STANDARDS ITS TRAINING

WELCOME

U.S. Department of Transportation

Office of the Assistant Secretary for Research and Technology

Mac Lister

Program Manager Knowledge and Technology Transfer
ITS Joint Program Office
Mac.Lister@dot.gov

www.pcb.its.dot.gov

Jeffrey Spencer

ITS Team Leader
Federal Transit Administration
Office of Research, Demonstration and Innovation
Jeffrey.Spencer@dot.gov

www.pcb.its.dot.gov

Federal Transit Administration

STANDARDS ITS TRAINING

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

ITS Transit Standards Professional Capacity Building Program

Module 5: Transit Management Standards, Part 2 of 2

ACTIVITY

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

Instructor

Carol L. Schweiger

President

Schweiger Consulting LLC

Wakefield, MA

Target Audience

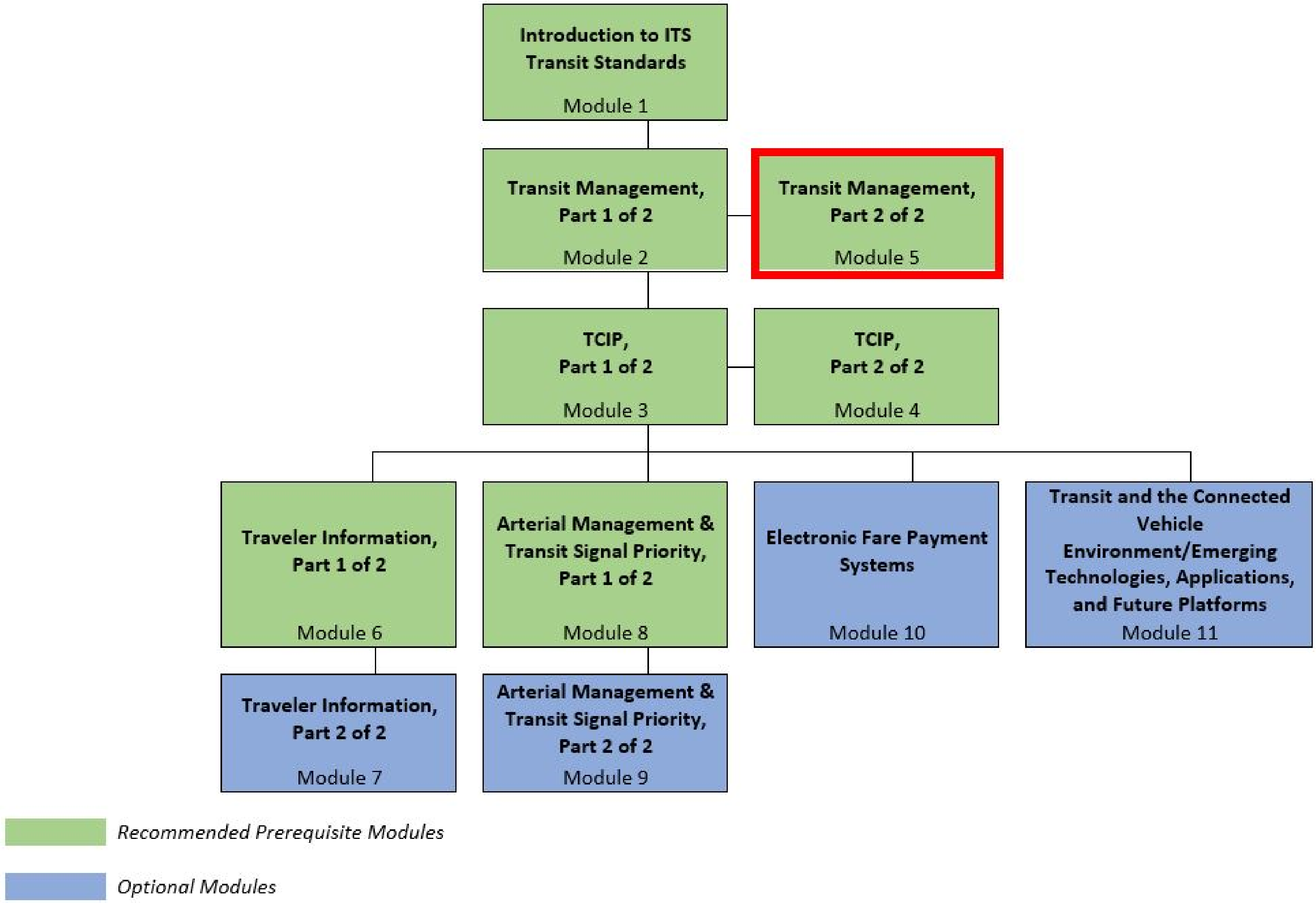
- Transit agency technical staff in planning, operations, maintenance, and information technology
- Technology vendors and consultants
- Transit agency procurement and grants staff (optional)

Recommended Prerequisite(s)

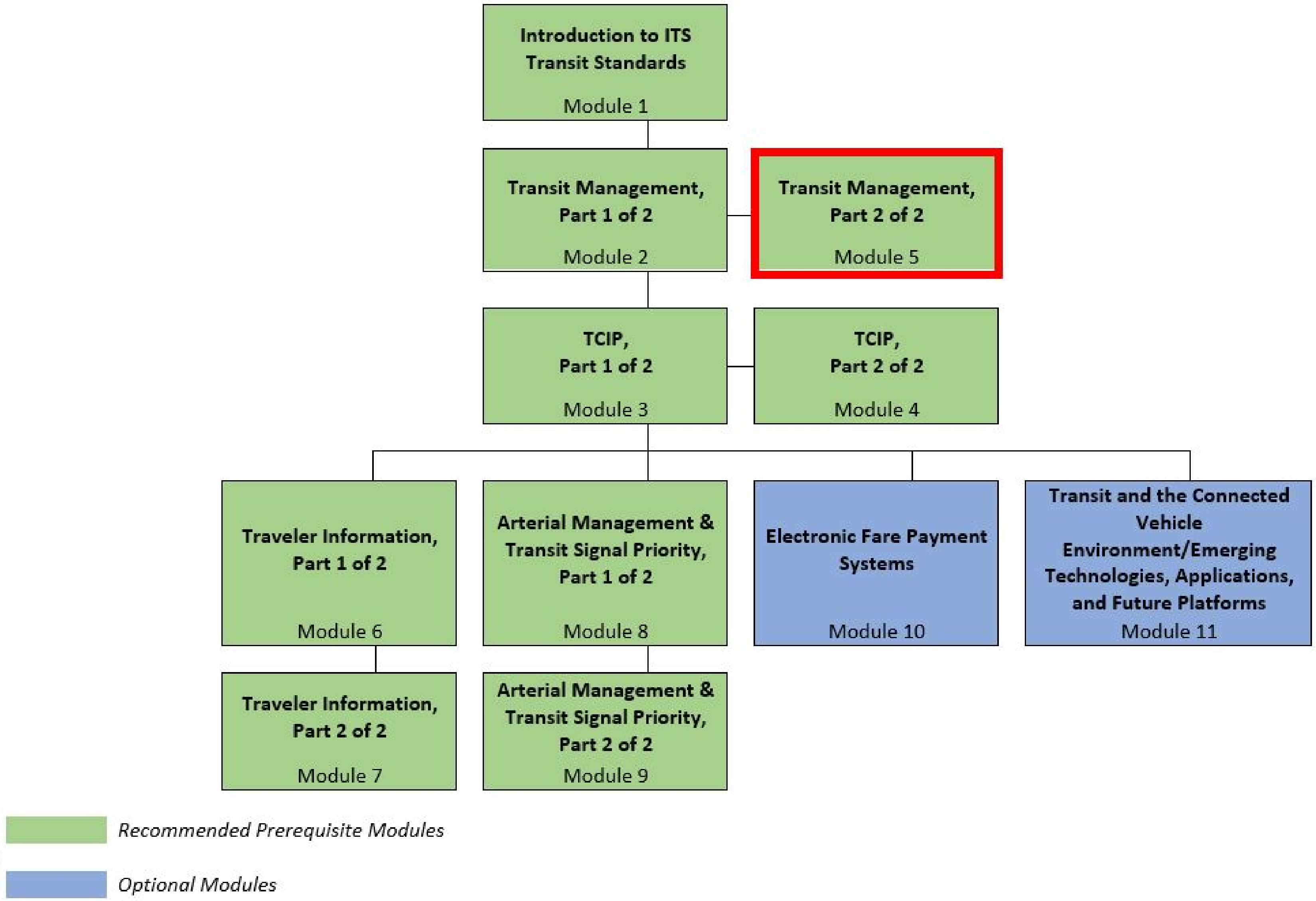
	Decision-Maker	Project Manager	Project Engineer
Module 1: Introduction to ITS Transit Standards	N/A	✔	✔
Module 2: Transit Management Standards, Part 1 of 2	N/A	✔	✔

- Recommend prior knowledge includes:
  - Basic understanding of transit-related portions (e.g., Service Packages) of the National ITS Architecture
  - Basic knowledge of systems engineering, which can be found in the National Transit Institute (NTI) course on Systems Engineering for Transit ITS Projects

Curriculum Path (Project Manager)



Curriculum Path (Project Engineer)



Learning Objectives

1. Summarize key concepts from Transit Management Standards, Part 1 of 2.
2. Illustrate the structure and use of data exchange standards for Transit Management systems.
3. Select appropriate ITS standards for data exchange among Transit Management systems, and between Transit Management systems and Traveler Information, Fare Collection, and other systems (e.g., Traffic Management systems).
4. Illustrate how to apply standards to the development of procurement specifications.

