MassDOT ITS Strategic Plan

Task 7: Provide Technical Assistance to Identify Protocols, Standards, and Best Practices for Supporting Statewide Interoperability

Course Title

Using Massachusetts Key ITS Standards in Deployment: Identification, Specification, and Testing

version 1.2

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Course Overview

Timetable	Item to Cover
8:30 to 9:00AM	Sign-in
9:00 to 9:30AM	Module 1 – Course Overview/Introductions
9:30 to 10:15AM	Module 2 – ITS Standards Overview
10:15 to 10:30AM	Coffee Break
10:30 to 11:00AM	Module 3 – Massachusetts Key ITS Standards
11:00 to 12:15PM	Module 4 – Identification of ITS Standards and Relation to ITS Architecture
12:15 to 1:00PM	Lunch
1:00 to 2:00PM	Module 5 – ITS Standards: How they work
2:00 to 2:30PM	Module 6 – Specifying ITS Standards
3:00 to 3:20PM	Module 7 – ITS Standards Testing
3:20 to 3:50PM	Module 8 – Connected Vehicles and Standards
3:50 to 4:00PM	Wrap-up

Module 1:
Course Overview

Why this Course

- Using ITS Standards is identified as a key element in the Massachusetts ITS Strategic Plan
- Support coordination efforts of the Statewide ITS Planning and Coordination Committee (SIPCC)
- Provide an overview of ITS Standards and opportunities for interoperability of ITS in Massachusetts
- Present Key ITS Standards for Massachusetts
- Discuss nomenclature and information related to ITS standards that you and your contractors may use in projects.

Course Learning Objectives

- Help you answer the question: *What ITS standards should I use in my project?*
- Help you to specify ITS Standards during procurements
- Help you test your ITS system deployments

ITS System Journey from Plan to Deployment

Regional Transportation Plan

During Design Phase
Alternatives Analysis

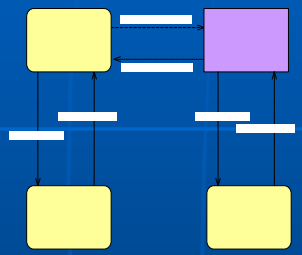
Use Cases & Requirements

Alternatives Analysis

User Interface | Center Systems | Commu-nications | Field Elements

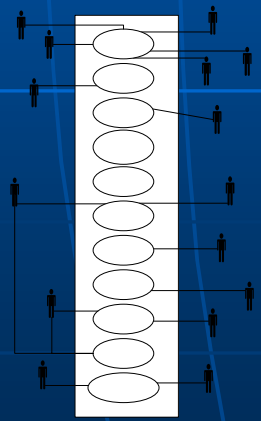
1

Develop Regional ITS Architecture



2

Identify Users and their Needs



3

Identify System Features and Requirements

4

Data Storage Retrieval

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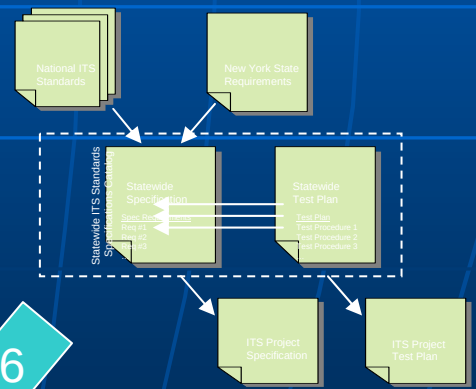
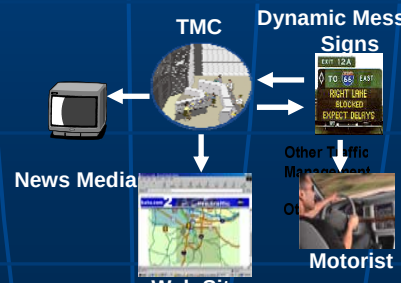
5

Write Specifications and Test Plans





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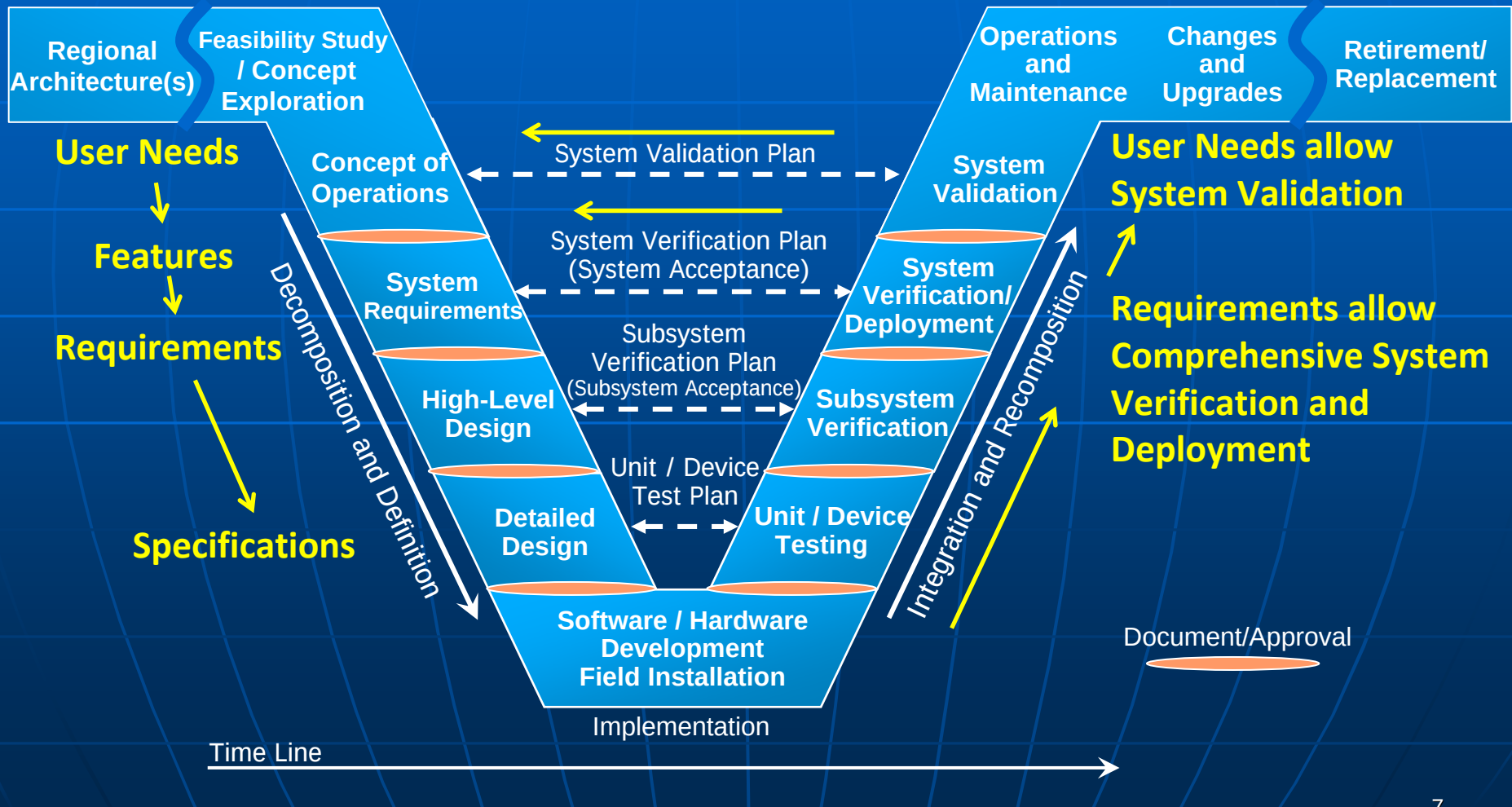
Implement the System: Build, Deploy, and Test

User Needs, Features, Requirements, Testing - The Systems Engineering Process

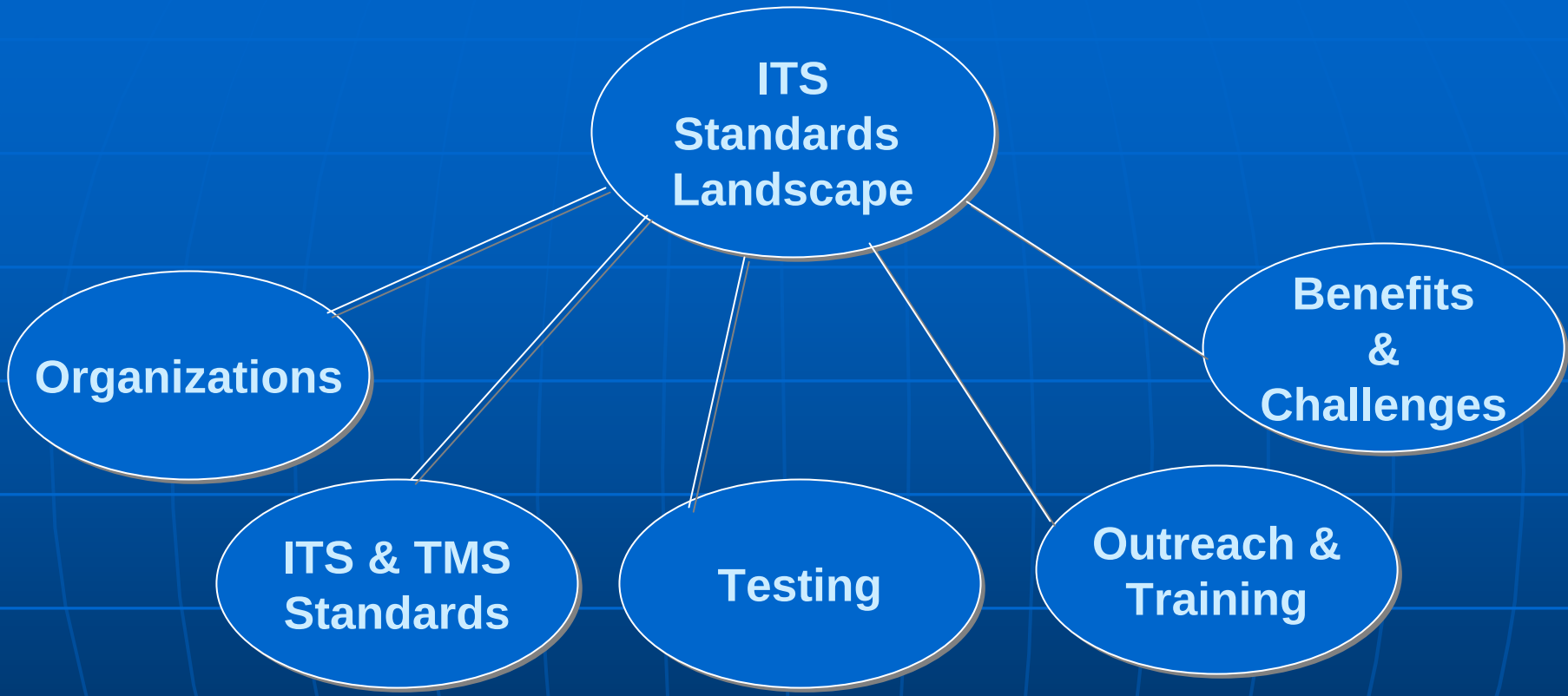


Introductions

- What is your role?
  - Regional Transportation Planning
  - Business and ITS Systems Analysis
  - Specification Development and System Acquisition
  - System Implementation and Testing
  - Manage, Operate and Maintain
- Introduce yourself and your role in ITS to the group

Module 2:
ITS Standards Overview

ITS Standards Landscape



Standards Development Organizations and Relevant Standards

- AASHTO - American State and Highway Transportation Officials AND
- ITE - Institute of Transportation Engineers
  - TMDD – Standard for Traffic Management Center-to-Center Communications
- IEEE - Institute of Electrical and Electronics Engineers
  - IEEE 1512 – Family of data dictionaries for information exchanges between public safety centers and traffic management centers
- SAE - Society of Automotive Engineers
  - SAE-J2354 - Advanced Traveler Information System Message Set (ATIS)
- APTA - American Public Transportation Association
  - TCIP – Transit Communications Interface Profiles
- NEMA - National Electrical Manufacturers Association
  - NTCIP – National Transportation Communications for ITS Protocol

Organizations

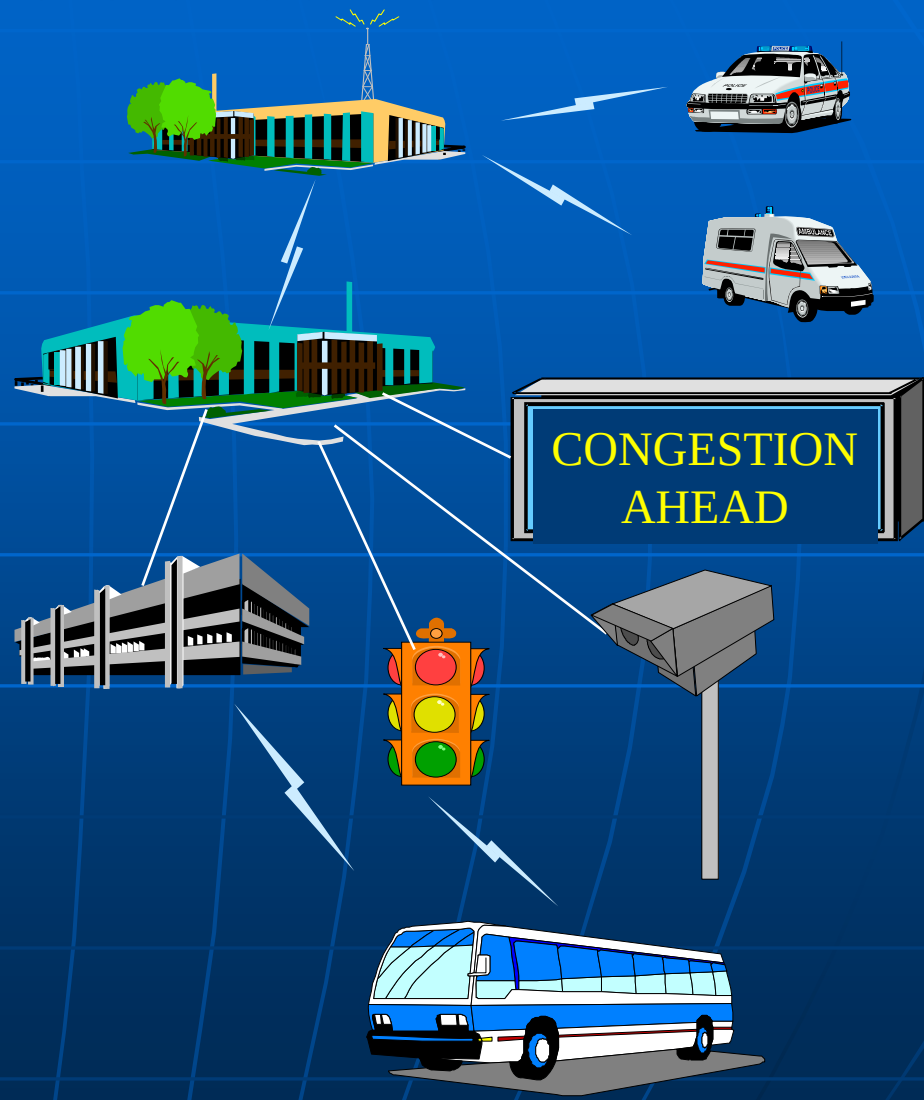
- **Standards Development Organizations**
  - AASHTO
  - APTA
  - IEEE
  - ITE
  - NEMA
  - SAE
- **USDOT**
  - ITS Standards Program
  - Deployment Assessment
  - ITS Architecture Program
- **Public Agencies**
  - System Users
  - System Operators
  - System Maintainers
  - System Acquisition
    - -Specifications
    - -Testing
- **Product Vendors**
  - Center Systems
  - Field Hardware
  - Vehicle Systems

