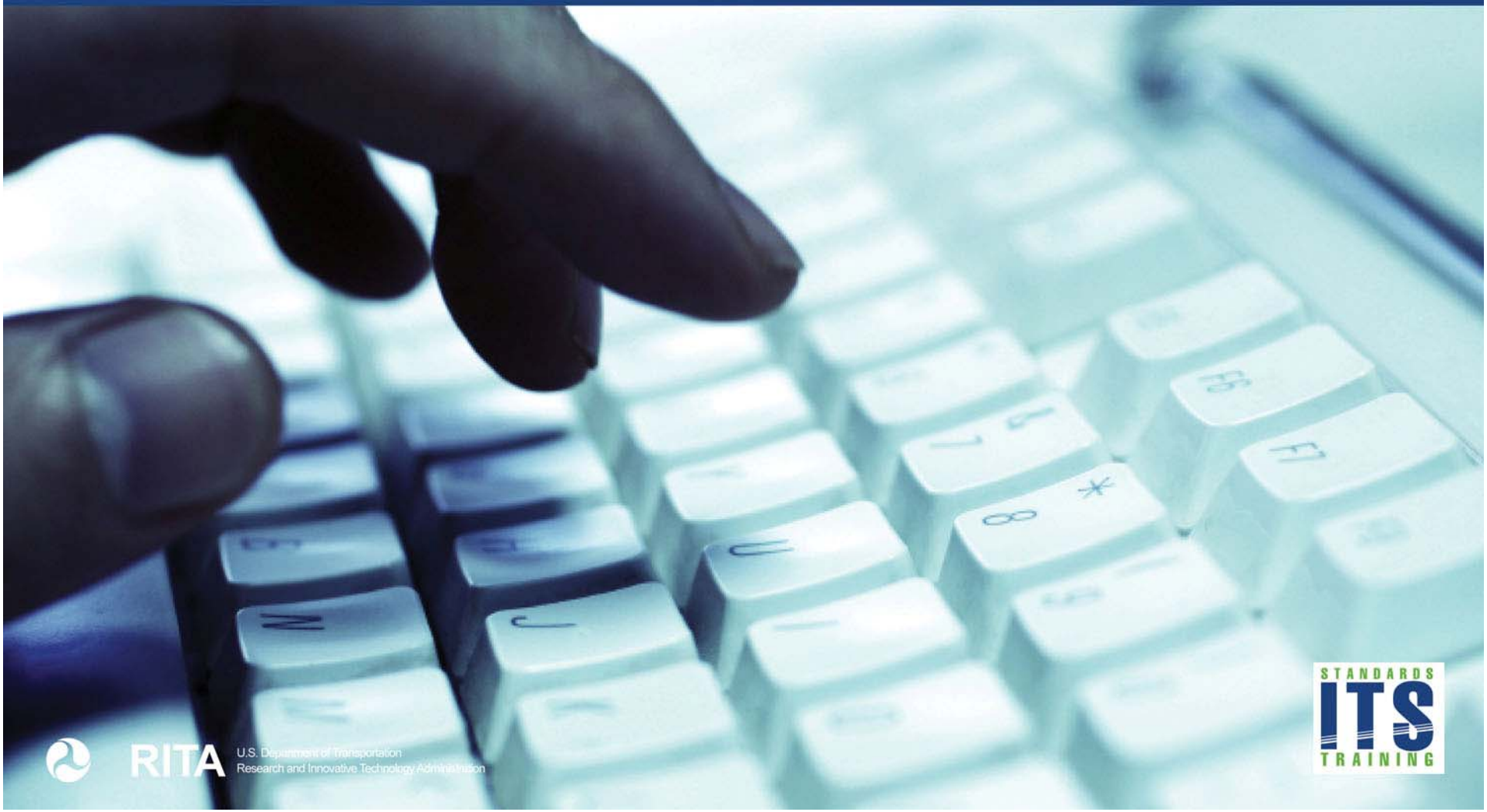
5.1.20.1 Send Amber Alert to Media Dispatch Traffic Control Operations shall send an Amber Alert notification to Media Dispatching.

5.1.20.2 Send Amber Alert to DMS Control Media Dispatching shall send an Amber Alert notification to Radio Stations.

Verifying That Requirements Are Complete and Correct

- Correctness
- Completeness
- Using Traceability

ACTIVITY



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Verifying Requirements Are Correct

5.1.21.6 Acknowledge Alert

Traffic Control Operations shall acknowledge the receipt of an Amber Alert notification.

[Actor] [Action] [Target] [Constraint] [Localization]

Is it well-formed? Necessary? Concise?
Attainable? Standalone? Consistent?
Unambiguous? Verifiable?

Validating Requirements Are Complete

- Are the requirements logically consistent with parent requirements and user needs?
- Are the requirements consistent with sibling requirements?
- Is there traceability between the needs and requirements?

Need-to-Requirement Logical Consistency

What is inconsistent about this need and requirement?

[Need]

4.3.1.9 Extreme Temperatures and Humidity
The user needs the TFCS to operate under extreme hot, cold and humid environmental conditions.