Learning Objective #1: Summarize Key Concepts from Transit Management Standards, Part 1 of 2

- Transit Management taxonomy and technologies
- Relationships and information exchanges among Transit Management technologies
- Using systems engineering (SE)
- National ITS Architecture Service Packages related to Transit Management

Fleet Operations and Management

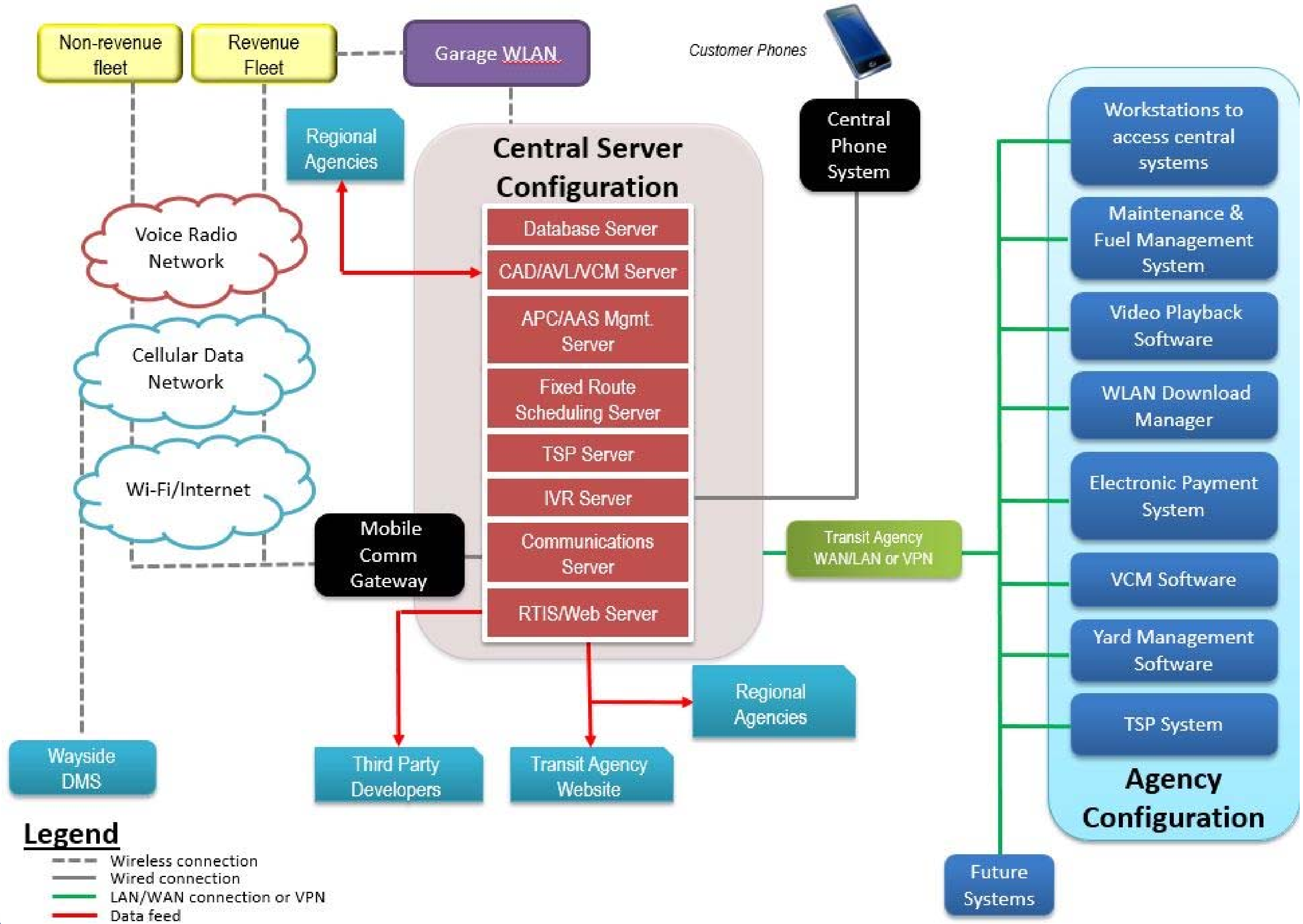
Category	System/Technology	Dependent on
Fleet Operations and Management	Communications technologies	Public/private voice and data communication backbones
	Computer-aided dispatch (CAD)	• Voice and data communications technologies • Automatic vehicle location (AVL) system • Route and vehicle schedule data
	Automatic vehicle location (AVL)	• Data communications technologies • Global positioning system (GPS) or other location enabling technologies, such as Wi-Fi
	Automatic passenger counters (APCs)	• AVL system • Route and vehicle schedule data
	Scheduling (fixed-route and paratransit) systems	Stop database (contains data such as stop name, location, routes that stop at this stop, direction of travel from this stop, list of amenities available at this stop)

Fleet Operations and Management (cont.)

Category	System/Technology	Dependent on
Fleet Operations and Management	Transfer connection protection (TCP)	• AVL system • CAD system
	Transit signal priority (TSP)	• AVL system • CAD system (when TSP used based on schedule adherence status) • Roadside signal infrastructure
	Yard management	Indoor positioning systems (e.g., radio frequency identification [RFID]-based, Wi-Fi-based)
	Intelligent vehicle technologies (e.g., collision warning and precision docking)	Varies by technology application and deployment
	Lane control technologies	• AVL system • CAD • Virtual mirror • Lane guidance systems • Roadside signal infrastructure

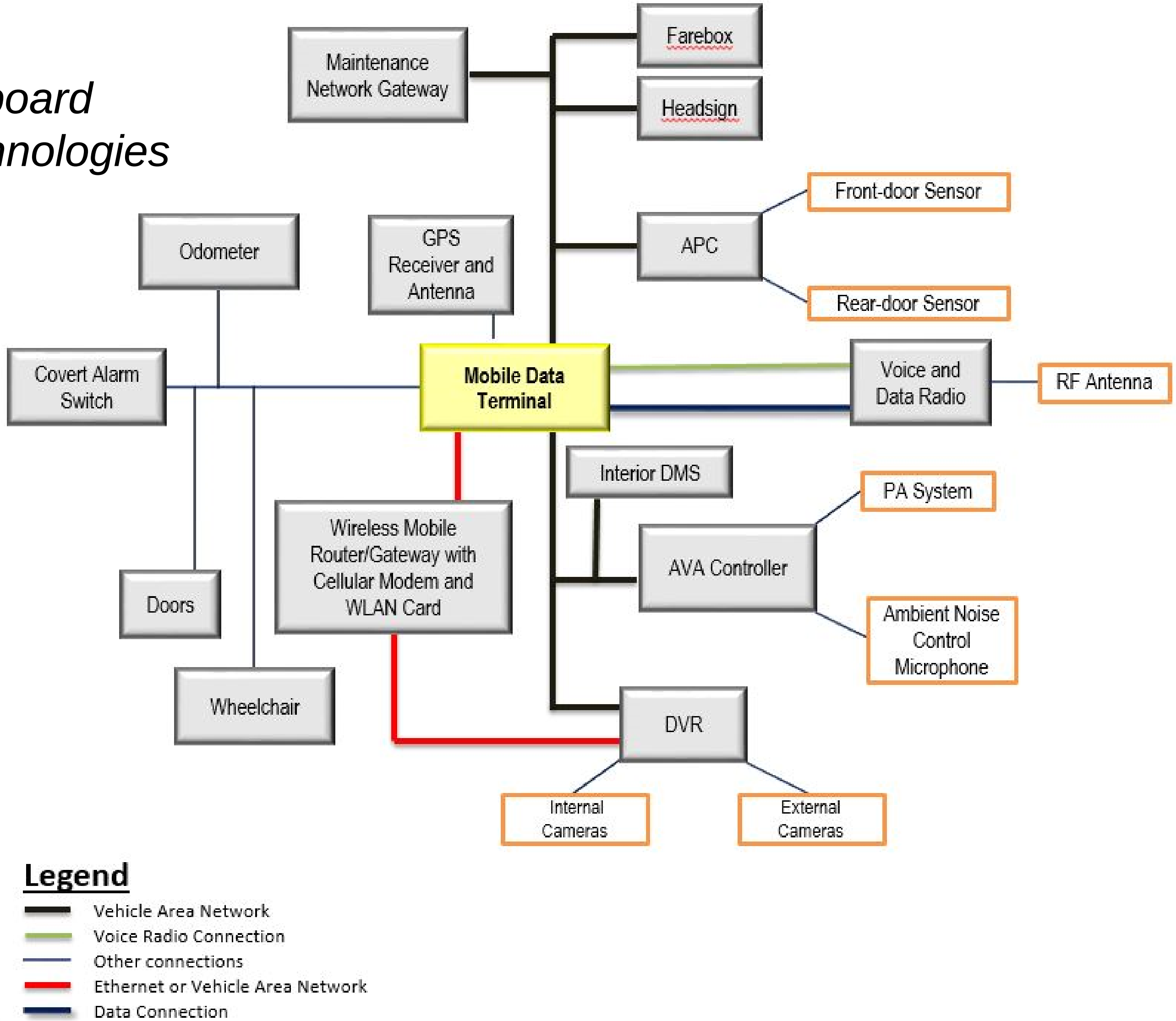
Example of Central System Technology Relationships