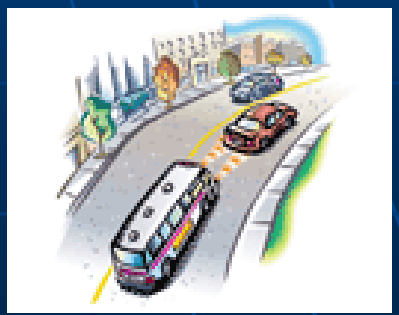
ITS Standards Infrastructure

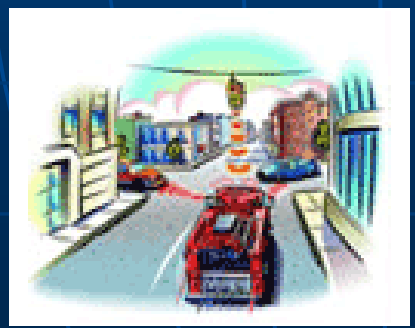
- The standards can be broadly classified into
  - ITS Communications Standards
    - Information Content and Protocols
  - Field Hardware Standards
    - Controllers and Cabinets

National ITS Architecture is a Framework for ITS Standards

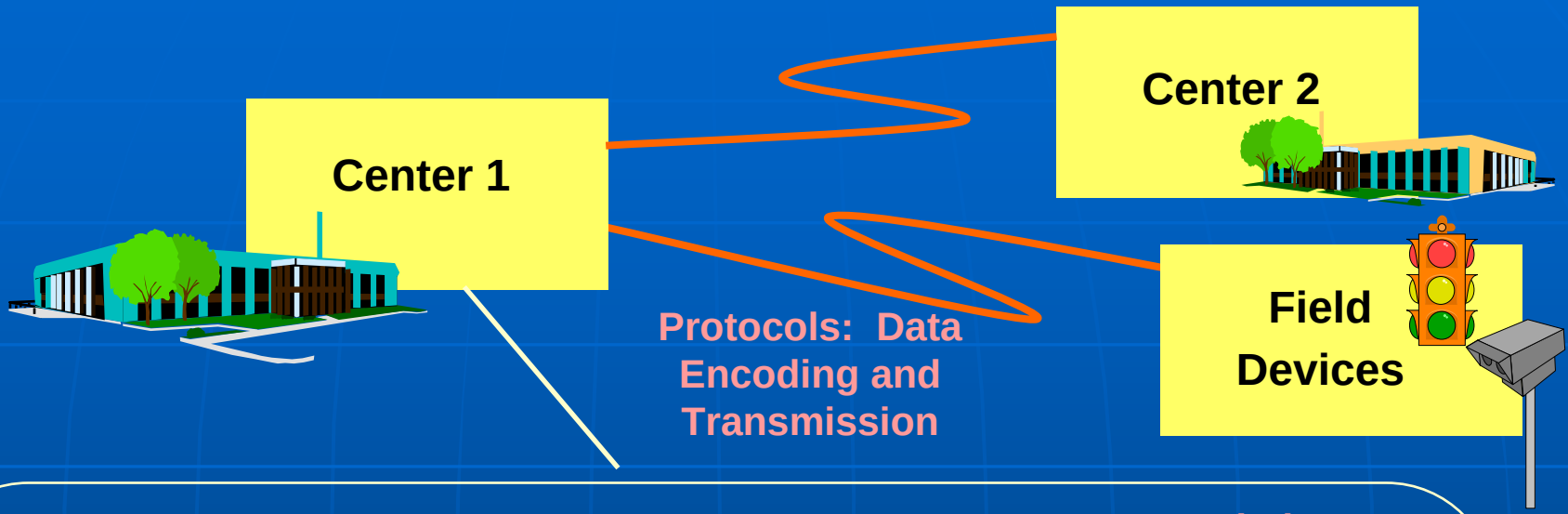
- Center-to-Center
- Center-to-Field
- Center-to-Vehicle
- Connected Vehicles
  - Vehicle to Infrastructure
  - Vehicle to Vehicle

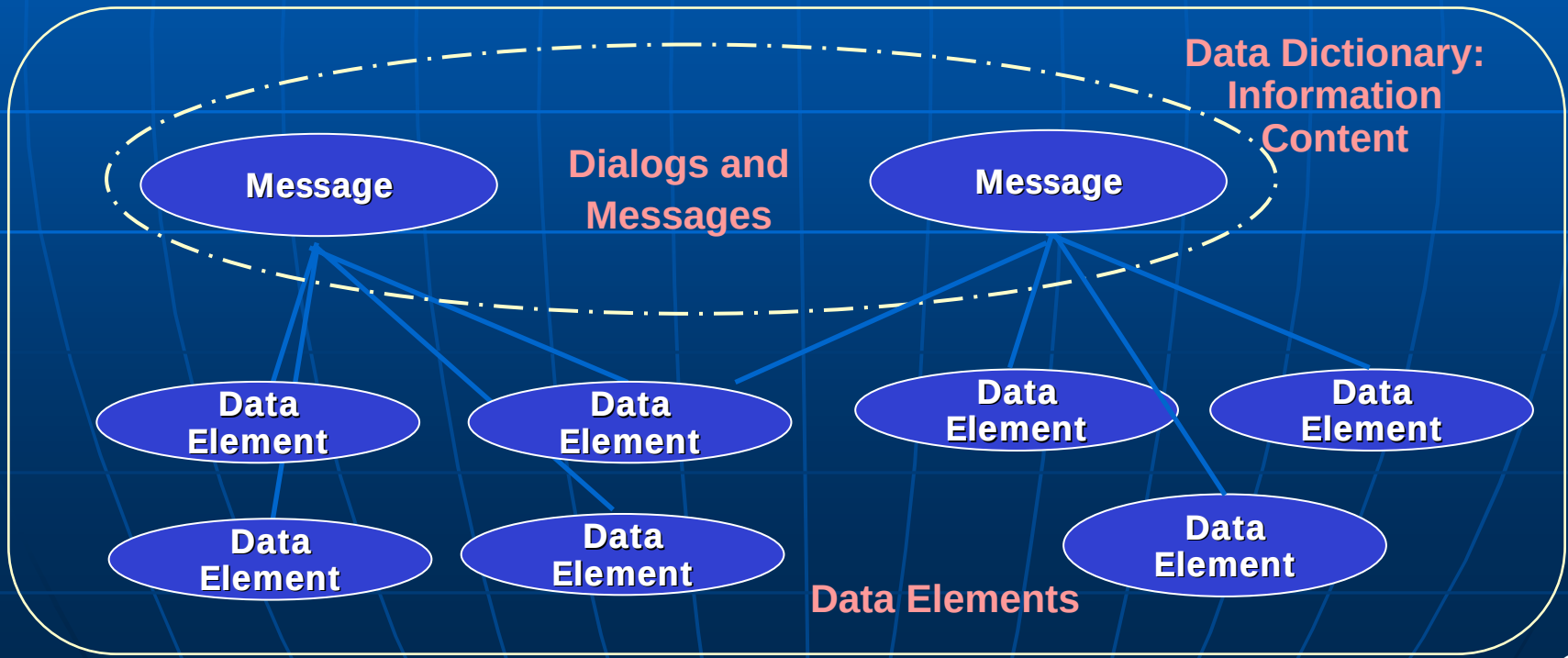






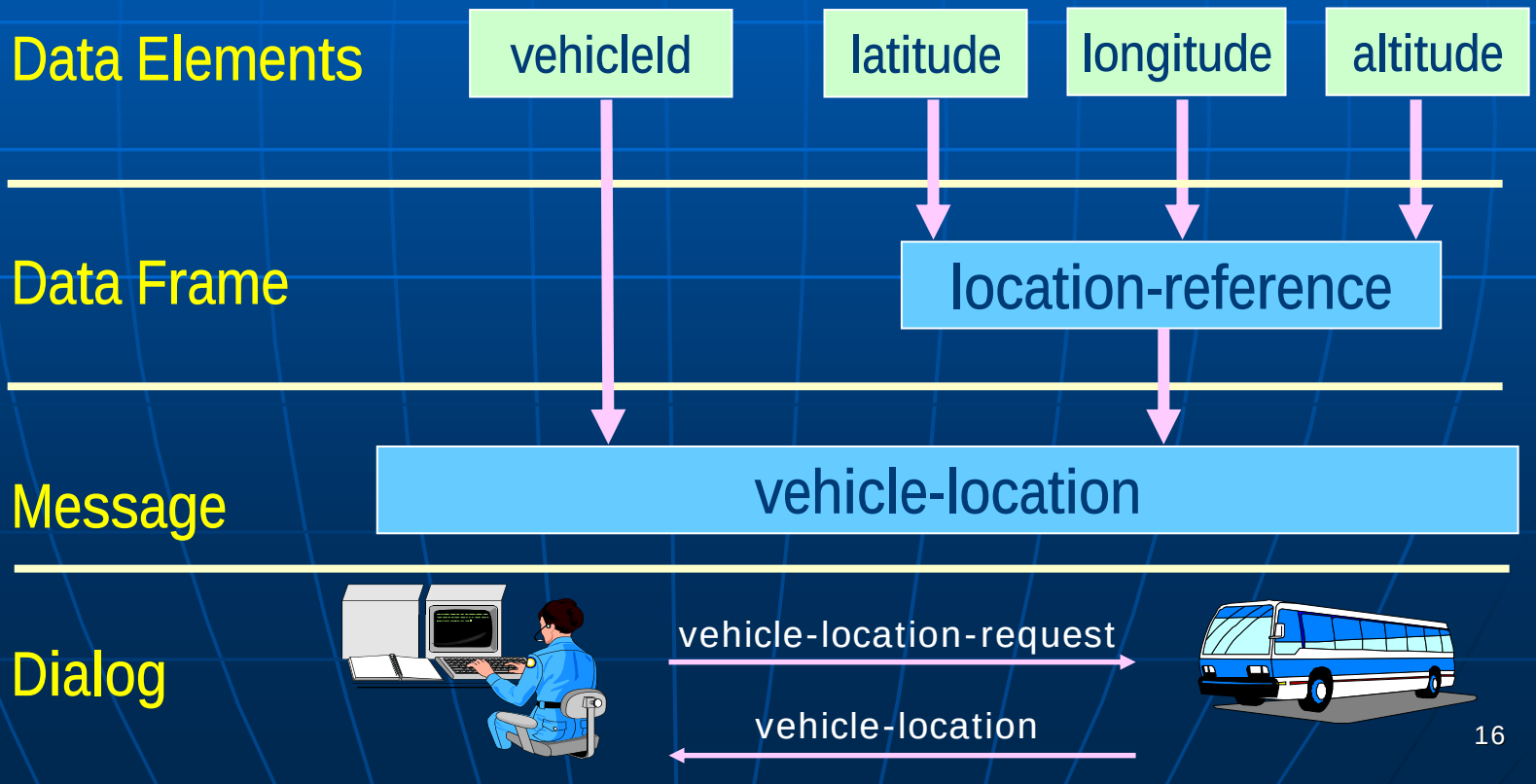
Structure of ITS Communications Standards





Hierarchy and Structure of ITS Standards

- Dialogs
  - Messages
    - Data Frames
      - Data Elements



An Analogy of the Structure of the Communication Standards and Language

- ITS Standards mostly deal with the movement of information
  - Data elements (words)
  - Data frames (phrases)
  - Messages (sentences)
  - Dialogs (rules of exchange – e.g., taking turns to speak, or saying “excuse me can you repeat that.”)

ITS Communications Standards Content

- Data Dictionary: Information Content
  - Concept of Operations documents User Needs
  - Functional Requirements documents System Interface Features
  - Dialogs
    - Sequence of Data Exchanges
  - Information Content Structure
  - Test Procedures
- Protocols: Data Exchange
  - Data Encoding
    - Method of electronic formatting of data
  - Data Transport
    - Method of transmission of encoded data and error-checking

Examples of ITS Center-to-Center Standards

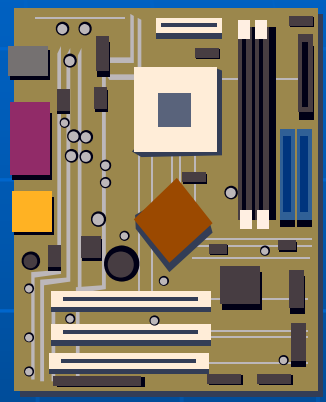
- Center-to-Center
  - Data Dictionaries
    - Traffic Management – ITE/AASHTO TMDD
    - Traveler Information – SAE-J2354
    - Public Transportation – APTA TCIP
    - Public Safety – IEEE 1512
  - Protocols
    - NTCIP 2306 – based on XML Web Services
    - HTTP – HyperText Transfer Protocol
    - FTP – File Transfer Protocol

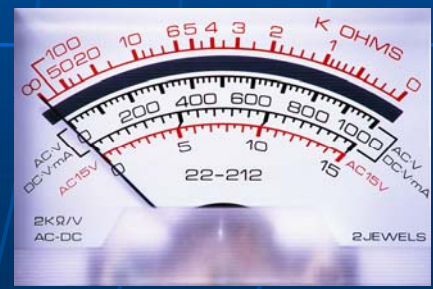
Examples of ITS Center-to-Field Standards

- Center-to-Field
  - Data Dictionaries
    - Actuated Signal Controller – NTCIP 1202
    - Dynamic Message Signs – NTCIP 1203
    - Environmental Sensor Stations – NTCIP 1204
    - Surveillance Cameras (CCTV) – NTCIP 1205
  - Protocols
    - NTCIP 2301 – based on SNMP (Simple Network Management Protocol)
    - UDP/IP

Hardware Standards Content

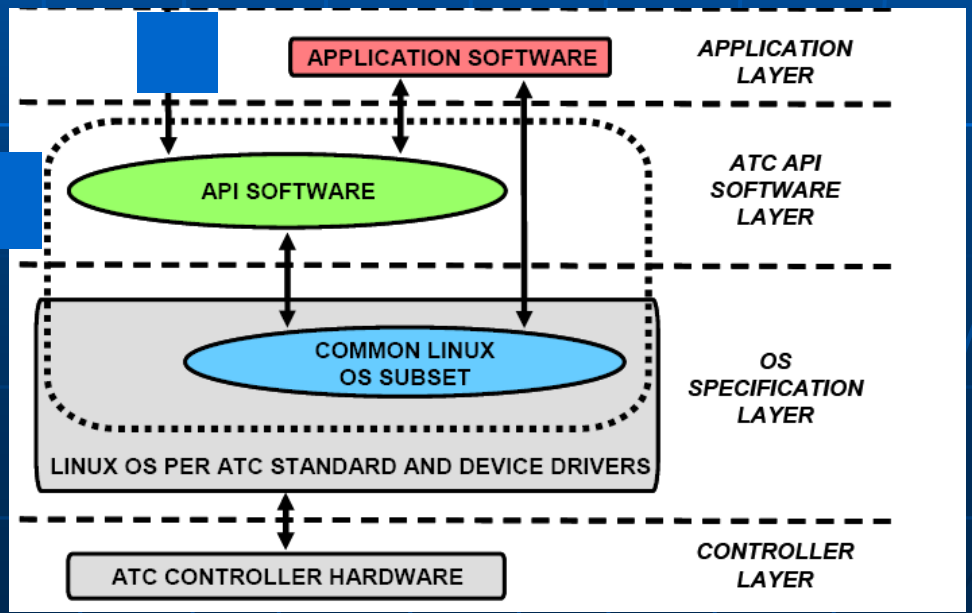
- Hardware and Environmental Specifications
  - Electrical
    - Data Communications
    - Bus and Input/Output
    - Power and Limits
  - Physical and Mechanical
    - Dimensions
    - Location and Size of Openings
    - Harnessing
    - Construction, Materials, and Fasteners
  - Environmental
    - Humidity, pressure, temperature, vibration, shock, radiation and electro-magnetic





Advanced Transportation Controller (ATC) Hardware Standards

- Advanced Transportation Controller
- ITS Cabinet
- Application Programming Interface (API)