[Requirement]

5.1.25 Ambient Temperature Range
The TFCS shall be capable of withstanding an ambient storage temperature range of -45 degrees Celsius to +85 degrees Celsius.

Requirement Consistency

What is inconsistent in these requirements?

5.4.3 120 VAC Switch Pack Modules

The output assembly shall accept switch pack modules suitable for controlling field displays that operate at nominal 120 VAC 60Hz.

5.4.4 Low Voltage Load Switch Packs

The output assembly shall accept switch packs suitable for controlling field displays that operate at 48 VDC (+/- 2.0 VDC).

Using Traceability

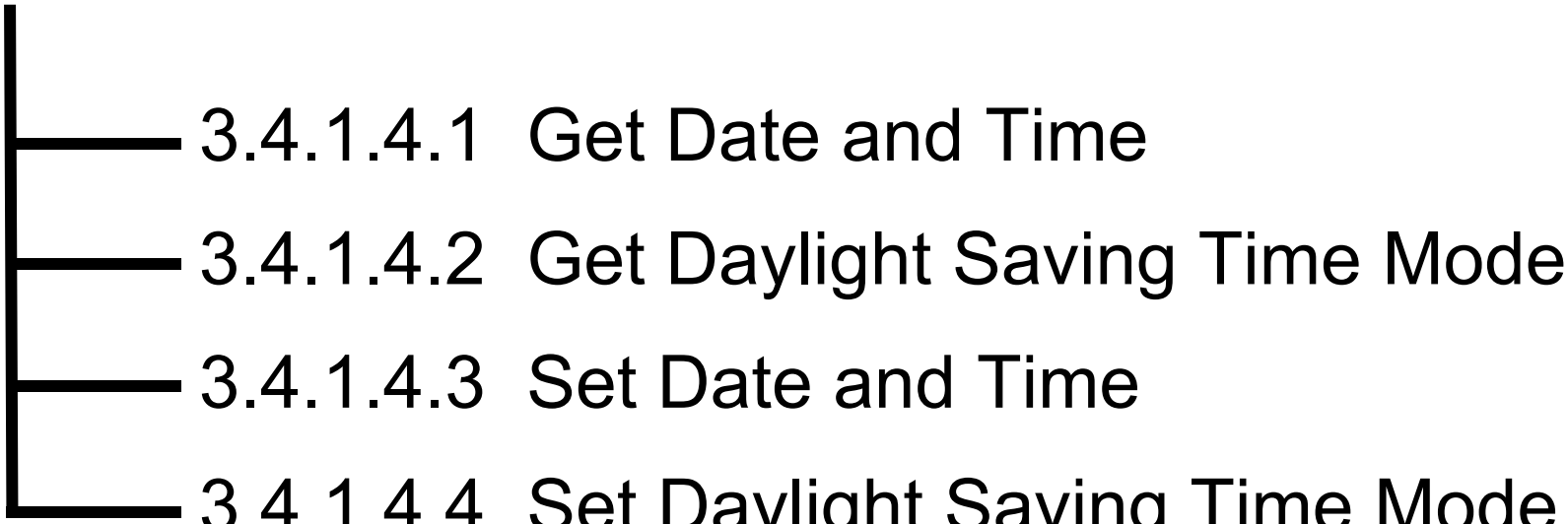
- A tool used to help verify completeness and correctness
- Every need must be addressed by at least one requirement
- Every requirement must trace to at least one need
- Any need that is not addressed by at least one requirement means:
  - A requirement was missed, or
  - The user need must be reevaluated

Using Traceability (cont.)

- Every requirement that does not address at least one need means:
  - The requirement must be reevaluated, or
  - A user need was missed
- Every aspect of each user need should be addressed in requirements

Using Traceability Graphical Representation

2.5.2.6 Manage the Real-Time Clock



Using Traceability Needs-to-Requirements Traceability Matrix (NRTM)

User Need ID	User Need	Req ID	Requirement
2.5.2.6	Manage Real-Time Clock	3.4.1.4.1	Get Date and Time
		3.4.1.4.2	Get Daylight Saving Time Mode
		3.4.1.4.3	Set Date and Time
		3.4.1.4.4	Set Daylight Saving Time Mode

Using Traceability
Example One-to-Many Relationship

2.5.2.6 Manage the Real-Time Clock

This user needs the management station to configure a Real-Time Clock on the TSS for the purpose of providing timestamps on sample data. *Accurate timing stamps across the system are critical to all data collection and sampling activities of the TSS. The clock should be able to support Daylight Saving Time adjustments so that local time stays consistent.*

Using Traceability Example One-to-Many Relationship (cont.)

3.4.1.4.1 Get Date and Time

The TSS shall allow a management station to get the current sensor system date and time.

3.4.1.4.2 Get Daylight Saving Time Mode

The TSS shall allow a management station to get the current daylight saving time mode.

Using Traceability Example One-to-Many Relationship (cont.)

3.4.1.4.3 Set Date and Time

The TSS shall allow a management station to set the sensor system date and time to within one second of receiving the command.

3.4.1.4.4 Set Daylight Saving Time Mode

The TSS shall allow a management station to set the daylight saving time mode.