Main Point: *Shows the relationships among central Transit Management and other transit ITS technologies.*



Example of On-board Technology Relationships

Main Point: *Shows the relationships among on-board Transit Management technologies*



Safety and Security

Category	System/Technology	Dependent on
Safety and Security	Fixed video surveillance	Data communications technologies
	Covert emergency alarm and covert live audio monitoring	• Voice and data communication technologies • CAD system • AVL system
	On-board digital video surveillance	No dependence on other systems
	G-force monitoring	AVL system

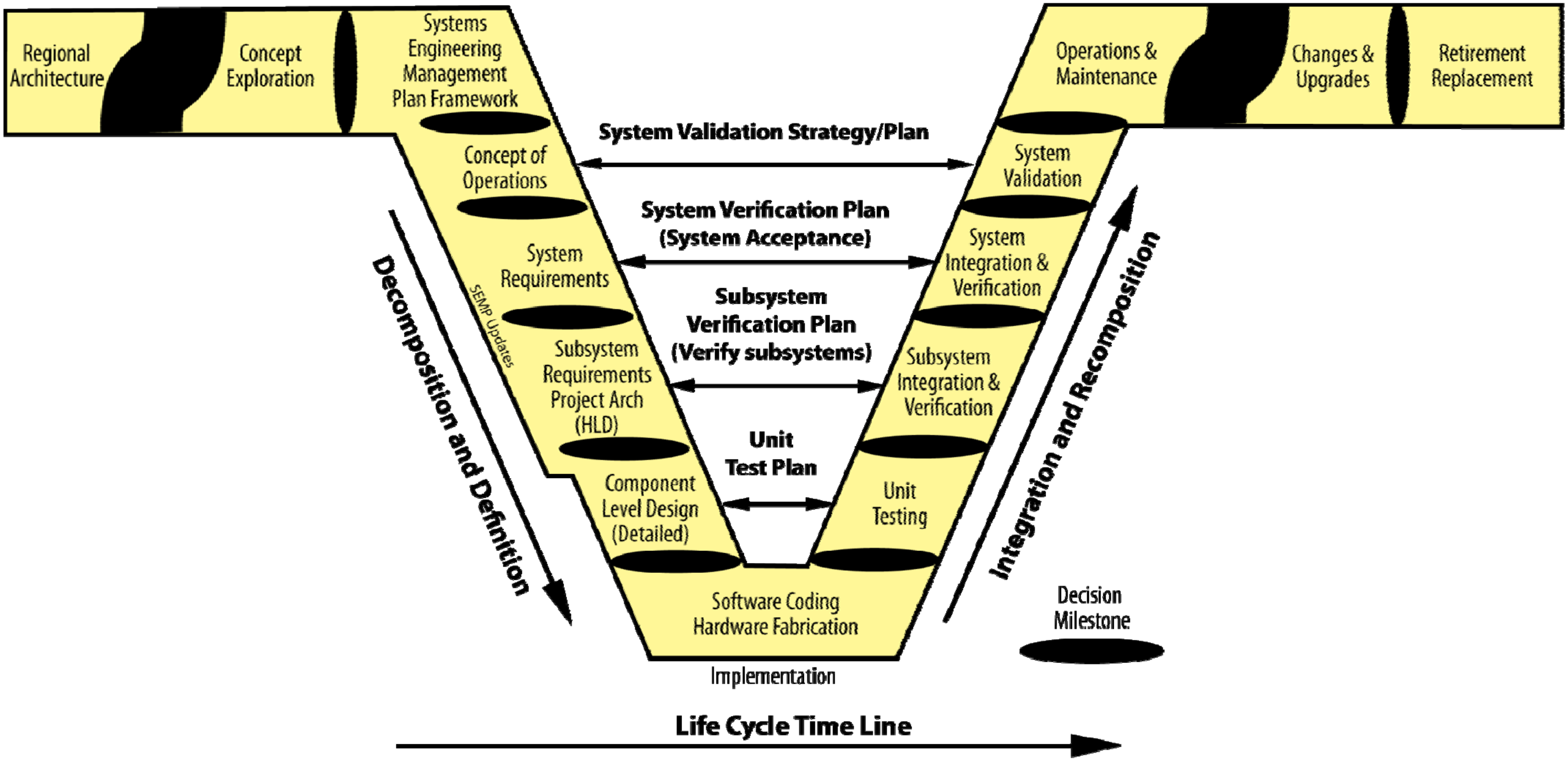
Maintenance

Category	System/Technology	Dependent on
Maintenance	Engine and drivetrain systems monitoring	OBD-II or Society of Automotive Engineers (SAE) J1708/J1939 compatibility of on-board computers within engine and drivetrain
	Maintenance software to schedule and track scheduled and unscheduled maintenance activities, and manage parts inventory	No dependence on other systems
	Fuel Management System	No dependence on other systems

Data Management

Category	System/Technology	Dependent on
Other	Enterprise database/ datawarehouse and reporting	• Open databases • Data dictionary
	Technology integration	Multiple dependencies
	Geographic information system (GIS) application	Spatial data recording and management systems
	Service coordination facilitated by technology	• CAD/AVL systems shared across participants • Voice and data communications technologies
	Open data for third-party application development	Standard format for data such as General Transit Feed Specification (GTFS) and GTFS-realtime

What Is the "Vee" Model



Service Packages (SPs)

- Represent slices of physical architecture
- Collect subsystems, equipment packages and architecture flows that provide desired service
- There are 11 public transportation SPs:
  - Transit Vehicle Tracking
  - Transit Fixed-Route Operations
  - Demand Response Transit Operations
  - Transit Fare Collection Management
  - Transit Security