Testing Standards

- ITS Communications Standards:
  - Focus is on the format and content of test documentation (NTCIP 8007), including test cases and procedures
- Hardware Standards:
  - These standards already include test procedures for performance and environmental testing
- Several guides exist to describe a testing process
  - A consistent theme in the guides is the need for testing to be requirements-based – a part of the Systems Engineering Process

Outreach and Training (Links on next two slides)

- Guides
  - Systems Engineering
  - NTCIP Guide
  - Test Planning and Testing
- ITE Professional Capacity Building Program
  - Standards Overview
  - Center-to-Center Communications
  - Environmental Sensor Stations
  - Dynamic Message Signs
- ITS Standards Fact Sheets
  - Executive summary style description of standards
  - Excellent entry-point to learn about the standards
- ITS Standards Web Sites
  - FHWA, ITE, NTCIP

Available Guides/Reports

ITS Standards Fact Sheets	http://www.standards.its.dot.gov/factsheets.asp
TMDD Guide	www.ite.org/standards/TMDDstandardv03Guide.pdf
APTA TCIP	http://www.aptastandards.com/StandardsPrograms/ITStandardsProgram/TCIPProgram/tabid/113/language/en-US/Default.aspx
GTFS	https://developers.google.com/transit/overview
IEEE 1512	http://grouper.ieee.org/groups/scc32/imwg/guide.pdf
ATC Overview	www.ite.org/standards/atc
Standards Testing	http://www.standards.its.dot.gov/learn_stdsTest.asp
NTCIP Testing (NTCIP 9012)	http://www.ntcip.com/library/documents/

Additional Web Resources

- www.standards.its.dot.gov
- www.ite.org
- www.aashto.org
- www.nema.org
- www.apta.com
- www.standards.ieee.org
- www.sae.org
- www.ntcip.org

What are the Benefits of Standards

- Interoperability
  - Ability of systems to exchange and interpret information from another system
- Shared Communications Network across ITS Devices
  - Multiple Phased Deployment
  - Multiple and Choice of Vendors
  - Multiple Devices
- Standardized Test Procedures

What are the Challenges

- Lack of awareness of level of effort to specify, implement, and test the communications standards
- There are no certification programs for vendors' products
  - Several agencies have started there own programs: example, California, Florida, Texas.
- Testing conformance and compliance remain a challenge
  - Public agencies are new to communications protocols
  - Do not have staff to dedicate to specification development and testing of ITS Standards
  - Consultants have developed expertise but not always part of the implementation team

Module 3:
Massachusetts Key ITS Standards

Criteria to Determine Key ITS Standards for Massachusetts

- Based on Assessment of ITS Projects in Massachusetts
- Applicability to Massachusetts ITS systems, existing and planned
- Maturity of the standard
- National and Massachusetts project experience with implementation of the ITS standard
- There is a draft report available

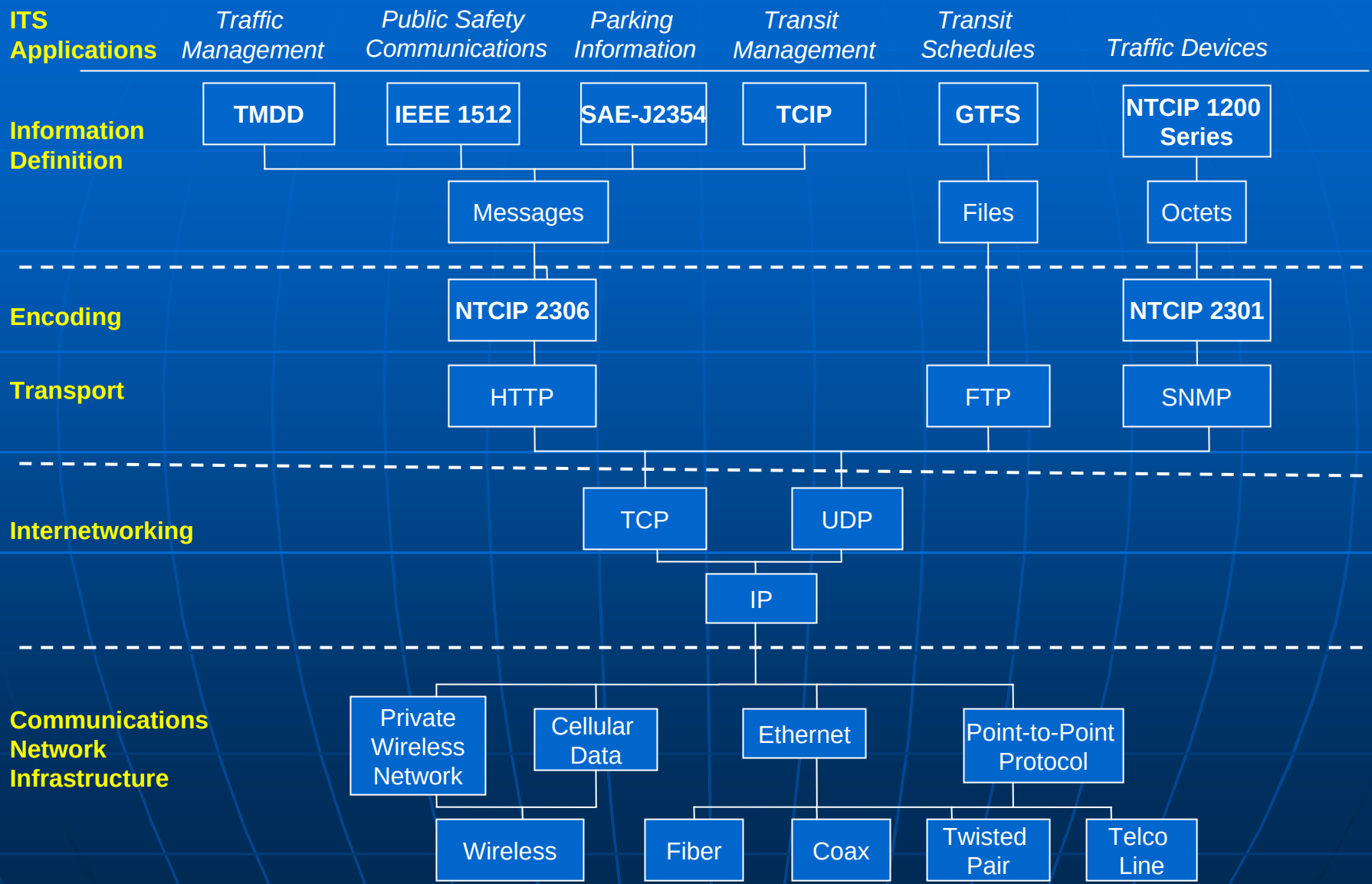
Partial Massachusetts ITS Projects (from Key ITS Standards Report)

Responsible Agency	Project Name	Stage	Location	Project Type	Candidate ITS Standards
MassDOT - Highway Division	Transit Signal Priority in Northhampton	Programmed	Route 9	Transit Signal Priority	TCIP / NTCIP 1211
FRTA	Fixed Route AVL	Programmed	FRTA Region	Automatic Vehicle Location for Transit	TCIP / GTFS
Pioneer Valley Planning Commission	Interactive Voice Response	Programmed	PVTA Region	Traveler Information	TCIP / GTFS-realtime
PVTA	System Integration	Planned	PVTA Region	Transit Back End Infrastructure	TCIP / GTFS
PVTA	Automatic Vehicle Location	Planned	PVTA Region	AVL for Transit	TCIP / GTFS-realtime
PVTA	Traveler Information	Planned	PVTA Region	Transit Traveler Information	TCIP / GTFS-realtime

Massachusetts Key ITS Standards Framework

- Framework is organized into 5 Levels
  - **ITS Applications** – Derived from ITS projects
  - **Information Definition** – Information specification of the content needed to support ITS Applications
  - **Encoding and Transport** – Information formatting and handling of sending/receiving
  - **Internetworking** – TCP/IP "Glue" between communications software and the communications network infrastructure
  - **Communications Network Infrastructure**
    - Communications network plant and media.
    - Hardware and signaling interfaces.
      - E.g. RJ-45, Ethernet, RS-485, USB

Massachusetts ITS Standards Framework



Massachusetts Key ITS Standards (1 of 2)

ITS Application	Key ITS Standard	Description / Purpose of Standard
Traffic Management	TMDD	The Traffic Management Data Dictionary provides for information and control exchanges related to roadway and traffic management operations.
Public Safety Communications	IEEE 1512	IEEE Standard for Traffic Incident Management Message Sets for Use by Emergency Management Centers focuses on the exchange of information about traffic and public safety agency resources used during traffic incident response.
Parking Traveler Information	SAE-J2354	The Message Set for Advanced Traveler Information System (ATIS) contains sections relevant to parking management and related traveler information.
Transit Management	TCIP	The Transit Communications Interface Profile covers transit operations and communications between centers, and centers and transit vehicles. Especially relevant are sections on Fare Collection, Passenger Counting, and Transit Priority.
	GTFS	The General Transit Feed Specification is a community-based standard developed outside of the USDOT Standards program. It is being widely deployed by transit agencies and is used to define transit schedule and real time transit service information.
Traffic Devices	NTCIP 1200 Series	The NTCIP 1200 Series contains definition of information elements for the configuration, status monitoring, and control of ITS field equipment related to traffic management (e.g., CCTV, Dynamic Message Signs, Environmental Sensor Stations, Traffic Sensors and Counters, to name a few.)

Massachusetts Key ITS Standards (2 of 2)

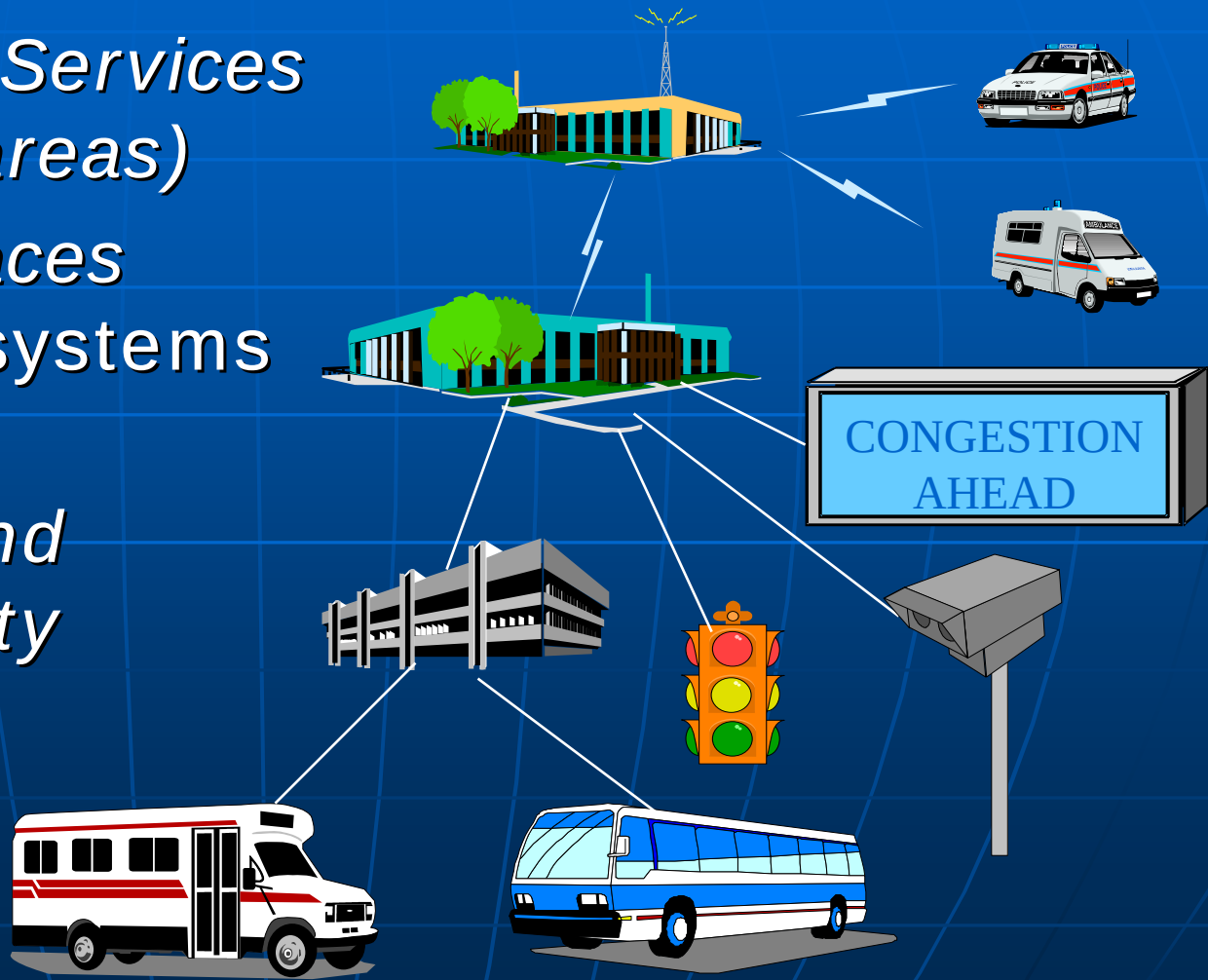
Encoding Transport Internetworking	Key ITS Standard	Description / Purpose of Standard
Center-to-Center Communications	NTCIP 2306	NTCIP 2306 defines encoding and transport communication of messages between transportation management centers including traffic management centers, transit management centers, or public safety. It is largely based on the Web Services Architecture and standards of the World Wide Web Consortium.
Center-to-Field Communications	NTCIP 2301	NTCIP 2301 defines encoding and transport communication between a traffic management center and field device. The standard is largely based on Internet Engineering Task Force Simple Network Management Protocol (SNMP)
Internetworking	TCP/IP and UDP/IP	A protocol for the transmission of data across an internetwork.