Traceability Beyond Requirements

- Traceability can extend beyond user needs and requirements to:
  - Design
  - Testing
  - System Acceptance & Validation
  - Procurements

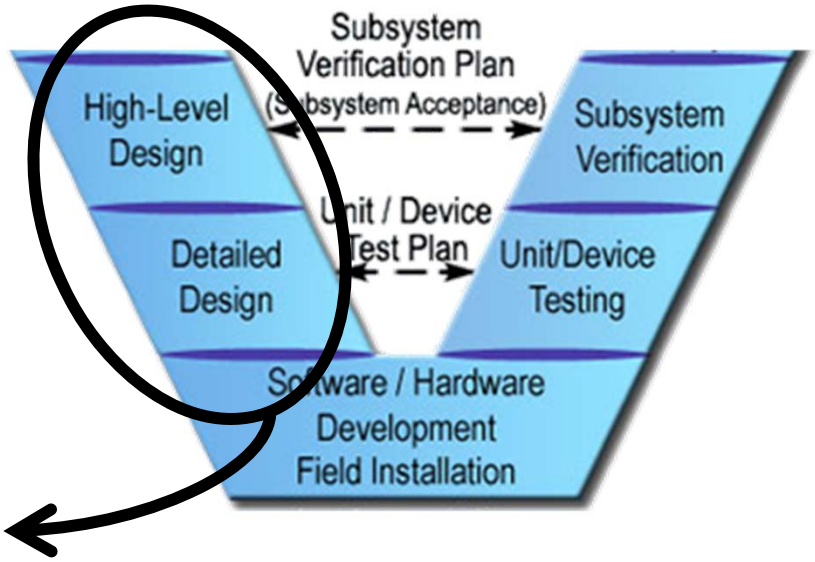
Applying What We Learned to ITS Communications Standards

- Systems Engineering Process (SEP) Applied to ITS Communications Standards
- Other Modules

Systems Engineering Process Applied to ITS Communications Standards

- Use of standards usually starts in the design phases of the system
- Typically considered a part of subsystems development
- An SEP is being applied to standard's development and to standard's content

Systems Engineering Process Applied to ITS Communications Standards



Contents of ITS Center-To-Field Communication Standards *With* SEP Content

- General
- Concept of Operations (ConOps)
- Functional Requirements
- Design Details
  - Dialogs and Interface Specifications
  - Object Definitions (MIB)
- Annexes
  - Requirements Traceability Matrix
  - Test Procedures
  - Documentation of Revisions

Example Requirements Traceability Matrix (RTM)

Req ID	Req	Dialog ID	Dialog	Object ID	Object
3.4.1.2.8	Determine Maximum Number of Classes				
		4.3.3.1	Retrieve Sensor Zone Sequence Parameters		
				5.2.4	maxSensorZones
				5.4.3.1	numSampleDataEntries
				5.4.3.2	numSensorZoneClass

PCB Modules on Standards *With* SEP Content

- Dynamic Message Signs
  - A311A Understanding User Needs for DMS Systems Based on NTCIP 1203 Standard
  - A311B Specifying Requirements for DMS Systems Based on NTCIP 1203 Standard
- Environmental Sensor Systems
  - A313A Understanding User Needs for ESS Systems Based on NTCIP 1204 V03 Standard
  - A313B Specifying Requirements for ESS Systems Based on NTCIP 1204 V03 Standard

PCB Modules on Standards *With* SEP Content (cont.)

- Traffic Management Data Dictionary
  - A321A Understanding User Needs for Traffic Management Systems Based on TMDD v03 Standard
  - A321B Specifying Requirements for Traffic Management Systems Based on TMDD v03 Standard

Contents of ITS Center-To-Field Communication Standards *Without* SEP Content

- Overview
- General Information
- Object Definitions (MIB)
- Conformance Groups
- Conformance Statement

A203 Module on Writing Requirements for ITS Standards *Without* SEP Content

The participant will learn to:

- Review key concepts from previous modules
- Understand what is needed before attempting to write requirements
- Write requirements when an ITS communication standard does not have SEP content

What did we Learn Today?

1) To define requirements for overall operation to satisfy ***USER NEEDS***

2) The concept of a ***WELL FORMED*** requirement

3) To define the system and interfaces as a ***FUNCTIONAL*** architecture

4) To use ***DECOMPOSITION*** of the architecture and requirements as necessary to properly define the system

5) To verify that requirements are ***COMPLETE*** and ***CORRECT***

6) How requirements development ***APPLIES*** to ITS communication standards

Sources for More Information

Alexander, Ian and Ljerka Beus-Dukic. Discovering Requirements. Wiley, 2009

FHWA Systems Engineering Guidebook for Intelligent Transportation Systems Version 3.0

IEEE 1233-1998 IEEE Guide for Developing System Requirements Specifications

IEEE 830-1998 Recommended Practice for Software Requirements Specifications

INCOSE Systems Engineering Handbook v3.2

NTCIP Guide, TMDD Guide, IEEE 1512 Guide

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QUESTIONS?

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