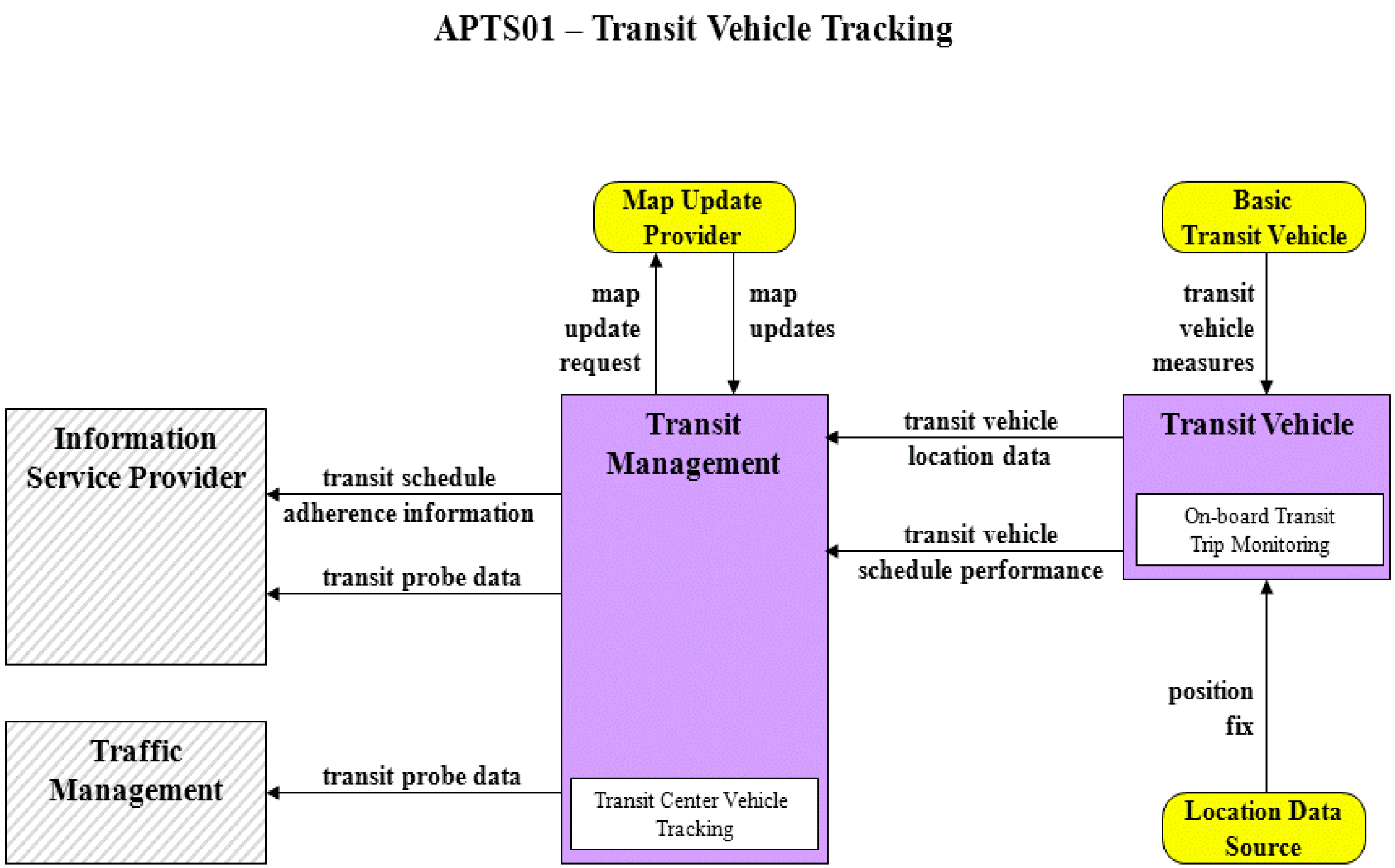
Service Packages (SPs) (cont.)

(11 public transportation SPs cont.):

- Transit Fleet Management
- Multimodal Coordination
- Transit Traveler Information
- Transit Signal Priority
- Transit Passenger Counting
- Multimodal Connection Protection

Transit Management Service Package Example

Main Point: *An example of one transit SP diagram*



ACTIVITY

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

How many Public Transportation Service Packages are there in the National ITS Architecture?

Answer Choices

a) 4

b) 10

c) 11

d) 15

Review of Answers

a) 4

Incorrect. There are 11 Public Transportation Service Packages.

b) 10

Incorrect. There are 11 Public Transportation Service Packages.

c) 11

Correct! There are 11 Public Transportation Service Packages.

d) 15

Incorrect. There are 11 Public Transportation Service Packages.

Which of these is not a Public Transportation Service Package?

Answer Choices

a) Transit Vehicle Tracking

b) Multimodal Connection Protection

c) Multimodal Coordination

d) Broadcast Traveler Information

Review of Answers

a) Transit Vehicle Tracking

Incorrect. This SP is a Public Transportation Service Package.

b) Multimodal Connection Protection

Incorrect. This SP is a Public Transportation Service Package.

c) Multimodal Coordination

Incorrect. This SP is a Public Transportation Service Package.

d) Broadcast Traveler Information

Correct! It is not defined as a Public Transportation Service Package (but it is related to something that transit agencies do).

Summary of Learning Objective #1

Summarize Key Concepts from Transit Management Standards, Part 1 of 2

- All fleet operations and management technologies are dependent upon other technologies
- “Vee” Model is systems engineering process (SEP) that facilitates system development and deployment, including the identification and incorporation of ITS standards
- 11 Transit Service Packages (SPs)

Learning Objective #2: Illustrate the Structure and Use of Data Exchange Standards for Transit Management Systems

- How to meet user needs by using standards
- Structure of standards in addition to TCIP (e.g., GTFS)

Standards Facilitate Meeting User Needs

- User need:
  - Requirement for system to solve problem experienced by user
  - Part of systems engineering process (SEP)
  - Federal Transit Administration (FTA) National ITS Architecture Policy includes identification of applicable ITS standards
  - May be satisfied by using standards
- Standards being used to meet user needs:
  - Users may not need customized solutions
  - Data exchanges facilitated among applications and entities
  - Can choose most suitable and cost-effective applications, knowing they use common standards

Standards Facilitate Meeting User Needs (cont.)

- Benefits from using standards:
  - Reducing complexity and cost in procurement, development, and management
  - Ensure wider choice of suppliers
  - Certain types of standards strategic to economic performance of systems

Standards Facilitate Meeting User Needs: Example

- Transit agency provides real-time data to developers for creation of mobile applications
- Using standards makes it easier for developers to create applications
- Require automatic vehicle location (AVL) system to generate information in General Transit Feed Specification (GTFS)-realtime format (considered de facto standard)
- AVL data could be provided in any format to meet user need, but greatly facilitated by use of GTFS-realtime format/standard

Standards Facilitate Meeting User Needs: Value

- Protection of investment:
  - Modularization and incremental deployment
  - Choice of suppliers
  - Reuse
- Interoperability:
  - Roadmap for evolution
  - Data management
- Improved quality and value:
  - Risk reduction
  - Better abstraction
  - Better testing
  - Process and tool support
  - Modularization
  - Reuse

Standards Facilitate Meeting User Needs: Criteria for Evaluating a Standard

- Technical:
  - How well it represents a problem
  - What technologies it uses
- Organizational:
  - How mature it is
  - If it is actively supported
  - How long it will last

Standards Facilitate Meeting User Needs: Starting Point for Identifying Standards

- National ITS Architecture divided into interface classes
- Interface classes:
  - Defined by type of system at each end of the communications path: center, field (a.k.a. infrastructure), vehicle, and traveler
  - Subdivided into application areas
  - Public transit management interface classes (all bidirectional) are:
    - Center-to-infrastructure (C2I)
    - Center-to-vehicle/traveler (C2V)
    - Center-to-center (C2C)
- Example: Application area within C2I includes bidirectional communication between transit dispatch center and dynamic message signs at transit stop.

Center-to-Infrastructure (C2I) Application Area Capabilities Related to Transit

Covers interface between transit management center and specific type of infrastructure: Dynamic Message Signs (DMS) and Transit Signal Priority (TSP)

- DMS:
  - Provides information to travelers
  - May use various technologies capable of displaying messages using any combination of characters
- TSP:
  - Provides intersection control through local traffic signal controller
  - Provides interface between traffic management center and on-street master controller
  - Based on analysis of transit vehicle's conditions (e.g., schedule adherence) and traffic characteristics for a given time and type of day
  - Center invokes appropriate preconfigured traffic signal control system timing plan

Center-to-Vehicle/Traveler (C2V) Application Area Capabilities Related to Transit: Vehicle

Covers interface between transit management center and transit or paratransit vehicles

- Collecting automated vehicle location information
- Collecting operational and maintenance data
- Providing transit vehicle driver with electronic dispatch and routing instructions
- Providing traveler information to vehicle
- Providing schedule information used to develop corrective actions on-board
- Providing fare management information, including invalid traveler credit identities, to transit vehicles
- Supporting transit vehicle operator authentication and ability to remotely disable vehicle in emergency situations

Center-to-Vehicle/Traveler (C2V) Application Area Capabilities Related to Transit: Traveler

Covers interfaces between traveler information providers and devices used by traveling public

- General traveler information, including traffic information, transit information (fares, real-time schedules, and transactions), incident information, event information, and parking information
- Emergency traveler information, including alerts and advisories, and evacuation information
- Traveler services information (e.g., dining, lodging, etc.)
- Trip planning, using various modes of surface transportation and route options
- Route guidance