Module 4:
ITS Standards in Context -
National and Regional ITS Architecture Overview

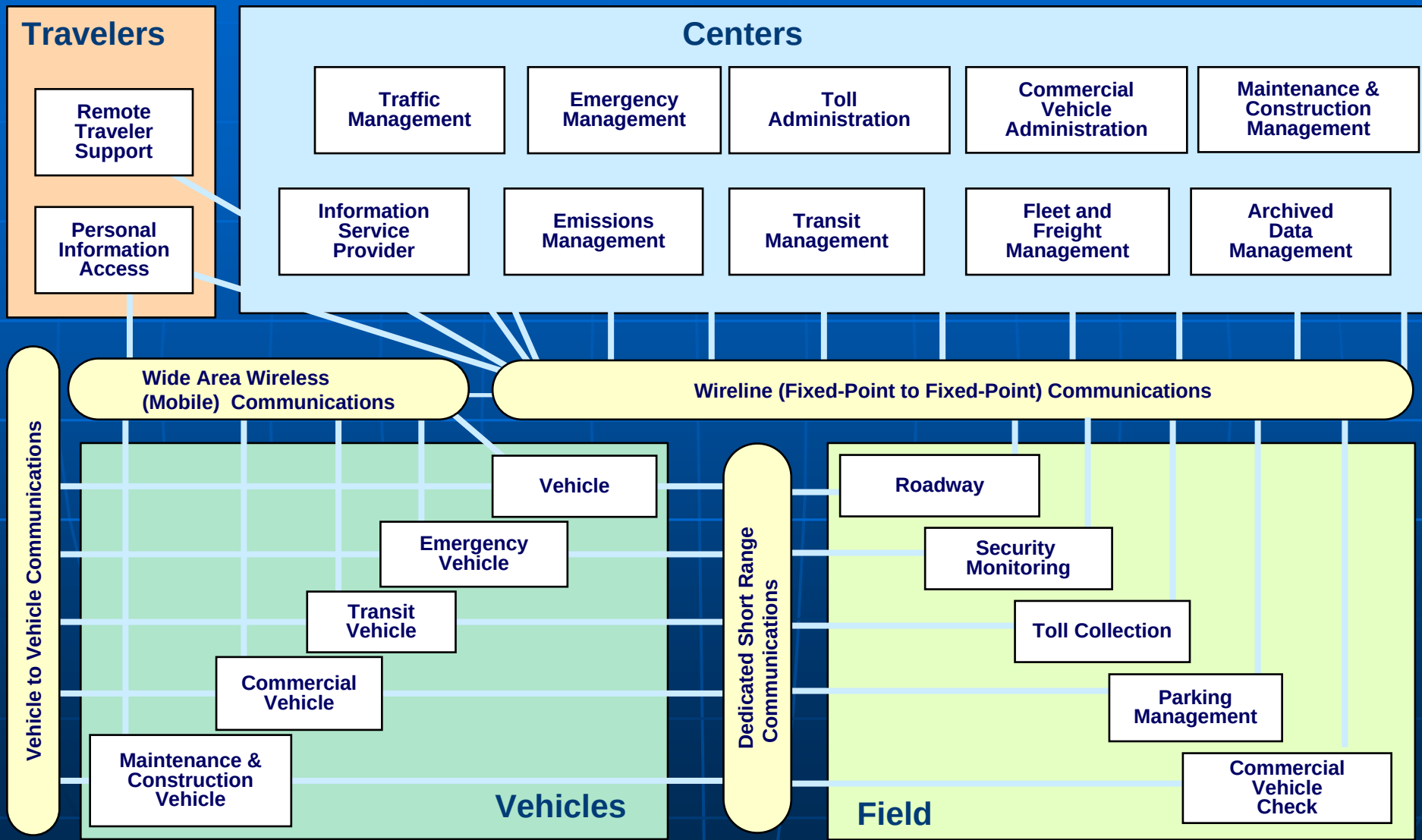
Module 4.1:
Introduction to ITS Architecture

The National ITS Architecture is a Framework to Help:

- Describe *ITS Services (application areas)*
- Define *interfaces* between subsystems
- Blueprint for *integration and interoperability (standards)*

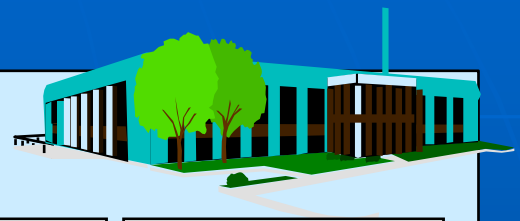


National ITS Architecture
"Sausage Diagram"



Center Subsystems

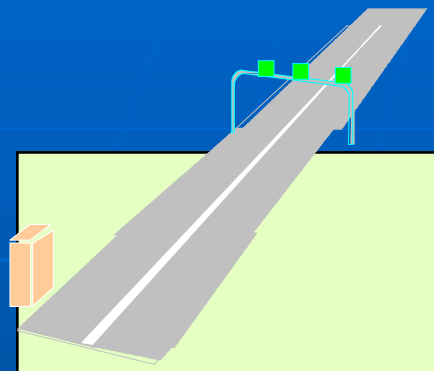
Centers



Traffic Management	Emergency Management	Toll Administration	Commercial Vehicle Administration	Maintenance & Construction Management
Information Service Provider	Emissions Management	Transit Management	Fleet and Freight Management	Archived Data Management

- Perform management and administration functions
- Coordinate with other Center Subsystems

Field Subsystems

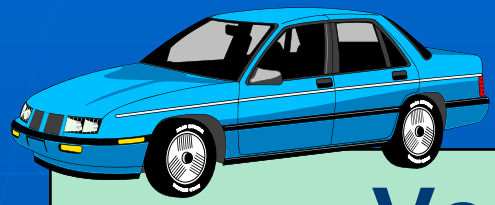


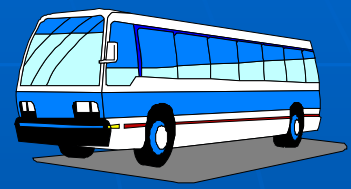
Field

- Roadway
- Toll Collection
- Commercial Vehicle Check
- Parking Mgmt.
- Security Monitoring

- *ITS* infrastructure
- *On* or *along* the transportation network
- Surveillance
- Control plans
- Supply information

Vehicle Subsystems





Vehicles

- Vehicle
- Transit Vehicle
- Emergency Vehicle
- Commercial Vehicle
- Maintenance & Construction Vehicle

Traveler Subsystems

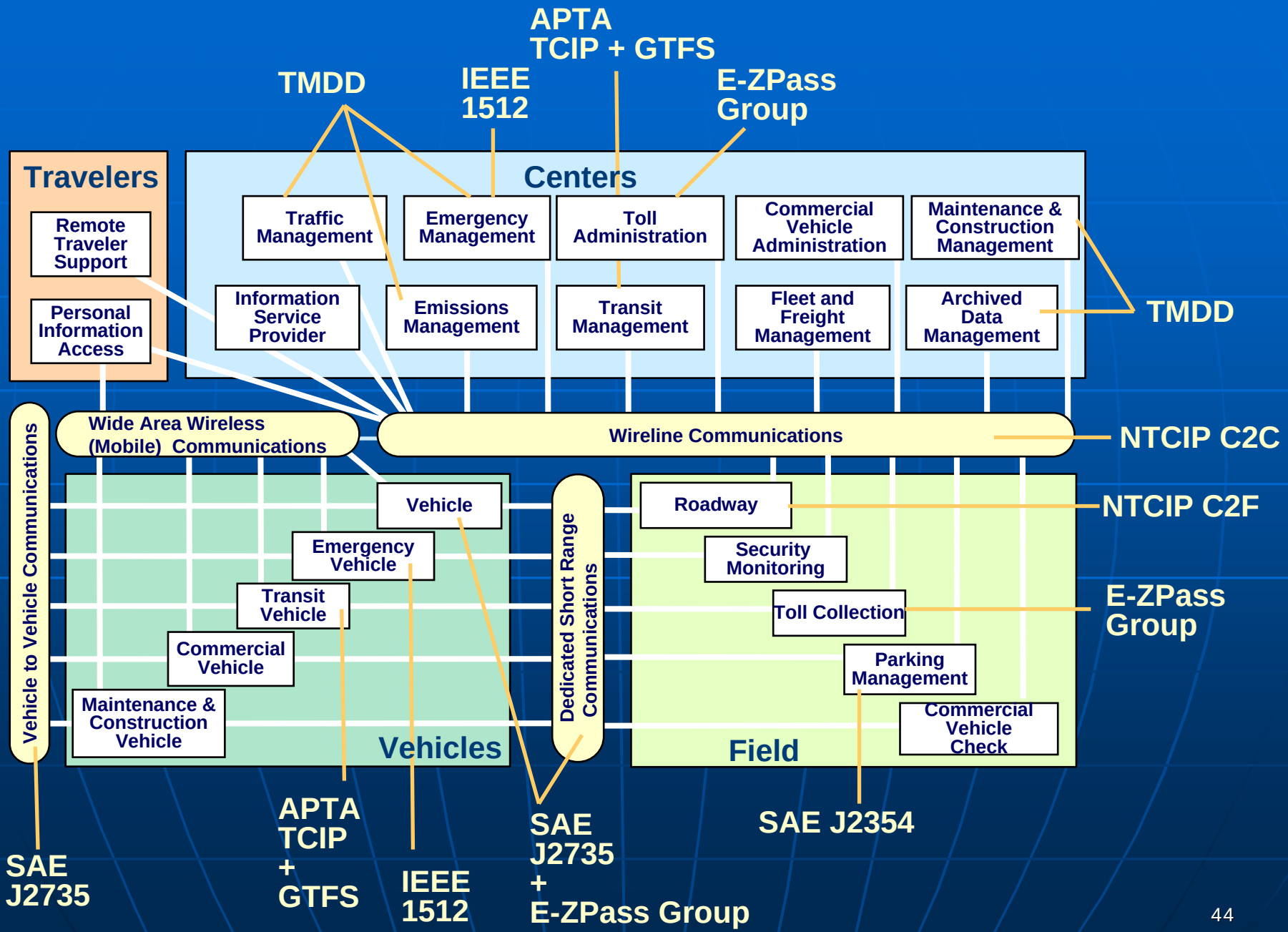
Travelers

Personal Information Access (PIAS)

Remote Traveler Support (RTS)

- Equipment To Access ITS Services
- PIAS represents "Personal" Devices
- RTS represents "Public" Devices

Massachusetts Key ITS Standards in relation to the National ITS Architecture

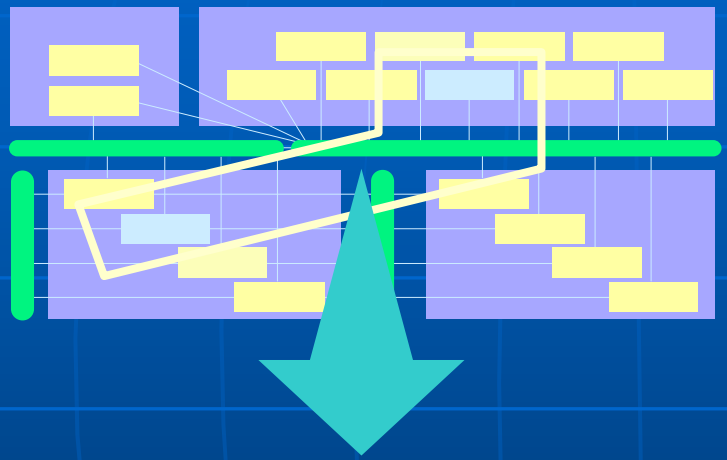


Module 4.2:
Introduction to ITS Architecture
Service Packages (previously Market Packages) and Architecture Flows

Modeling ITS Architecture Solutions: Service Packages

- The National ITS Architecture introduced the term *Service Package* (previously Market Package)
- *Service Packages* illustrate ITS elements that can be grouped to provide ITS services to transportation system users.

Service Packages



ITS Architecture

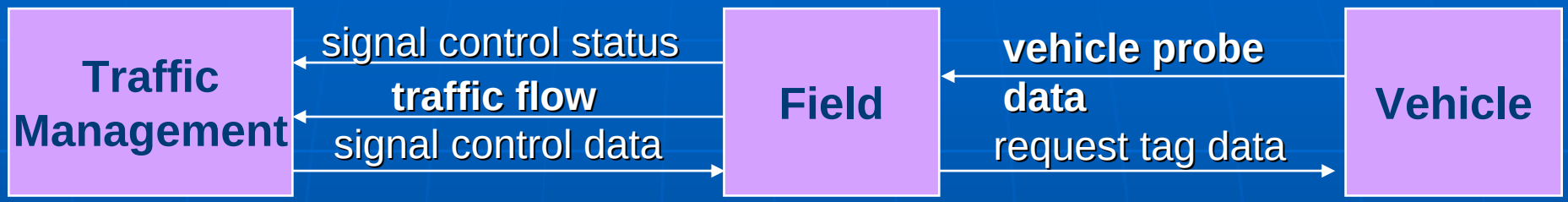
Framework spanning all of ITS

Service Packages

Pieces of the architecture that provide a particular transportation service.

Architecture Flows

Moving Standardized Information between ITS Elements: Architecture Flows



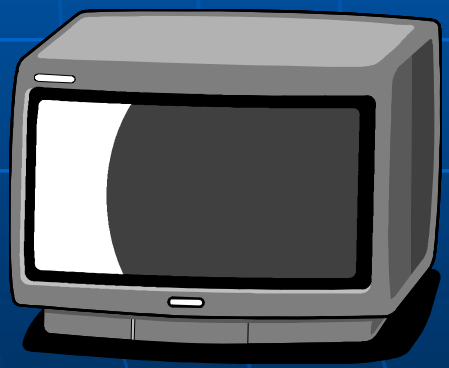
- *Architecture Flows*
  - Identify the expected types of information messages that flow between ITS elements
  - Provide a high-level mapping to ITS standards