Center-to-Center (C2C) Application Area Capabilities Related to Transit

- Multimodal coordination between transit agencies and other public transportation modes
- Transit incident information, schedules, and fare and pricing information
- Transit information suitable for media use
- Emergency transit schedule information to other operation centers
- Transit system information to traffic management centers
- Personalized transit routes requested by travelers
- Financial institution approval and status of electronic fare payments
- Law enforcement regarding the notification of violations

Identifying Appropriate Standards

- Application Areas provide a starting point for identifying appropriate ITS standards
- Use USDOT's ITS Standards website
- Example: Transit Management, which is in the C2C Interface Class

Applicable Standards

In general, the following standards are applicable to Transit Management deployments. To determine which specific standards are applicable for a deployment you will need to determine which architecture flows will be needed for the Transit Management piece of your deployment. Contact your local FHWA ITS Division Specialist or an ITS Standards Program Field Support Team contact

Standard	Development Status
APTA TCIP-S-001 3.0.0 Standard for Transit Communications Interface Profiles;	Published
NTCIP 1102 Octet Encoding Rules (OER) Base Protocol;	Published
NTCIP 1104 Center-to-Center Naming Convention Specification;	Published
NTCIP 2104 Ethernet Subnetwork Profile;	Published
NTCIP 2202 Internet (TCP/IP and UDP/IP) Transport Profile;	Published
NTCIP 2303 File Transfer Protocol (FTP) Application Profile;	Published
NTCIP 2304 Application Profile for DATEX-ASN (AP-DATEX);	Published
NTCIP 2306 Application Profile for XML Message Encoding and Transport in ITS Center-to-Center Communications (C2C XML);	Published
NTCIP 8003 Profile Framework;	Published
NTCIP 9001 NTCIP Guide;	Published
SAE J2266 Location Referencing Message Specification (LRMS);	Published
SAE J2354 Message Set for Advanced Traveler Information System (ATIS);	Published
SAE J2540 Messages for Handling Strings and Look-Up Tables in ATIS Standards;	Published
SAE J2540/1 RDS (Radio Data System) Phrase Lists;	Published
SAE J2540/2 ITIS (International Traveler Information Systems) Phrase Lists;	Published
SAE J2540/3 National Names Phrase List;	Published

Structure of Standards: Open Systems Interconnection (OSI)

- International Organization for Standardization (a.k.a. ISO) standard for worldwide communications that defines networking framework for implementing standards/protocols in seven layers
- Seven layers:
  - Physical
  - Data Link
  - Network
  - Transport
  - Session
  - Presentation
  - Application

A C T I V I T Y

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

Which one of these is not a layer within the Open Systems Interconnection (OSI) model?

Answer Choices

a) Application

b) Data Link

c) Service

d) Physical

Review of Answers

a) Application

Incorrect. This is Layer 7 within the OSI model.

b) Data Link

Incorrect. This is Layer 2 within the OSI model.

c) Service

Correct! This is not a layer within the Open Systems Interconnection (OSI) model.

d) Physical

Incorrect. This is Layer 1 within the OSI model.

Structure of Standards: SAE J1708

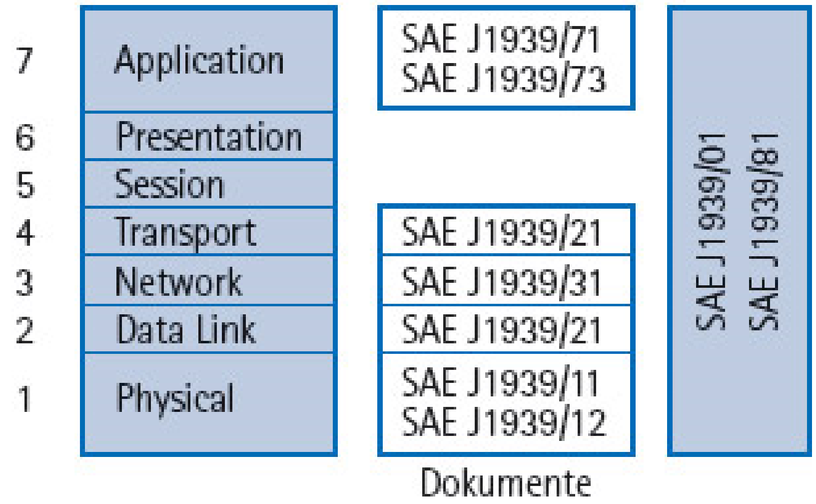
- Facilitates vehicle area network (VAN)
- Only describes two lowest layers
  - Physical
  - Data Link
- Used in conjunction with SAE J1587, which:
  - Is an application layer
  - Defines format of J1708 messages sent between microprocessor devices in transit vehicles
  - Supports communication with external devices connected to the vehicle area network (VAN)
- J1708 message consists of Message Identification (MID) character, data bytes, and checksum

Structure of Standards: SAE J1939

- High speed ISO 11898-1 Controller Area Network (CAN)-based communications network:
  - Supports simple information exchanges and diagnostic data exchanges between on-components physically distributed throughout vehicle
  - Allows components associated with different manufacturers to communicate with each other
- Successor to SAE J1708/J1587 low speed networks – those earlier standards provided simple information exchange between on-board components
- Every J1939 message uses an identifier that defines:
  - The message priority
  - From whom it was sent
  - The data that are contained within it

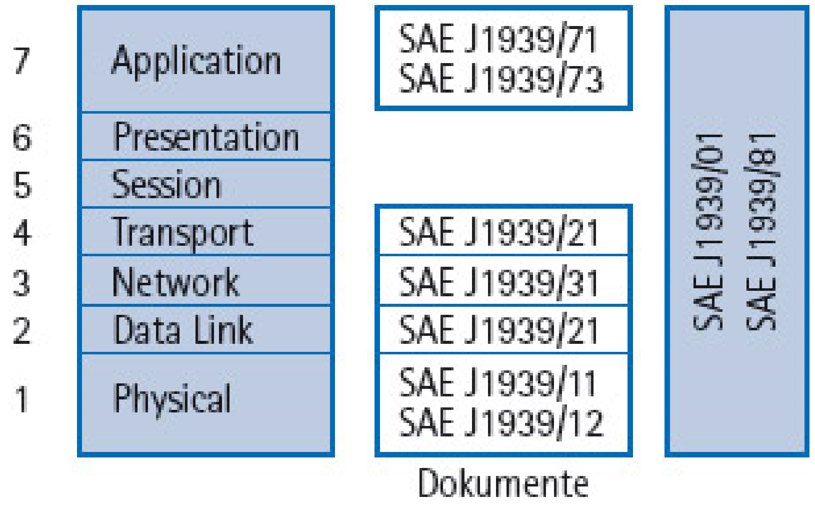
Structure of Standards: SAE J1939 (cont.)

- Layer 1 (physical layer) – electric interface with physical medium
- Layer 2 (data link layer) – data communication via Controller Area Network (CAN) (an ISO standard (ISO 11898) for serial data communication) based on CAN 2.0B
- Layer 3 (network layer) – functionality of bridge for transmission of messages between two network segments



Structure of Standards: SAE J1939 (cont.)

- Layer 4 (transport layer) – various network services for message request mode, acknowledged transmission, and fragmented transmission of large data blocks
- Layer 7 (application layer):
  - Actual data (parameters or network variables with value range, resolution, physical unit, and type of transmission)
  - Each message unambiguously referenced by parameter group number
- Network management – automatic allocation or determination of node addresses (plug & play principle)



ACTIVITY

STANDARDS ITS TRAINING

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

Which of these standards are on-board vehicle area network (VAN) standards?

Answer Choices

a) SAE J1939

b) ISO 11898

c) SAE J1708

d) All of the above

Review of Answers

a) SAE J1939

This is an on-board VAN standard, but b) and c) are as well.

b) ISO 11898

This is an on-board VAN standard, but b) and c) are as well.

c) SAE J1708

This is an on-board VAN standard, but b) and c) are as well.

d) All of the above

Correct! All of these are on-board VAN standards.