… let's look at a few examples

Traffic Information Dissemination

Web Site

Motorist

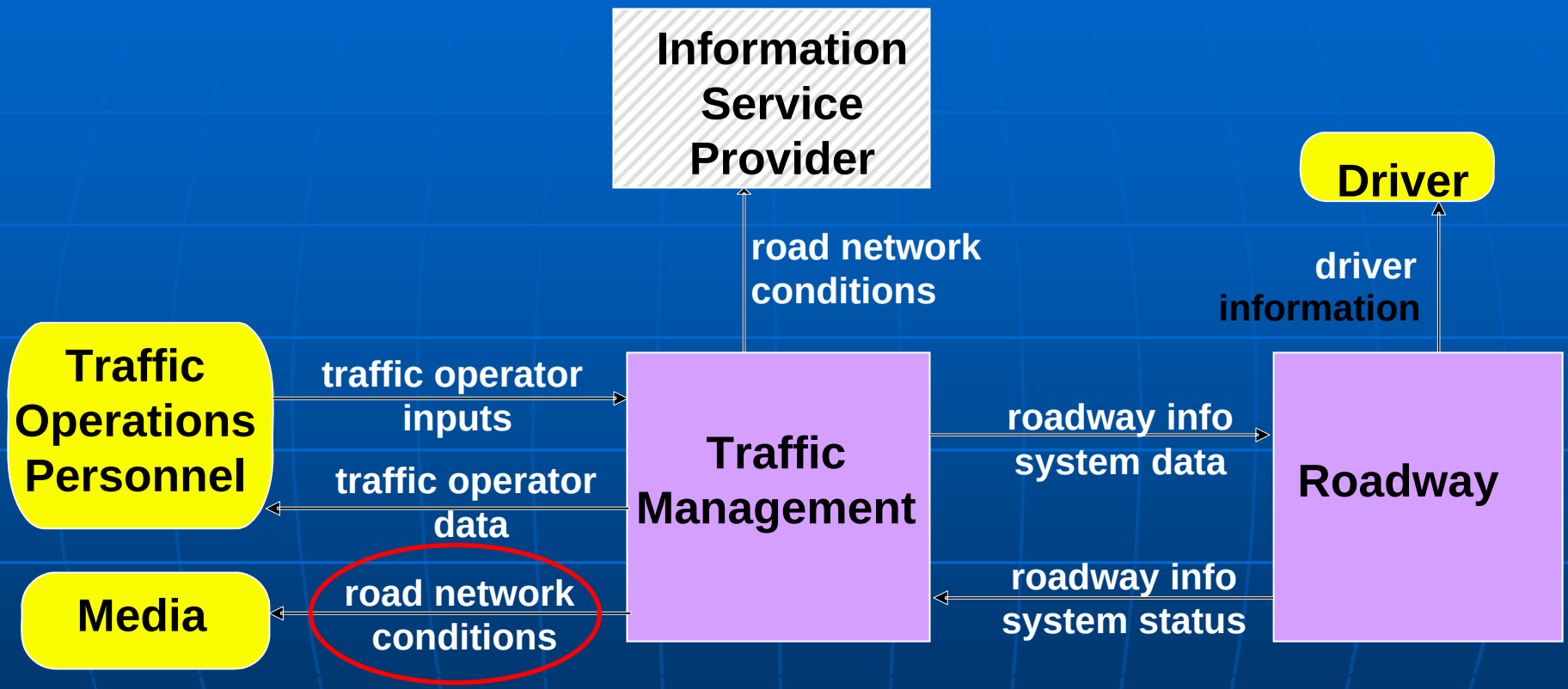


Television Station

Traffic Management Center

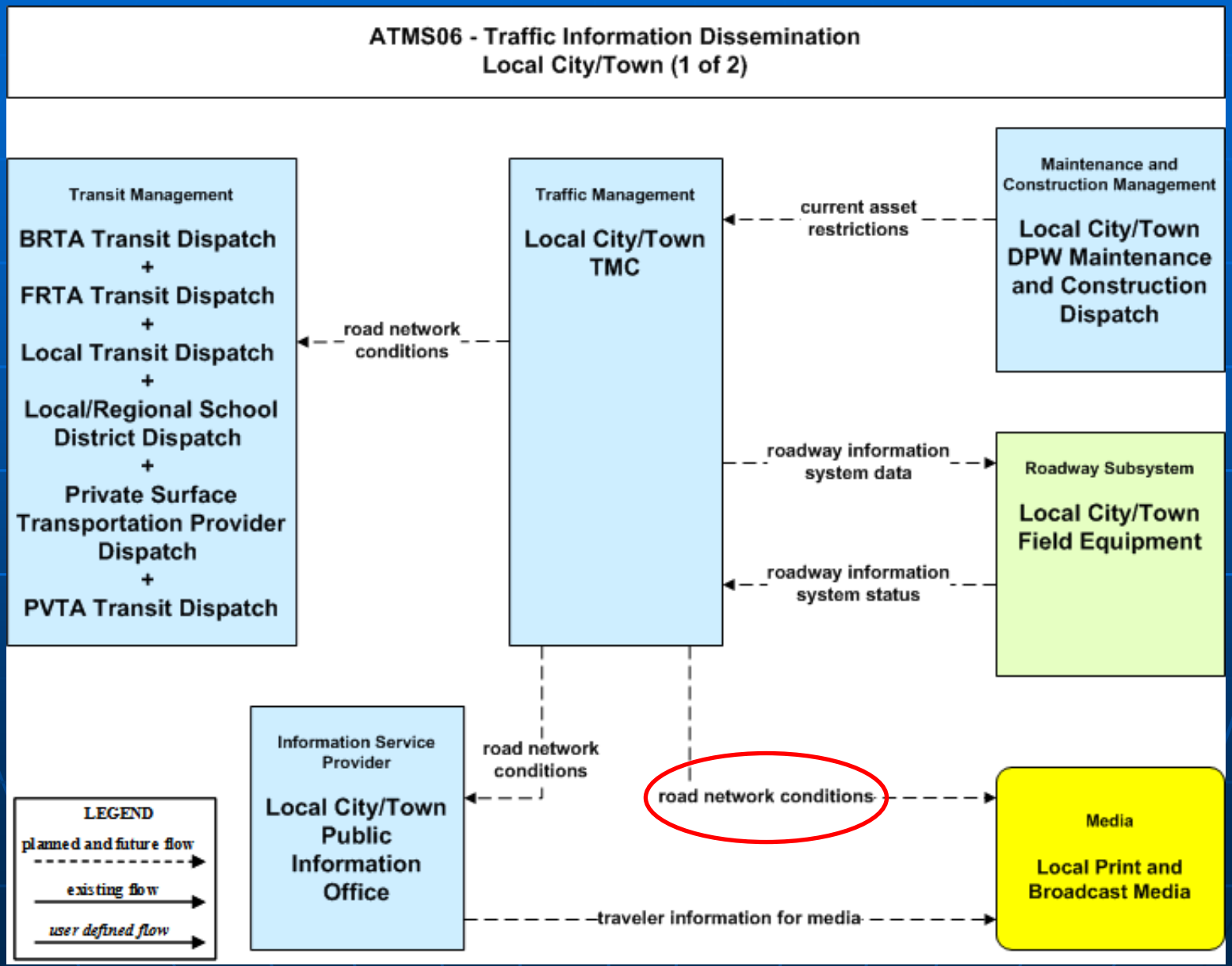
Dynamic Message Signs

ATMS06 – Traffic Information Dissemination [National ITS Architecture]



We'll track *road network conditions* from National ITS Architecture to Regional ITS Architecture and identify applicable ITS standards

ATMS06 – Traffic Information Dissemination [Massachusetts ITS Architecture]



ITS Architecture Flow Mapping to ITS Standards

- road network conditions
  - NTCIP C2C: NTCIP Center-to-Center Standards Group
  - ITE TMDD: Traffic Management Data Dictionary and Message Sets for External TMC Communication (TMDD and MS/ETMCC)

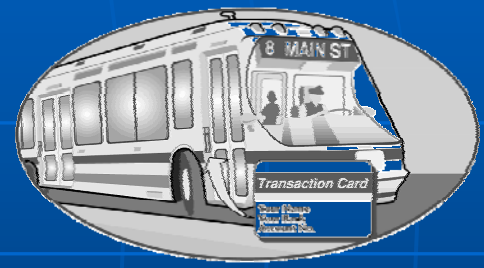
Automated Transit Fare Payment

Enforcement

Financial Institution

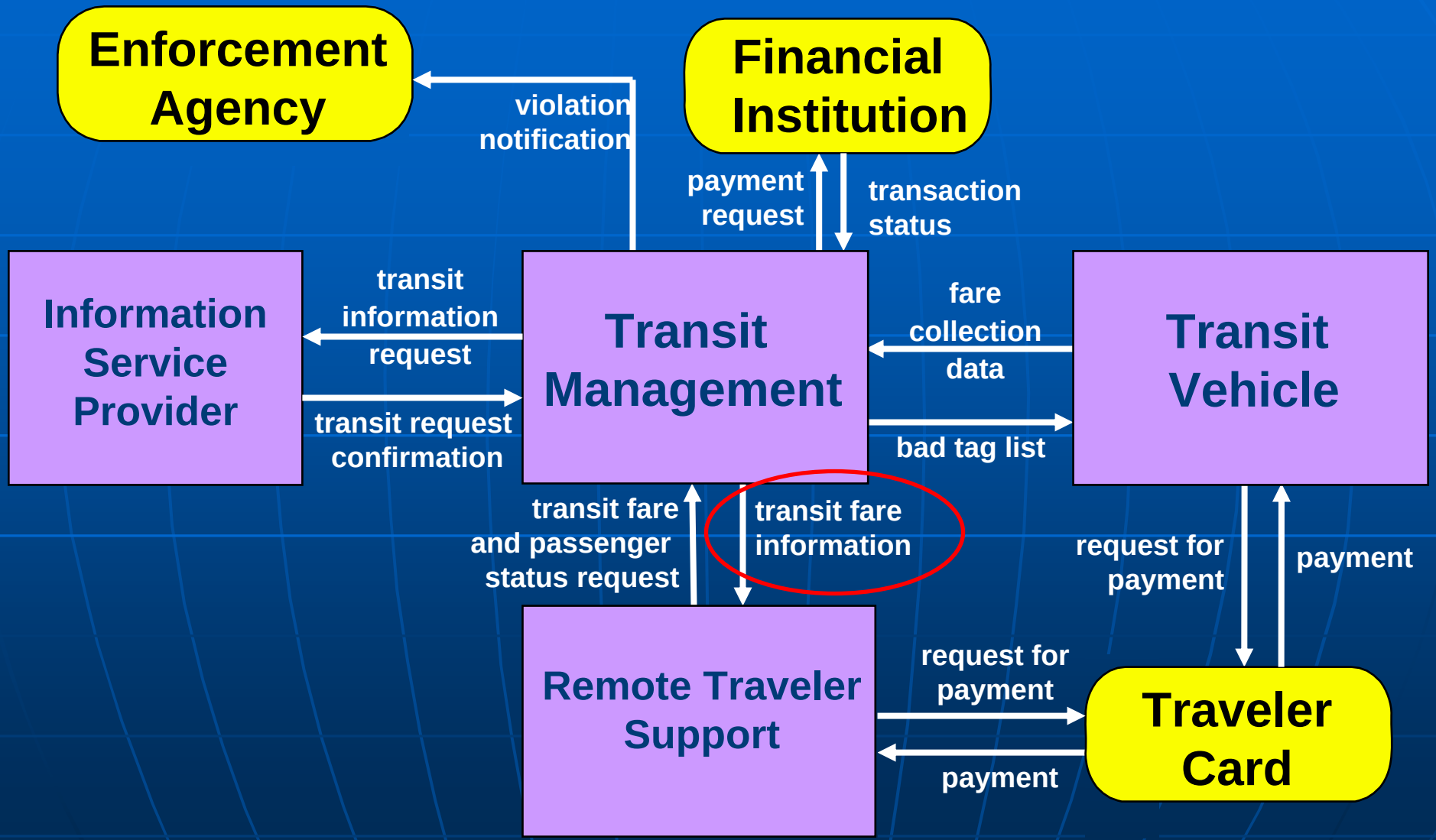
Transit Management Center

Transit Vehicle

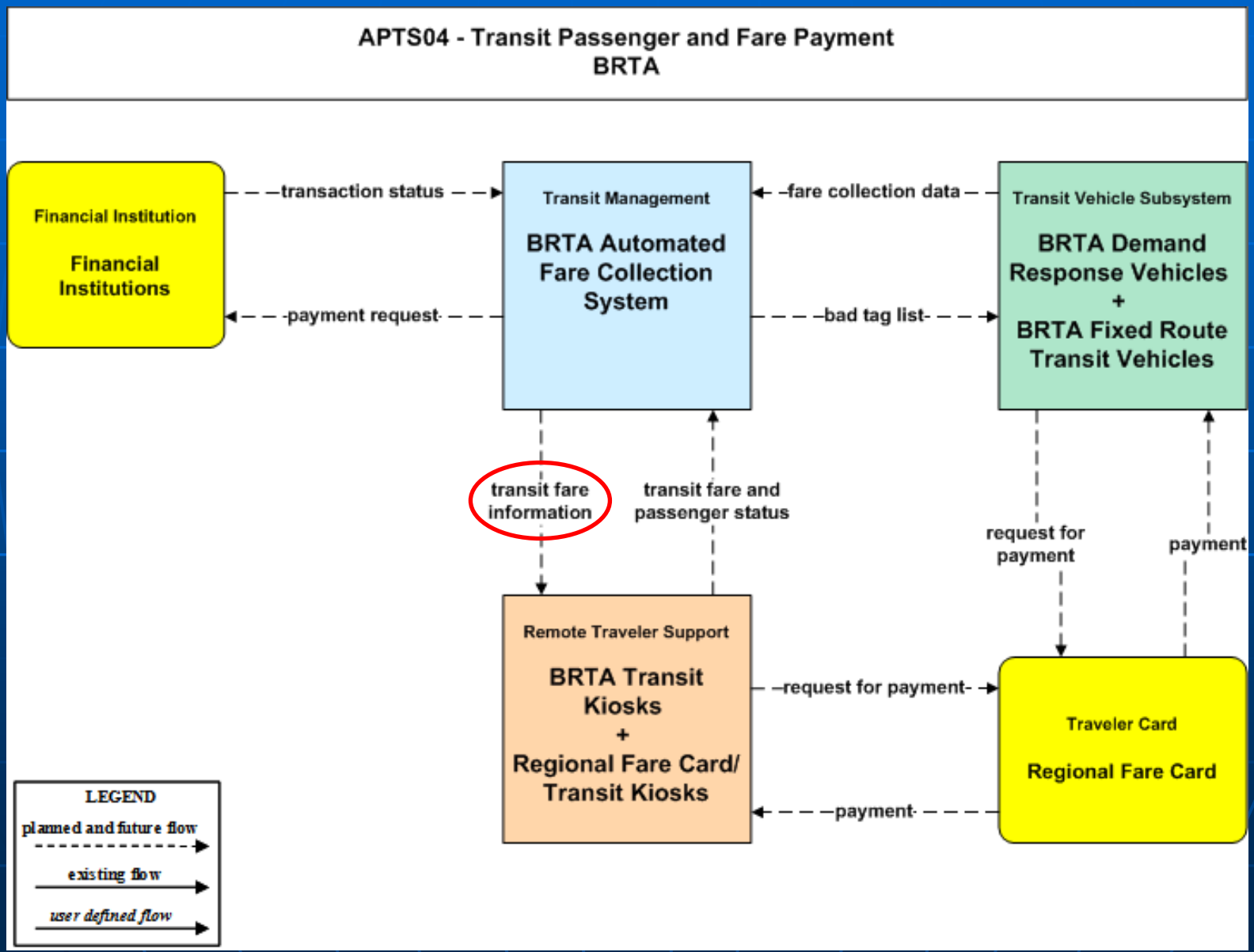


Point of Sale / Kiosk

APTS4 - Automated Fare Payment Market Package [National ITS Architecture]



ATMS04 – Automated Fare Payment [Massachusetts ITS Architecture]



ITS Architecture Flow Mapping to ITS Standards

- transit fare information
  - ATIS General Use: SAE J2354 - Advanced Traveler Information Systems (ATIS)
  - APTA TCIP: Standard for Transit Communications Interface Profiles

Module 4.3:
ITS Architecture Flow to Standards Mapping

Center-to-Center Mapping (Partial)

Source Standard	Message	Architecture Flow
TMDD	Organization Information	traffic information coordination
TMDD	DMS Inventory	traffic information coordination
TMDD	DMS Status	traffic information coordination
TMDD	DMS Status	field equipment status
TMDD	DMS Control Request	traffic control coordination
TMDD	CCTV Inventory	traffic images_ud
TMDD	CCTV Status	traffic images_ud
TMDD	CCTV Status	field equipment status
TMDD	CCTV Inventory Request	video surveillance control
TMDD	CCTV Inventory	traffic images_ud
TMDD	CCTV Inventory Request	video surveillance control
TMDD	ESS Inventory	environmental conditions data
TMDD	ESS Status	environmental conditions data
TMDD	ESS Status	field equipment status
TMDD	HAR Inventory	traffic information coordination
TMDD	HAR Status	traffic information coordination
TMDD	HAR Status	field equipment status
TMDD	HAR Control Request	traffic control coordination

Center-to-Center Mapping

- A complete set of center to center standards mappings to architecture flows will be added as an appendix to the Final Massachusetts Key ITS Standards Report

Center-to-Field Mapping

Source Standard	Message or MIB	Architecture Flow
NTCIP 1202 - ASC	Actuated Signal Control	signal control data
NTCIP 1202 - ASC	Actuated Signal Control	signal controls status
NTCIP 1203 - DMS	Dynamic Message Sign	roadway information system data
NTCIP 1203 - DMS	Dynamic Message Sign	roadway information system status
NTCIP 1204 - ESS	Environmental Sensor Station	environmental sensors control
NTCIP 1204 - ESS	Environmental Sensor Station	environmental probe data
NTCIP 1204 - ESS	Environmental Sensor Station	environmental conditions data
NTCIP 1205 - CCTV	Closed Circuit Television	traffic flow
NTCIP 1205 - CCTV	Closed Circuit Television	traffic images
NTCIP 1205 - CCTV	Closed Circuit Television	video surveillance control
NTCIP 1206 - DCM	Data Collection and Monitoring	data collection and monitoring control
NTCIP 1206 - DCM	Data Collection and Monitoring	roadside archive data
NTCIP 1207 - RM	Ramp Meter	freeway control data
NTCIP 1207 - RM	Ramp Meter	freeway control status
NTCIP 1209 - TSS	Traffic Sensor Station	traffic sensor control
NTCIP 1211 - SCP	Signal Control Priority	request for right-of-way
NTCIP 1213 - ELMS	Electrical and Roadway Lighting Systems	lighting system control data
NTCIP 1213 - ELMS	Electrical and Roadway Lighting Systems	lighting system status

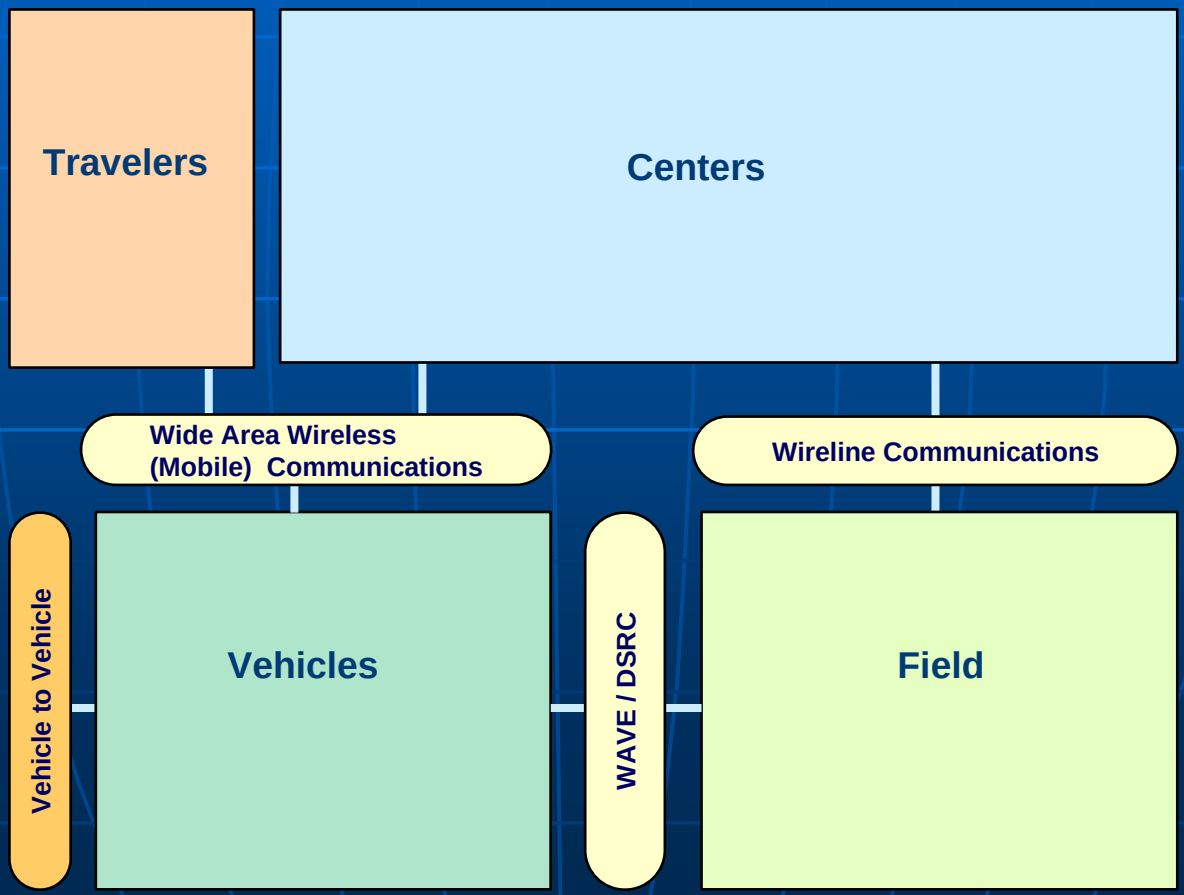
Module 4.4:
Identify System Interfaces

What is a System Interface?

- One goal of the ITS Standards is to support the development of interoperable system interfaces for real-time information exchange.
- The IEEE Standard Glossary of Software Engineering Terminology defines a *system interface* as a shared boundary across which information is passed.
- The ITS Standards are specifications for system interfaces.
- *Interoperability* is defined as the ability of two or more systems or components to exchange information and to use the information that has been exchanged.

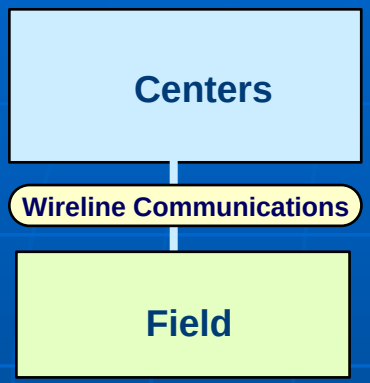
National ITS Architecture gives context to the ITS Standards

- Stripped down, the ITS architecture is all about system interfaces and information exchange

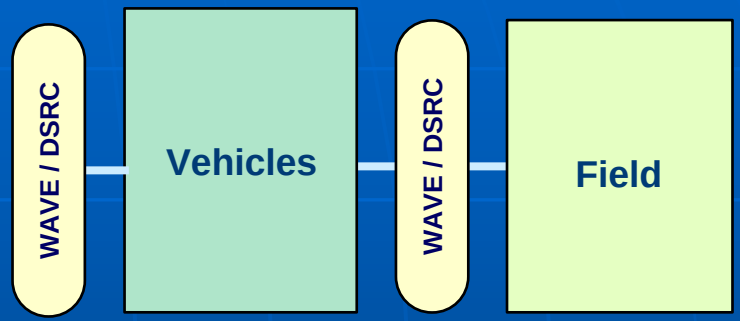


Interfaces in the ITS Architecture

1 Center-to-Field

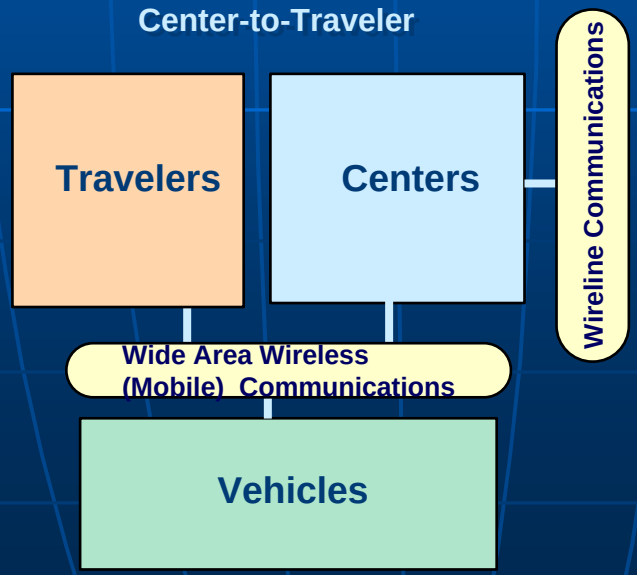


3 Connected Vehicles

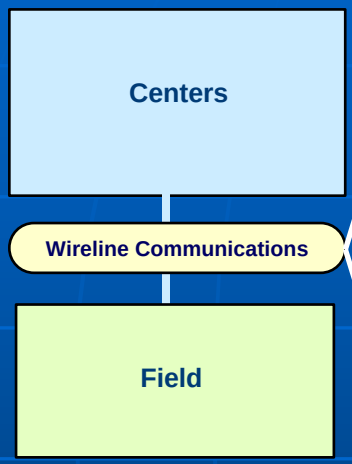


Vehicle-to-Infrastructure
Vehicle-to-Vehicle

2 Center-to-Center
Center-to-Vehicle
Center-to-Traveler



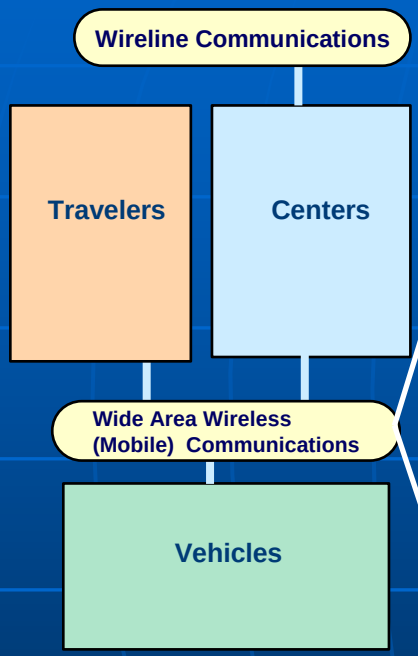
Wireline Communications



Level	Implementation	Standards
Information Definition	NTCIP MIB Objects	NTCIP 1200 Series
Encoding and Transport	SNMP	NTCIP 2301
Internetworking	UDP/IP	NTCIP 2202 identifies the use of these IETF Standards
Communications Network Infrastructure		

This “communications stack” also works for wireless devices.

Wireline Center-to-Center & Wide Area Wireless Communications



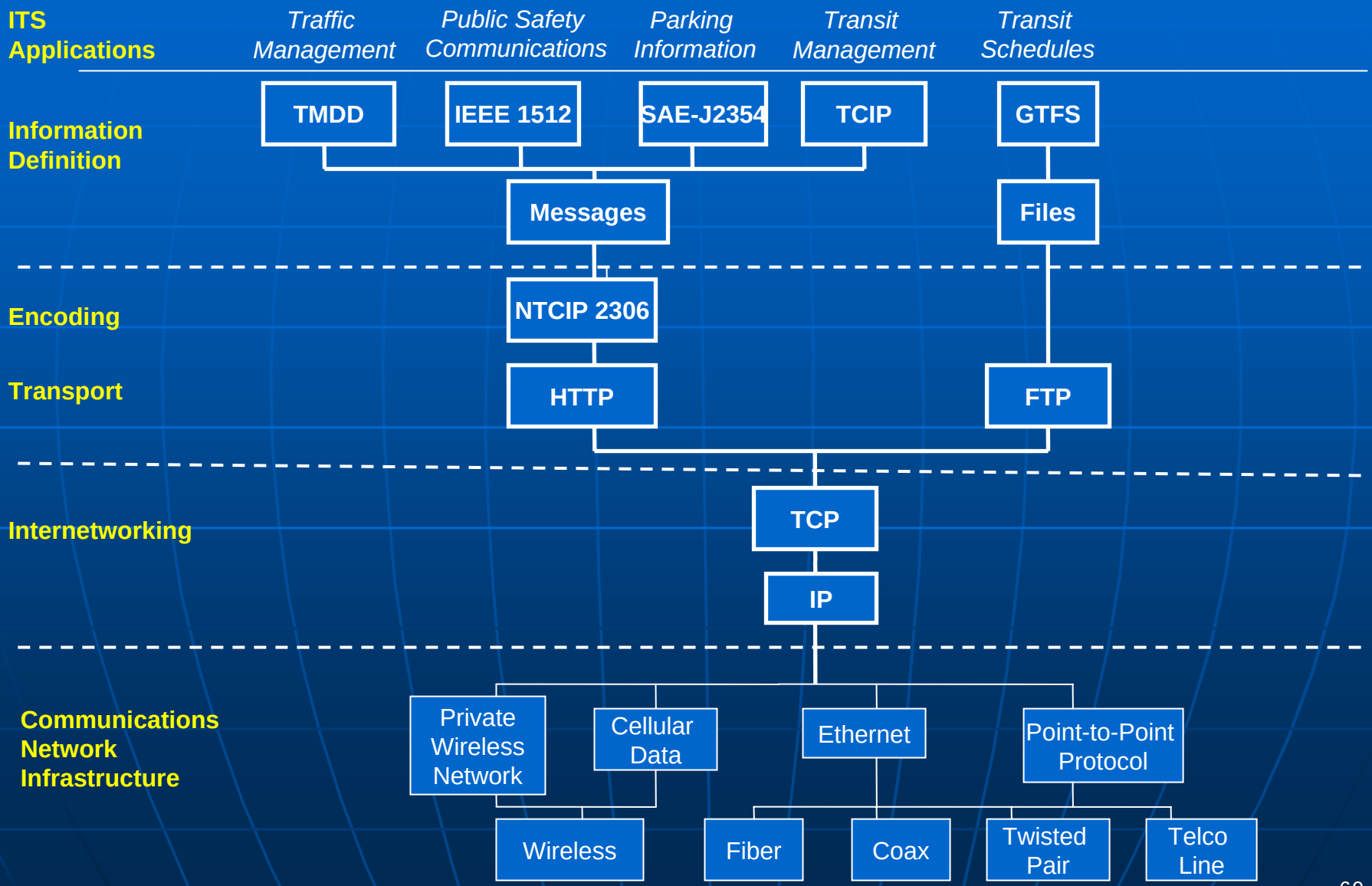
Level	Implementation	Standards
Information Definition	XML Schema WSDL	IEEE 1512.x APTA TCIP TMDD SAE J2354
Encoding	XML Add Gzip compression for transfer of large files or for wireless	NTCIP 2306
Transport	HTTP/ HTTPS	NTCIP 2306 references these standards.
Internetworking	TCP/IP	
Communication Network Infrastructure		

This “communications stack” works for wireline center-to-center.

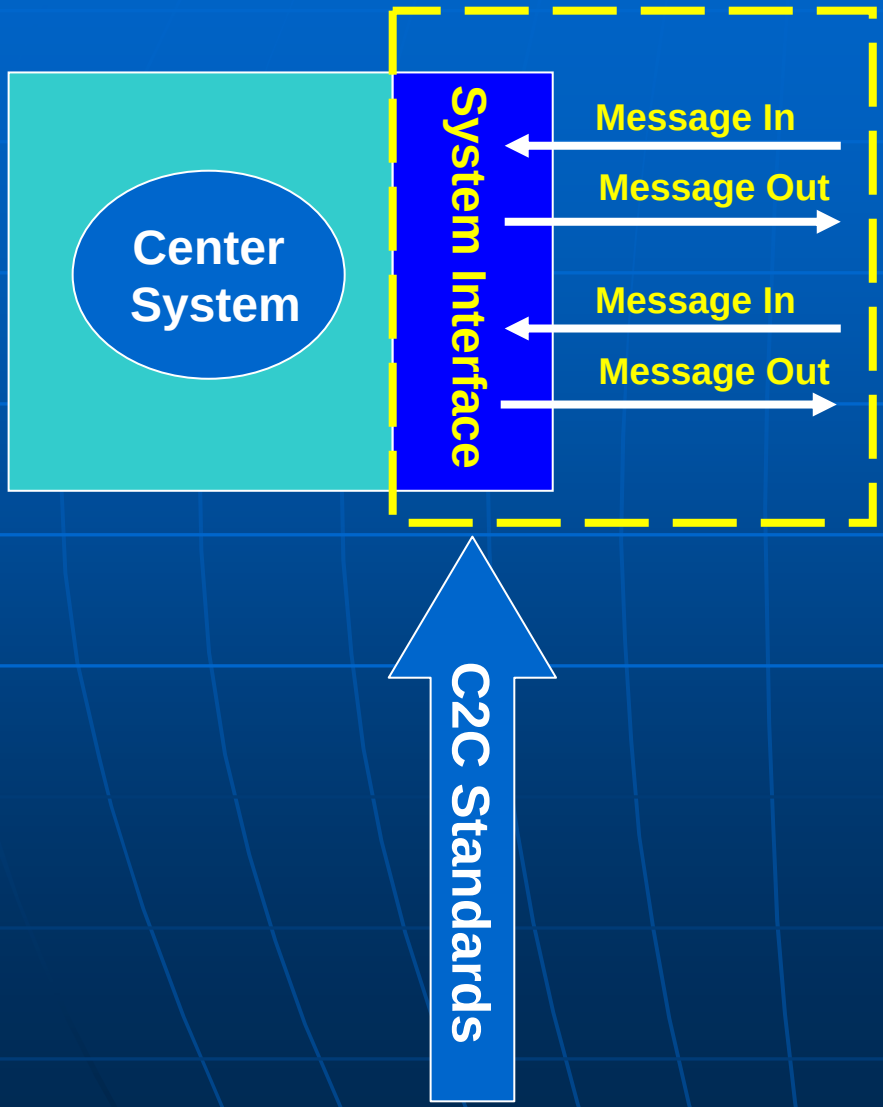
Module 5:
ITS Standards: How they work

Module 5.1:
Center-to-Center ITS Standards

Massachusetts ITS Standards Framework
Center-to-Center ITS Standards



Domain of ITS C2C Standards



- Standards only standardize the **dialogs, messages and data elements**
- Standards only standardize the **system interfaces, not system functions**
- Standards may need to be supplemented with additional information to meet local needs

Traffic Management

Joint AASHTO / ITE

Traffic Management Data Dictionary (TMDD) Standard for Traffic Management Center Communications

TMDD C2C Operations

- 2 Volumes
  - Vol 1: Concept of Operations & Requirements
  - Vol 2: Design
- TMDD identifies the operational needs in the concept of operations document
- Manage assets and other entities
- Manage information
- Monitor status
- Control devices