Structure of Standards: GTFS

- General Transit Feed Specification (GTFS):
  - Defines common format for public transportation schedules and associated geographic information
  - “Feeds" allow public transit agencies to publish their transit data and developers to write applications that consume that data in an interoperable way
- Structure: Comma-delimited text files
  - Six mandatory files: agency information, stops, routes, trips, stops times, and calendar
  - Seven optional files: calendar dates, fare attributes, fare rules, shapes, frequencies, transfers, and feed info
- Considered “de facto” standard
- Adoption substantially outpaced TCIP and Service Interface for Real Time Information (SIRI) standards in North America

Structure of Standards: GTFS-realtime

- Feed specification that provides real-time updates about public transit fleet to application developers
- An extension to GTFS and designed around:
  - Ease of implementation
  - GTFS interoperability
  - Focus on passenger information
- Currently supports the following types of information:
  - Trip updates – delays, cancellations, changed routes
  - Service alerts – stop moved, unforeseen events affecting a station, route, or entire network
  - Vehicle positions – information about vehicles including location and congestion level
- Updates of each type provided in separate feed. Feeds served via HTTP and updated frequently
- Format based on protocol buffers

Structure of Standards: Other Relevant Standards/Formats

- JavaScript Object Notation (JSON)
- Protocol Buffers
- Representational State Transfer (REST)
- Simple Object Access Protocol (SOAP)
- eXtensible Markup Language (XML)

- Other transit standards for Transit Management exist in:
  - International Organization for Standardization (ISO)
  - Comité Européen de Normalisation (CEN) (French for European Committee for Standardization)
  - UK – TransXChange, for example

Summary of Learning Objective #2

Illustrate the Structure and Use of Data Exchange Standards for Transit Management Systems

- Three interface classes: C2C, C2I, and C2V
- On-board standards use OSI layers
- Other standards are in a variety of formats:
    - GTFS and GTFS-realtime
    - JavaScript Object Notation (JSON)
    - Protocol Buffers
    - Representational State Transfer (REST)
    - Simple Object Access Protocol (SOAP)
    - eXtensible Markup Language (XML)

Learning Objective #3: Select Appropriate ITS Standards for Data Exchange Among Transit Management Systems, and Between Transit Management Systems and Traveler Information, Fare Collection, and Other Systems (e.g., Traffic Management Systems)

- Life-cycle cost considerations
- Case study for center-to-infrastructure (C2I) or center-to-vehicle (C2V) flows
- Case study for on-board flows using vehicle area network (VAN) standards
- Using standards to facilitate integration with legacy systems

Life-Cycle Cost Considerations

- **Standards-based products should**:
  - Be available from a <u>number</u> of suppliers at <u>lower</u> cost
  - Have a longer lifetime providing specific advantages
- **Modularization and incremental deployment** – technical advantages and allows for incremental approach to adoption, allowing users to spread investment over extended period
- **Choice of suppliers** – systems using interfaces based on standards can be implemented as discrete, pluggable modules that can be chosen from a wide variety of suppliers in competitive market
- **Reuse** – significantly reduce costs of specifying, procuring, and integrating system

Life-Cycle Cost Considerations (cont.)

- **Development** – standards are complex and expertise is needed to develop and validate
- **Availability** – must wait for standard to be published
- **Maintenance** – if standard changes, there can be additional costs to users
- **Procurement** – if standard is not used, costs associated with additional technical and marketplace complexity
- **Adaptation** – standard or organization may need to be adapted to meet specific requirements
- **Gold-plating** – using standards may give organizations items that it does not need

ACTIVITY

STANDARDS ITS TRAINING

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

Which of these issues typically drives the costs associated with using standards?

Answer Choices

a) Adaptation

b) Abstraction

c) Testing

d) All of the above

Review of Answers

a) Adaptation

Correct! A standard or organization may need to adapt to meet specific requirements.

b) Abstraction

Incorrect. Standards-based products usually have a higher level of generality and abstraction than one-off custom solutions.

c) Testing

Incorrect. Testing does not drive the costs associated with standards since operability was already tested when the standard was created. System components that use standards will work unless you have a proprietary system.

d) All of the above

Incorrect. Only a) is the correct answer.

Case Study for C2I Flows: Interurban Transit Partnership (ITP), Grand Rapids, MI

- ITP: 264 vehicles operating in max service/49,770,814 annual passenger miles
- ITP deployed real-time information (RTI) in 2013
- RTI sent from dispatch center-to-field infrastructure (dynamic message signs) located at:
  - Major transfer facility (called Central Station)
  - One other transfer location (Kentwood Station)
- Vendor originally developed solution using GTFS data
- GTFS required too much processing at sign:
  - Requiring a lot of CPU power from sign
  - Resulting slow process
  - A lot of unnecessary data being sent down to sign

Case Study for C2I Flows: ITP (cont.)

- Decided to use Representational State Transfer (REST) instead of GTFS:
  - Provides most flexibility without having to touch the infrastructure (DMS)
  - Can be consumed by a wide variety of web clients
  - Able to return JSON, XML, HTTP and other web standard formats
  - Provides simple ways to filter data
- Includes providing DMS diagnostics on continuous basis

ACTIVITY

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

What de facto standard did ITP's vendor use to successfully exchange data between the dispatch center and dynamic message signs in the field?

Answer Choices

a) General Transit Feed Specification (GTFS)

b) eXtensible Markup Language (XML)

c) JavaScript Object Notation (JSON)

d) Representational State Transfer (REST)

Review of Answers

a) General Transit Feed Specification (GTFS)

Incorrect. The vendor started the project using GTFS, but replaced it in the end.

b) eXtensible Markup Language (XML)

Incorrect. The vendor did not address the issues with XML.

c) JavaScript Object Notation (JSON)

Incorrect. The vendor did not address the issues with JSON.

d) Representational State Transfer (REST)

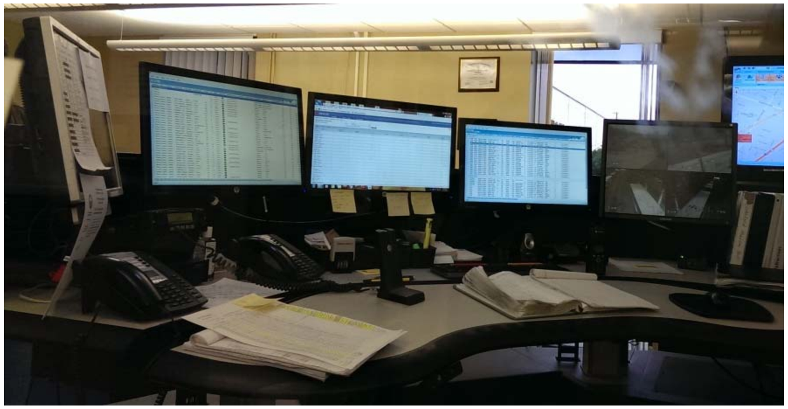
Correct. The vendor used REST.

Case Study for C2V Flows: Chattanooga Area Regional Transportation Authority (CARTA)

- CARTA: 66 vehicles operating in max service/10,040,856 annual passenger miles
- Required multiplex system on all buses purchased:
  - System connected to SAE J1939 data bus
  - Monitor common engine, transmission, and braking faults transmitted on data bus (e.g., high engine oil temperature, low oil pressure, high transmission oil temperature)
  - Log data for later retrieval
- Main purpose was for integration with other planned in-vehicle equipment
- Implemented daily upload of bus diagnostic information collected on-board to Automatic Vehicle Monitoring (AVM) server, making data available to maintenance staff

Case Study for C2V Flows: CARTA AVM

- Selection of standard(s) to incorporate in functional specifications for AVM system based on:
  - Availability
  - Applicability
  - Maturity
  - Vendors' use/acceptance



- Incorporated into specifications in appropriate location:
  - On-board Device Alarms Reporting
  - Automatic Vehicle Monitoring: On-board System
  - Student supplement contains specification language

Using Standards to Facilitate Integration with Legacy Systems: TriMet Case Study

- TriMet: 888 vehicles operating in max service/460,913,427 annual passenger miles
- Use ITS standards when developing systems to maximize vendor flexibility and data exchange compatibility
- Functional Integration example:
  - No Transmission Control Protocol/Internet Protocol (TCP/IP) standards for LED sign interface at time of DMS procurement
  - Forced to consider sign vendors that had proprietary protocols
  - TriMet required sign vendors to interface with TCP/IP protocols
  - Advantage to using TCP/IP and standard protocols that would enable use of different communication methods, yet retain same applications

Using Standards to Facilitate Integration with Legacy Systems: Central Puget Sound Case Study

- Comply with standards and select proven commercial off-the-shelf technology (hardware and software)
- Seven public transportation agencies in Central Puget Sound region. Modifying or customizing technology:
  - Entails greater risks
  - Has advantage of closely meeting needs
  - Has disadvantage of needing more development and testing
- Only on-board driver display unit significantly customized
- Customized software developed to accommodate partners' existing legacy systems

Using Standards to Facilitate Integration with Legacy Systems: Portland TriMet Case Study

- Integrating with existing legacy systems can save money associated with implementing a new system
- New real-time bus arrival estimation system built upon same platform as TriMet's existing AVL bus dispatch and rail central control systems
- Saved software development time and system costs
- Few minor changes needed because of different requirements necessary for reporting information to customers

ACTIVITY

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

Does complying with standards and using commercial off-the-shelf technology help make it easier to integrate existing systems with new ones?