TMDD V3.0 Domain

- Administrative
- Organization (Access Verification)
- Events (Incidents and Planned Events)
- Device
- Closed Circuit Television (CCTV)
- Dynamic Message Sign (DMS)
- Environmental Sensor Station (ESS)
- Gate Control
- Highway Advisory Radio
- Lane Control Signals
- Ramp Meter
- Traffic Signal Control
- Traffic Network (Routes, Links, Nodes, and Data)
- Traffic Detector
- Video Switch (VS)
- Weather Information

Incident Management

IEEE 1512
Emergency Management Center
Data Elements and Message Sets

IEEE 1512 Operations

- Addresses the exchange of data about **transportation-related incidents** between public safety centers and traffic management centers

Base Standard Message Sets

- **Status**
  - Incident Description (IDX)
  - Public Incident Description (PID)
  - Request Information (RIN)
- **Center Management**
  - Establish center on-line (ECO)
  - Disable center on-line (DCO)
  - Establish center properties (ECP)
  - Change center properties (CCP)
  - Request center plans (RCP)
- **Incident Management**
  - New Incident Event (NIE)
  - Split Incident Event (SIE)
  - Merge Incident Event (MIE)
  - Close Incident event (CIE)
  - Poll for hand off (PHO)
  - Available for hand off (AHO)
  - Request hand off (RHO)
  - Grant hand off (GHO)
  - Request verified incidents (RVI)
  - Request unverified incidents (RUI)

Advanced Traveler Information Systems

SAE J2354
Advanced Traveler Information System (ATIS) Message Set

SAE ITS Standards

- Advanced Traveler Information System Message Set (J2354)
- Location Referencing Message Specification (J2266)
  - A common reference for all C2C ITS Standards
- Dedicated Short Range Communications (J2735)
  - Connected Vehicles

Types of Information in ATIS

- Events (planned/construction)
- Incidents (unplanned events)
- Road/Link Information (travel times, speeds)
- Weather Conditions (observations, forecasts, surface weather)
- Itineraries (driving and/or transit)
- Flight Information (departure, arrival)
- **Parking (lot availability, reservations)**
- Preference settings (account management)
- Directory services (Yellow Pages, eCommerce)
- Mayday (emergency help requests)

Transit ITS Standards

APTA TCIP
Transit Communications Interface Profile

Types of Information in TCIP

- Common Public Transport
- Scheduling
- Passenger Information
- Transit Signal Priority
  - *NOTE*: NTCIP 1211 covers field side interfaces with traffic controller
- Control Center
- Onboard Systems
- Spatial Referencing
- Fare Collection

Transit Google Community Standard

GTFS
General Transit Feed Specification

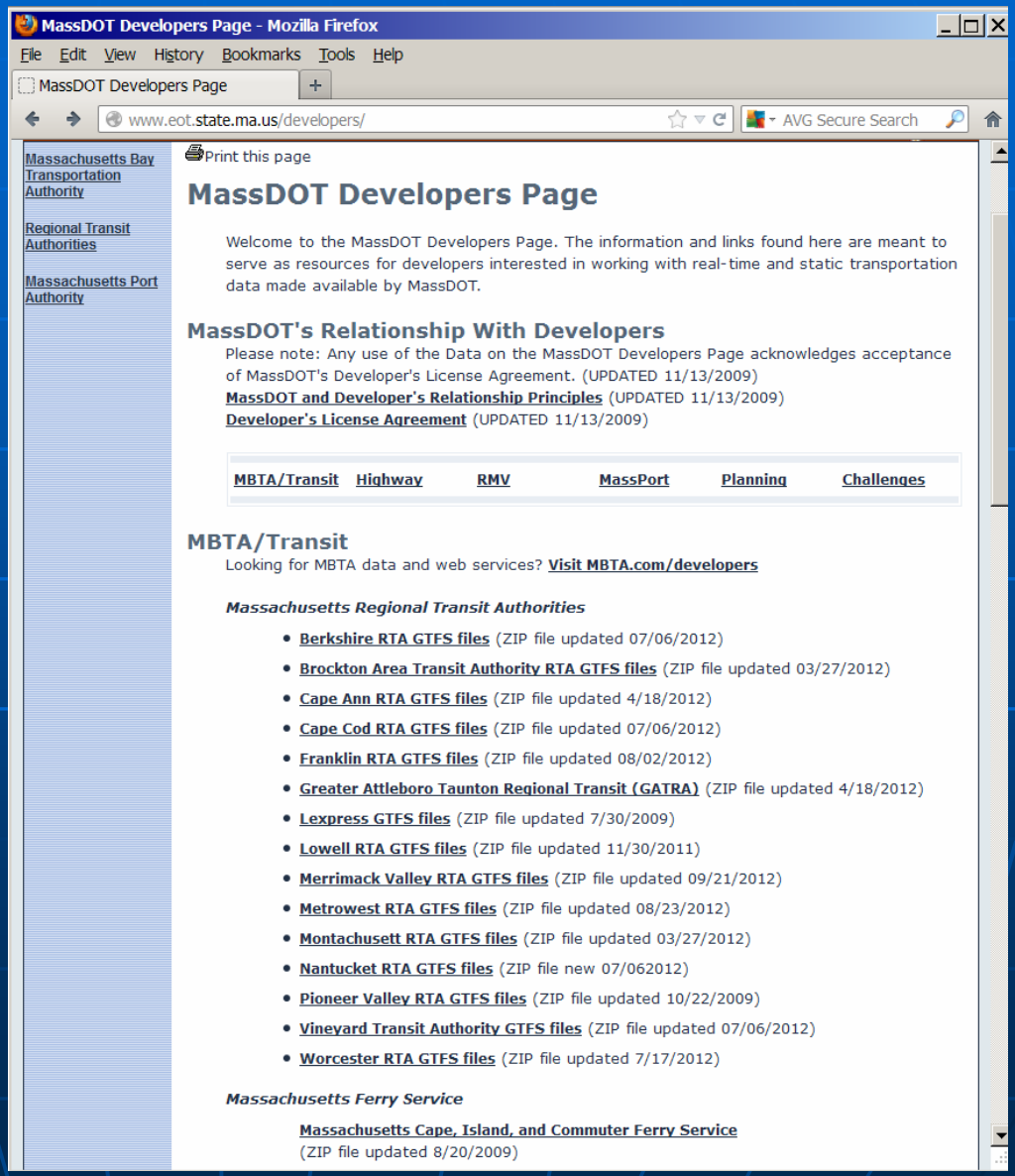
GTFS-realtime

Types of Information in 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.

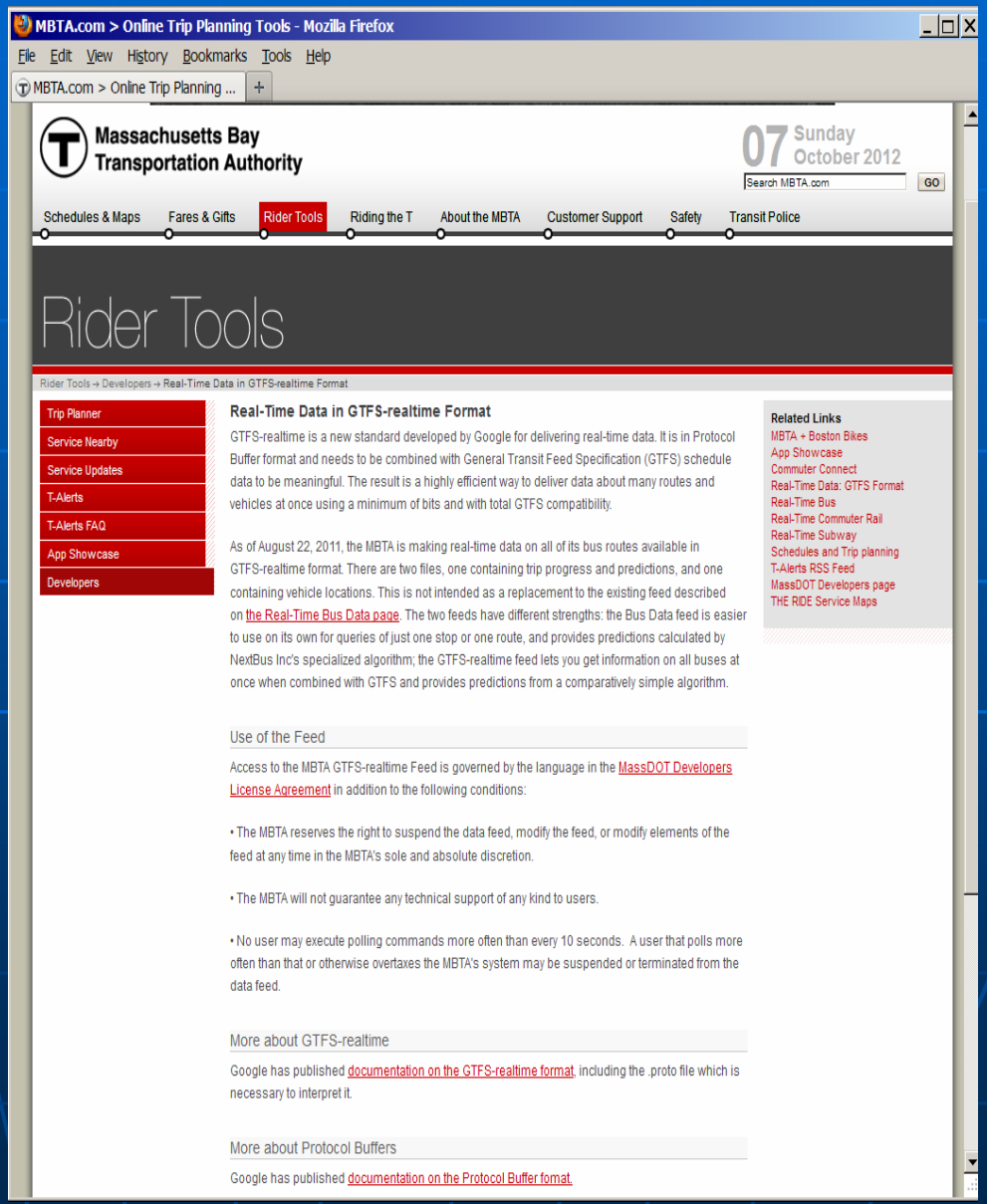
GTFS in Massachusetts

- GTFS is not an ITS standard
- 100s of Transit Agencies are using GTFS to publish schedule data
- Simple file format called CSV (Comma Separated Variables)



GTFS-realtime in Massachusetts

- GTFS is not an ITS standard
- Real-time bus location
- Schedule adherence
- Alerts



How the C2C Standards Work

How the C2C standards work

- The C2C data dictionaries (TMDD, 1512, ATIS, TCIP)
  - Define data concepts and structure
  - Data Elements - define the information type (e.g., string, numeric, or list), and value ranges.
  - Messages – define the sequence of data elements, and mandatory and optional attributes, to be transmitted.
  - Dialogs – define the sequence of message exchanges

Example TMDD Message

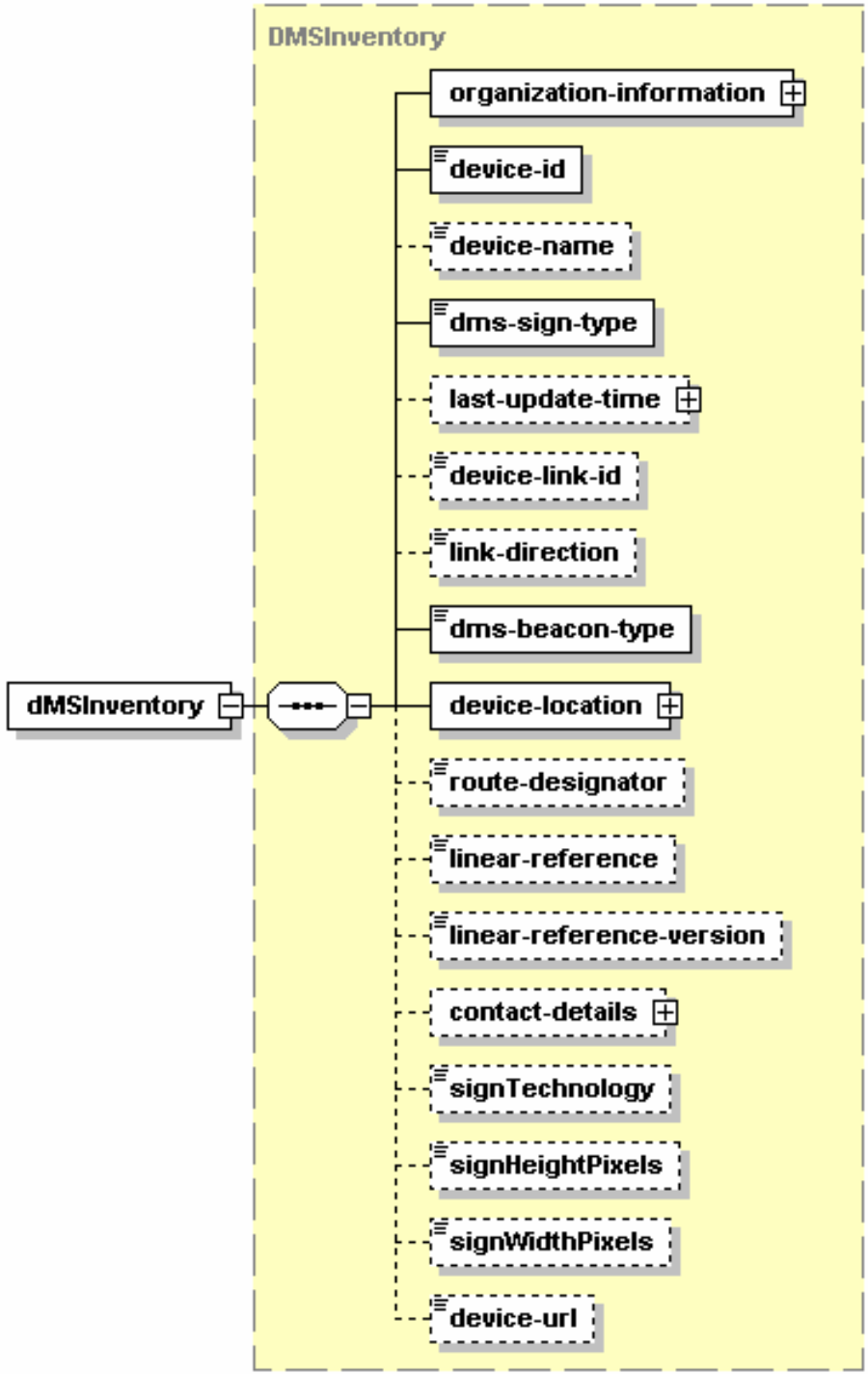
Graphical view of a DMS Inventory Message.