Answer Choices

a) Yes

b) No

Review of Answers

a) Yes

Correct! Complying with standards and using commercial off-the-shelf technology can help save money, minimize risks, and make it easier to integrate existing systems with new ones.

b) No

Incorrect. Modifying or customizing a particular technology entails greater risks, as demonstrated in the Central Puget Sound region.

Summary of Learning Objective #3

Select Appropriate ITS Standards for Data Exchange Among Transit Management Systems, and Between Other Systems

- Six main areas of life-cycle cost considerations:
  - Development
  - Availability
  - Maintenance
  - Procurement
  - Adaptation
  - Gold-plating
- C2I and on-board flows examples
- Issues associated with integration with legacy systems:
  - Comply with standards and select proven, commercial off-the-shelf technology
  - Plan on adequate development time and thorough system testing

Learning Objective #4: Illustrate How to Apply Standards to the Development of Procurement Specifications

- Read a standard
- Rigidity, flexibility, and change in the application of standards
- Incorporate a standard into a specification for procuring a Transit Management system
- Test and determine conformance with a standard
- Standards and intellectual property

Read a Standard

- Transit Management standards not structured the same way:
  - SAE J1939 based on OSI layers
  - GTFS is a series of comma-delimited text files
  - GTFS-realtime format based on Protocol Buffers
  - TransXChange (UK standard) is XML format
- Need to understand enough to:
  - Identify appropriate standard(s) based on aforementioned criteria
  - Define use of standard(s) in functional requirements/specifications
  - Define how compliance with standard(s) can be tested

Read a Standard: SAE J1939

Core J1939 Standards	
J1939	Recommended Practice for a Serial Control and Communications Vehicle Network
J1939-01	Recommended Practice for Control And Communications Network for On-Highway Equipment
J1939-02	Agricultural and Forestry Off-Road Machinery Control and Communication Network
J1939-03	On Board Diagnostics Implementation Guide
J1939-05	Marine Stern Drive and Inboard Spark-Ignition Engine On-Board Diagnostics Implementation Guide
J1939-11	Physical Layer - 250k bits/s, Twisted Shielded Pair
J1939-13	Off-Board Diagnostic Connector
J1939-15	Reduced Physical Layer, 250K bits/sec, Un-Shielded Twisted Pair (UTP)
J1939-21	Data Link Layer
J1939-31	Network Layer
J1939-71	Vehicle Application Layer
J1939-73	Application Layer - Diagnostics
J1939-74	Application - Configurable Messaging
J1939-75	Application Layer - Generator Sets and Industrial
J1939-81	Network Management
J1939-82	Compliance - Truck and Bus
J1939-84	OBD Communications Compliance Test Cases for Heavy Duty Components and Vehicles

Read a Standard: SAE J1939 (cont.)

- Most messages intended to be broadcast
- Data transmitted on the network without a specific destination:
  - Permits any device to use data without requiring additional request messages
  - Allows future software revisions to easily accommodate new devices
- When a message must be directed to a particular device, a specific destination address can be included within message identifier

Read a Standard: GTFS

Filename	Required	Defines
agency.txt	**Required**	One or more transit agencies that provide the data in this feed.
stops.txt	**Required**	Individual locations where vehicles pick up or drop off passengers.
routes.txt	**Required**	Transit routes. A route is a group of trips that are displayed to riders as a single service.
trips.txt	**Required**	Trips for each route. A trip is a sequence of two or more stops that occurs at specific time.
stop_times.txt	**Required**	Times that a vehicle arrives at and departs from individual stops for each trip.
calendar.txt	**Required**	Dates for service IDs using a weekly schedule. Specify when service starts and ends, as well as days of the week where service is available.
calendar_dates.txt	Optional	Exceptions for the service IDs defined in the calendar.txt file. If calendar_dates.txt includes ALL dates of service, this file may be specified instead of calendar.txt.
fare_attributes.txt	Optional	Fare information for a transit organization's routes.
fare_rules.txt	Optional	Rules for applying fare information for a transit organization's routes.
shapes.txt	Optional	Rules for drawing lines on a map to represent a transit organization's routes.
frequencies.txt	Optional	Headway (time between trips) for routes with variable frequency of service.
transfers.txt	Optional	Rules for making connections at transfer points between routes.
feed_info.txt	Optional	Additional information about the feed itself, including publisher, version, and expiration information.

Read a Standard: GTFS (cont.)

agency.txt

```
agency_id, agency_name,agency_url,agency_timezone,agency_phone,agency_lang
FunBus,The Fun Bus,http://www.thefunbus.org,America/Los_Angeles,(310) 555-0222,en
```

stops.txt

```
stop_id,stop_name,stop_desc,stop_lat,stop_lon,stop_url,location_type,parent_station
S1,Mission St. & Silver Ave.,The stop is located at the southwest corner of the intersection.,37.728631,-122.431282,,,
S2,Mission St. & Cortland Ave.,The stop is located 20 feet south of Mission St.,37.74103,-122.422482,,,
S3,Mission St. & 24th St.,The stop is located at the southwest corner of the intersection.,37.75223,-122.418581,,,
S4,Mission St. & 21st St.,The stop is located at the northwest corner of the intersection.,37.75713,-122.418982,,,
S5,Mission St. & 18th St.,The stop is located 25 feet west of 18th St.,37.761829,-122.419382,,,
S6,Mission St. & 15th St.,The stop is located 10 feet north of Mission St.,37.766629,-122.419782,,,
S7,24th St. Mission Station,,37.752240,-122.418450,,,S8
S8,24th St. Mission Station,,37.752240,-122.418450,http://www.bart.gov/stations/stationguide/stationoverview_24st.asp,1,
```

routes.txt

```
route_id,route_short_name,route_long_name,route_desc,route_type
A,17,Mission,"The ""A"" route travels from lower Mission to Downtown.",3
```

Rigidity, Flexibility and Change in the Application of Standards

- Standards are not perfect
- Extending standards are acceptable but:
  - Must be well documented
  - Follow prescribed procedures
- Vendors may claim “conformance to standards” but may not provide all features and value ranges allowed
- Beware of "cherry picking" from manufacturers’ datasheets
- Stick to functions needed to meet Concept of Operations (ConOps)

Rigidity, Flexibility and Change in the Application of Standards (cont.)

- Avoid specifying proprietary features and objects:
  - Both will result in nonstandard, noninteroperable solutions
  - If you must have a new or different "feature," document thoroughly for all to use

ACTIVITY

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

A good approach to defining the functions of your system is to select items from manufacturers' datasheets.

Answer Choices

a) True

b) False

Review of Answers

a) True

Incorrect. Selecting items from manufacturers' datasheets is not a good approach.

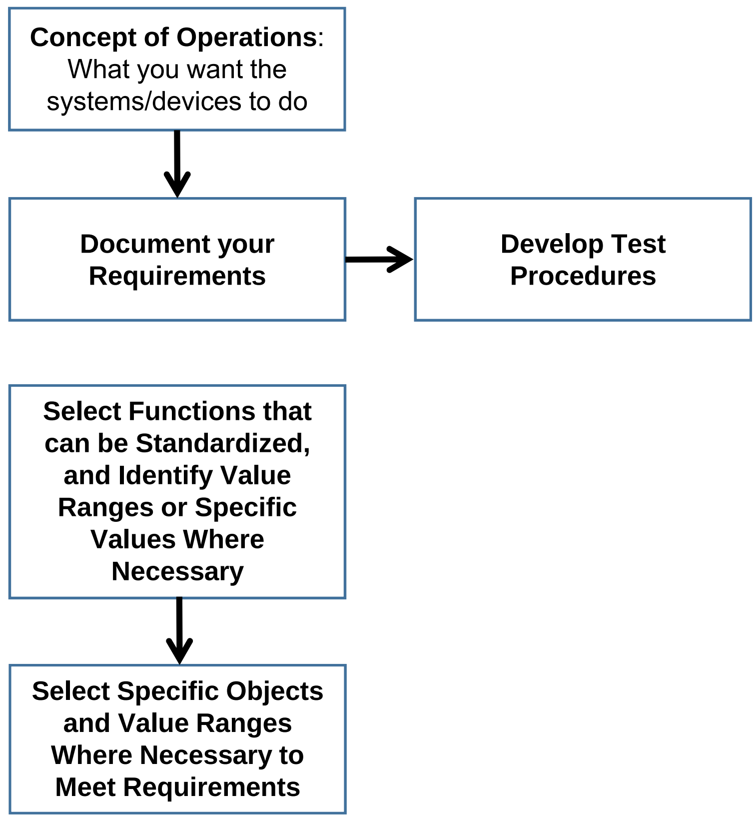
b) False

Correct! Vendors may claim "conformance to the standards" but may not provide all features and value ranges allowed in the standard, so "cherry picking" from manufacturers' datasheets as you are developing your requirements and specifications is not a good approach.

Incorporate a Standard into a Specification for Procuring a Transit Management System

- Discussion of Concept of Operations (ConOps)
- Components/devices you expect to be supplied in system
- Functions to be supported, value ranges, and optional capabilities required
- Detailed listing of requirements
- Language requiring use of standardized dialogs
- Testing program

Incorporate a Standard into a Specification for Procuring a Transit Management System



Structure of Standards: Excerpts from Functional Specification using J1708 or J1939

- On-board:
  - The Contractor shall install communications cabling and connections compliant with the Society of Automobile Engineers (SAE) J-1708/1587 or J-1939 network standard....
  - The Contractor shall fully document all supported Message IDs (MID) and Parameter IDs (PID) available for communications with on-board devices using the J-1708/1587 or J-1939 interface
- APC Installation/Integration: The Contractor shall integrate the APC controller with the on-board MDT, based on the standard SAE J-1708/J-1587 or J-1939 VAN
- Integration with Interior DMS: The Contractor shall install new interior DMS that shall communicate with the AVA controller over the J1708/1939 network
- Vehicle Component Monitoring (VCM) subsystem: The MDT shall be integrated with existing J1708/1587 and J1939 network on the fixed-route fleet to collect codes from....

Test and Determine Conformance with a Standard

- Conformance: testing to determine if implementation meets requirements of standard or specification
- Testing for:
  - Performance
  - Robustness
  - Behavior
  - Functions
  - Interoperability
- Conformance testing is different – requirements or criteria for conformance must be specified in standard/specification
- Some standards have subsequent documentation for test methodology and assertions to be tested. If criteria or requirements for conformance not specified, there can be no conformance testing

Test and Determine Conformance with a Standard (cont.)

- Prove beyond any doubt that implementation is correct, consistent, and complete with respect to specification
- Impossible for implementations of nontrivial specifications written in natural language
- Alternative is falsification testing, which:
  - Subjects implementation to combinations of legal and illegal inputs
  - Compares resulting output to set of corresponding "expected results“
    - If errors found, implementation does not conform to specification
    - If no errors, does not necessarily imply converse
  - Can only demonstrate nonconformance
  - The larger and more varied the inputs, the more confidence can be placed when testing generates no errors

Test and Determine Conformance with a Standard: Conformance Clause

- High-level description of what is required of implementers and application developers
- May specify:
  - Sets of functions
  - Minimal requirements for certain functions and minimal requirements for implementation-dependent values
  - Permissibility of extensions, options, and alternative approaches and how they are to be handled

Test and Determine Conformance with a Standard: Conformance Testing

- Ensure that "standard-based" products are implemented
- Benefits:
  - Quality products
  - Interoperability
  - Competitive markets with more choices
- Conformance involves two major components:
  - Test tool/suite – testing program cannot exist without this
  - Testing program (e.g., certification or branding) for those specifications/standards for:
    - Critical applications
    - Interoperability with other applications
    - Security of systems

Test and Determine Conformance with a Standard: Conformance Testing (cont.)

- Decision to establish program based on risk of nonconformance versus costs of creating and running program
- Conformance testing program usually includes:
  - Standard or specification
  - Test tool (e.g., tool, suite) and/or reference implementation
  - Procedures for testing
  - Organization(s) to do testing, issue certificates of validation, and arbitrate disputes

ACTIVITY

STANDARDS ITS TRAINING

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

Which of the following elements are included in a conformance testing program?

Answer Choices

a) Standard or specification

b) Procedures for testing

c) Organization(s) to do testing, issue certificates of validation, and arbitrate disputes

d) All of the above

Review of Answers

a) Standard or specification

This is included in a conformance testing program.

b) Procedures for testing

This is included in a conformance testing program.

c) Organization(s) to do testing, issue certificates of validation, and arbitrate disputes

This is included in a conformance testing program.

d) All of the above

Correct! You need all of these elements for a conformance testing program.

Standards and Intellectual Property

- Best technology for technical standard could be proprietary technology, protected by one or more patents
- Standards development more frequently anticipates technology rather than following it
- Leads to conflicts between standards and patents
- If patented technology is incorporated into standard without patent holder's agreement to share its patent rights, then patent holder may be only entity able to comply with standard

Standards and Intellectual Property (cont.)

- Agency should verify if any "essential" patent for which license is required, and broad terms and conditions under which license will be granted
- Information generally available from relevant Standards Developing Organization (SDO)
- If license obtained directly from patent holder, patent holder should be contacted and licensing agreement negotiated and signed prior to adopting standard
- Agency may have option of choosing from alternative technologies to comply with a given standard
- May include use of protected or patented technology

Standards and Intellectual Property (concluded)

- In all such cases, patents would not be considered to be “essential patents” but “useful patents”
- Essential patents may be pooled by patent holders
- Compliance with given standard or technical regulation may require using one or more patented technologies. In all such cases:
  - Required to obtain license from patent holder
  - Must be done prior to using the patented technology to conform to the requirements of the standard
- Know rules so you are able to negotiate best possible terms and conditions for use of proprietary or patented technology

Summary of Learning Objective #4

Illustrate How to Apply Standards to the Development of Procurement Specifications

- Different standards have different structures
- Standards not static and can change. Standard extensions can be used, but:
  - Must be well documented
  - Follow prescribed procedures
- Five components to incorporate standard into procurement
- Conformance testing program includes:
  - Standard or specification
  - Test tool
  - Procedures for testing
  - Organization(s) to do testing, issue certificates of validation, and arbitrate disputes
- Agency that plans to adopt standard should verify if any "essential" patent(s) for which a license is required

What We Have Learned

1) Service Packages represent slices of the __physical architecture__ that address specific services like surface street control.
2) The use of standards is desirable for both business and technical reasons. The principal benefits of standards are as follows:
   a) __protection of investment__
   b) __interoperability__
   c) __improved quality and value__
3) __Application areas__ provide a starting point for identifying the ITS standards and other resources, and are deployment-oriented categories that focus on commonly deployed ITS services or systems.
4) Using standards in a deployment can greatly __reduce__ component development costs, especially if standardized off-the-shelf components are available.
5) The requirements or criteria for __conformance__ must be specified in the standard or specification.

Resources

- Serial Control and Communications Heavy Duty Vehicle Network: http://standards.sae.org/j1939_201308/. Related standards:
  - SAE J1708, SAE J1587, SAE J1128, SAE J1944
- "Introduction to SAE J1708," http://www.kvaser.com/about-can/can-standards/j1708
- General Transit Feed Specification (GTFS): https://developers.google.com/transit/gtfs/
- General Transit Feed Specification (GTFS)-realtime: https://developers.google.com/transit/gtfs-real-time/
- ITS ePrimer: Module 7: Public Transportation, http://www.pcb.its.dot.gov/eprimer/documents/module7p.pdf
- Systems Engineering for Intelligent Transportation Systems: http://ops.fhwa.dot.gov/publications/seitsguide/section3.htm
- Webopedia definition of The 7 Layers of the OSI Model, http://www.webopedia.com/quick_ref/OSI_Layers.asp
- A Case Study on Applying the Systems Engineering Approach: Best Practices and Lessons Learned from the Chattanooga SmartBus Project, http://ntl.bts.gov/lib/32000/32600/32672/61027_se.pdf

Next Course Modules

Students who have completed Module 5 may delve into the following PCB modules:

- Module 6: Traveler Information, Part 1 of 2
- Module 7: Traveler Information, Part 2 of 2
- Module 9: Arterial Management & Transit Signal Priority, Part 2 of 2
- Module 10: Electronic Fare Payment Systems
- Module 11: Transit and Connected Vehicle Environment/Emerging Technologies, Applications, and Future Platforms

Thank you for completing this module.

Click here to open the feedback form

OR

Please provide us your feedback:

http://www.pcb.its.dot.gov/stds_training.aspx

(insert exact location for feedback for each module as well as link to Transit ITS Standards – page to be developed as part of standards training site)

STANDARDS ITS TRAINING

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