Typical of messages defined in TMDD, 1512, ATIS, and TCIP

Legend

mandatory

optional



Example TMDD DMS Data Element dms-sign-type (ASN.1)

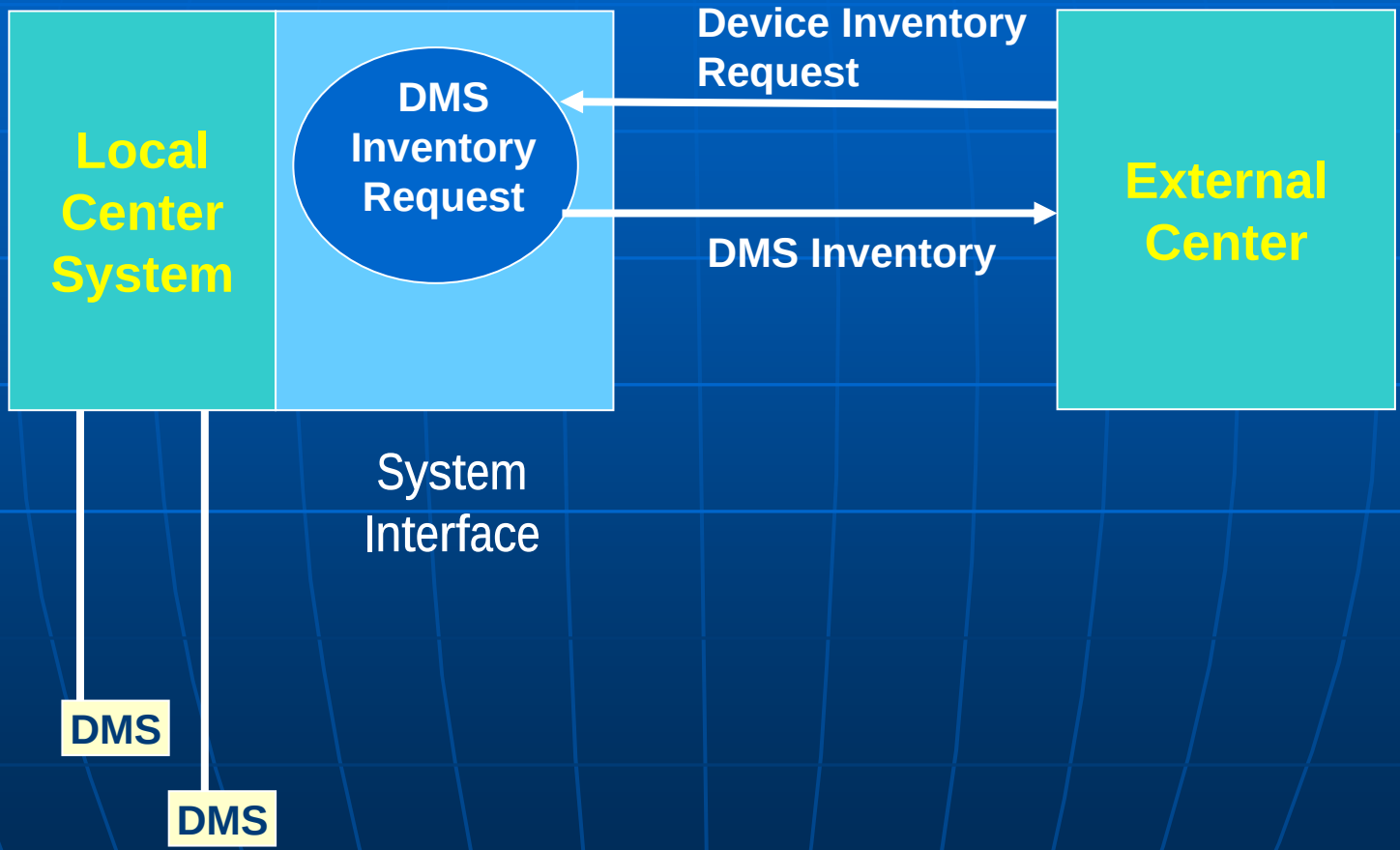
Dms-sign-type

DEFINITION
The sign type of a DMS device.

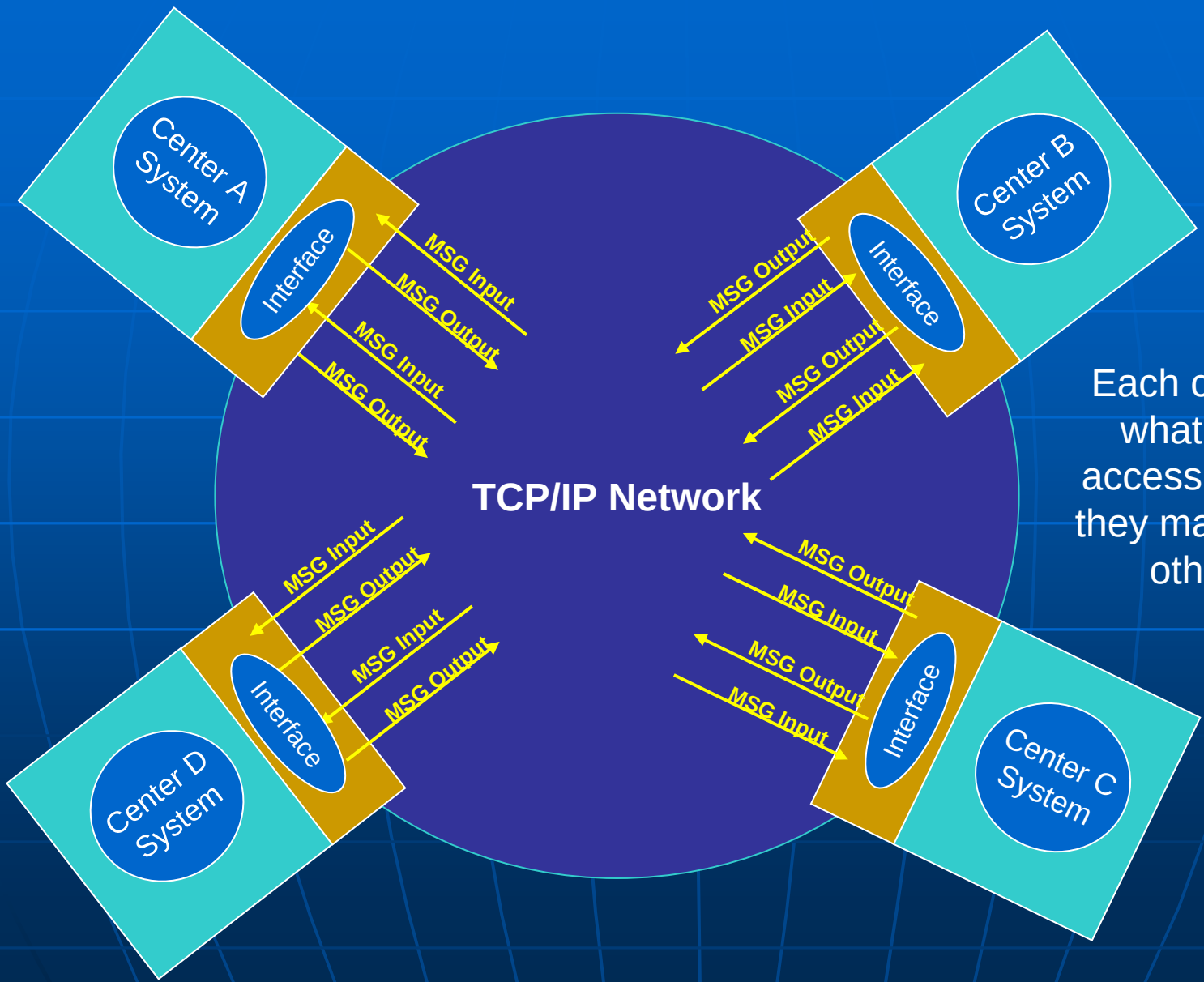
ASN.1 REPRESENTATION

```
dms-sign-type ITS-DATA-ELEMENT ::= {
        DESCRIPTIVE-NAME            "DMS.Dms-sign-type:cd“
        ASN-NAME                    "Dms-sign-type“
        ASN-OBJECT-IDENTIFIER       { tmddDataElements 34 }
        DEFINITION                  "The sign type of a DMS device.“
        DESCRIPTIVE-NAME-CONTEXT { "Manage Traffic“ }
        DATA-CONCEPT-TYPE           data-element
        STANDARD                    "TMDD“
        DATA-TYPE                   "Dms-sign-type ::= ENUMERATED {
                                            variable-message-sign-vms (1),
                                            changeable-message-sign-cms (2),
                                            blank-out-sign-bos (3),
                                            portable-vms (4),
                                            other (5),    ...
                                    }“
        FORMAT                      "ASN.1 encoding“
        UNIT-OF-MEASURE             ""
        VALID-VALUE-RULE            "see the ASN.1 DATA-TYPE“
}
```

Interface Dialog to DMS Inventory Request



Regional C2C Integration Concept



Each center controls what information, access, and functions they make available to other centers.

Deployments

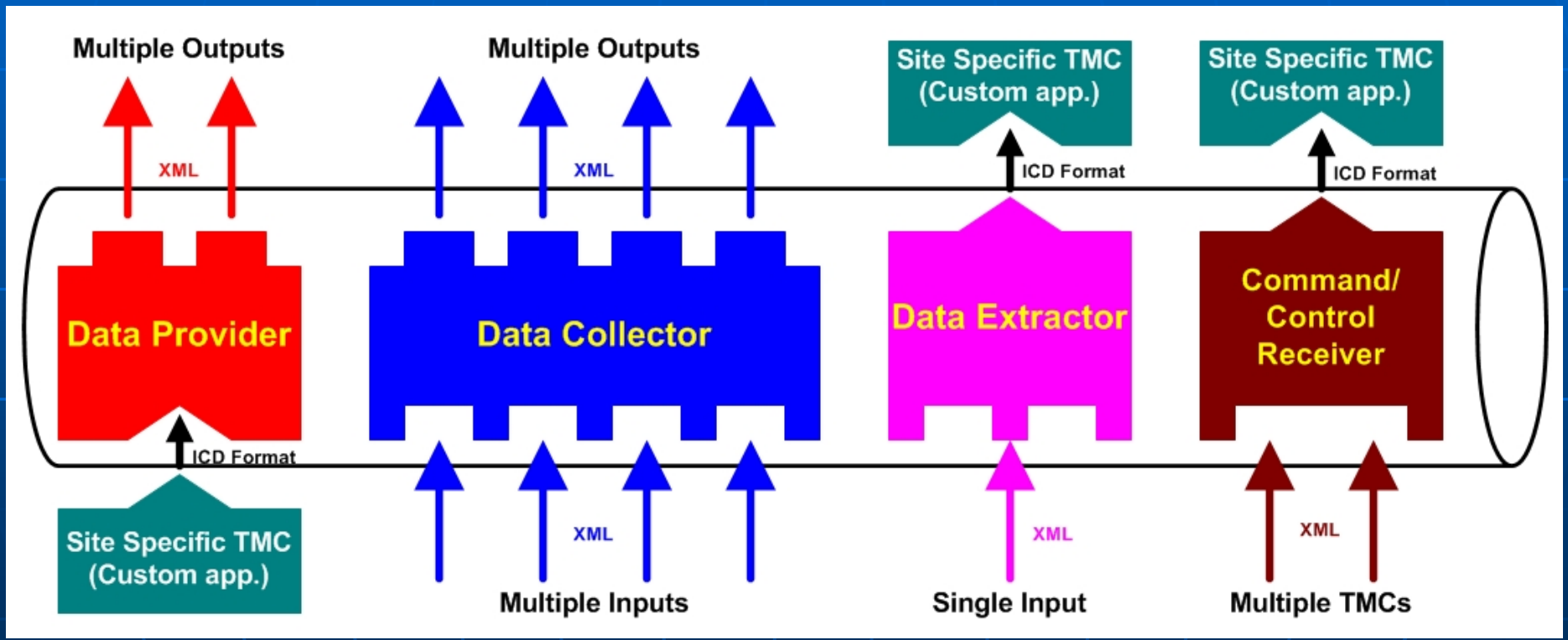
ITS C2C Deployments

- Greater Phoenix, Arizona (AZTech)
- Texas Statewide
- Florida Statewide
- New York Statewide Information Exchange Network (IEN)
- New York Integrated Incident Management System (IIMS)
- Wisconsin Statewide
- Utah DOT ATMS – State Police CAD Integration
- Condition Acquisition and Reporting System (CARS) - 15 State DOTs from Alaska to New Mexico to Maine.
- Los Angeles County Regional Integration of Intelligent Transportation Systems (RIITS)
- TRANSCOM – Tri-State New York / New Jersey / Connecticut
- I-95 Corridor Coalition – U.S. East Coast Seaboard Florida to Maine

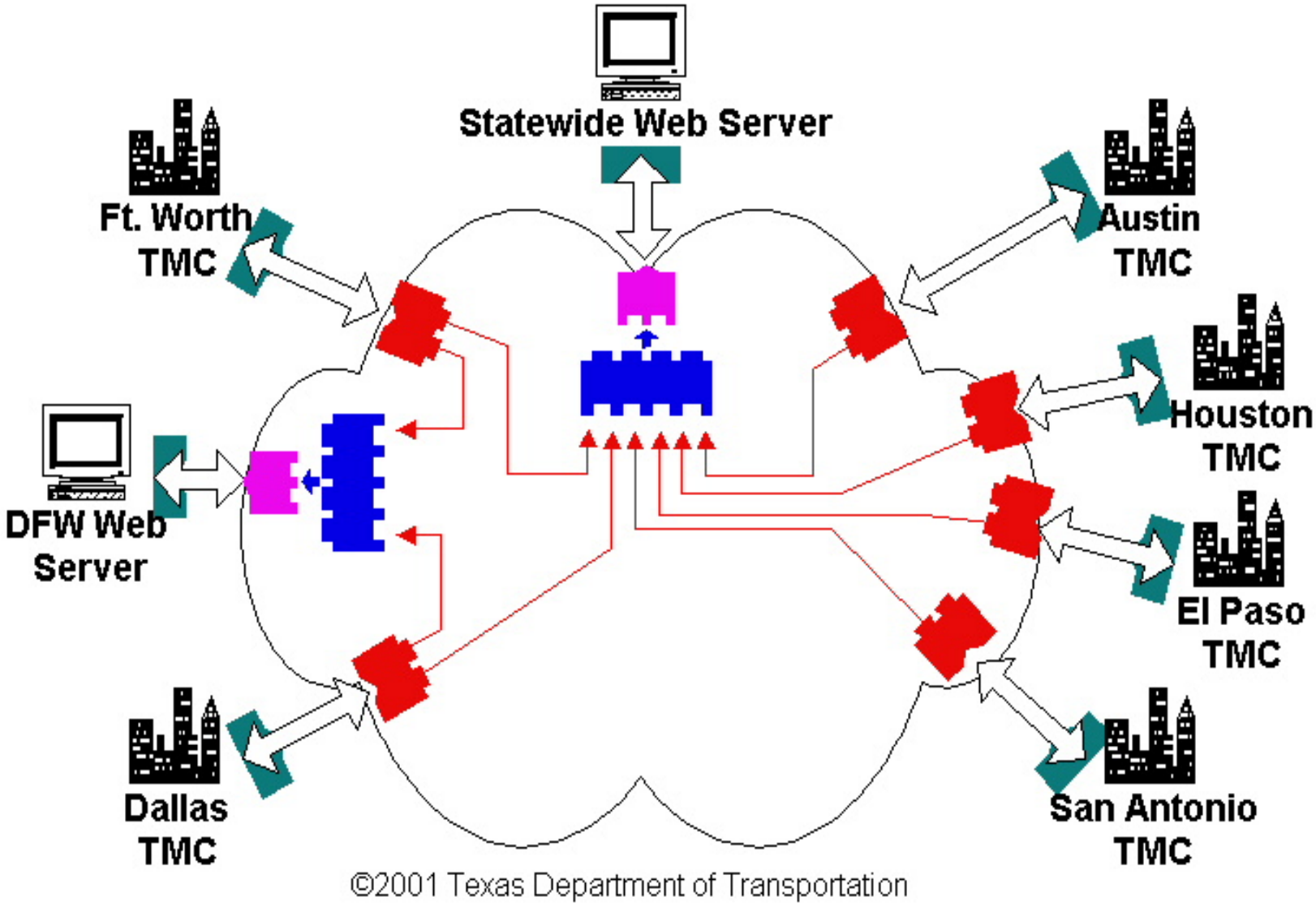
Goals and Needs

- Agencies needed a way to share information, though systems where islands unto themselves
- TxDOT wanted ability to leverage software investments across multiple centers in Texas
- Five unique “code bases” for centers in Texas:
  - Austin / Amarillo / Wichita Falls / Laredo / El Paso
  - Dallas DalTrans
  - Ft. Worth TransVISION
  - Houston TranStar
  - San Antonio TransGuide

C2C Infrastructure Concept: A Set of "Building Blocks" for Growth



Deployment Concept: Statewide Implementation

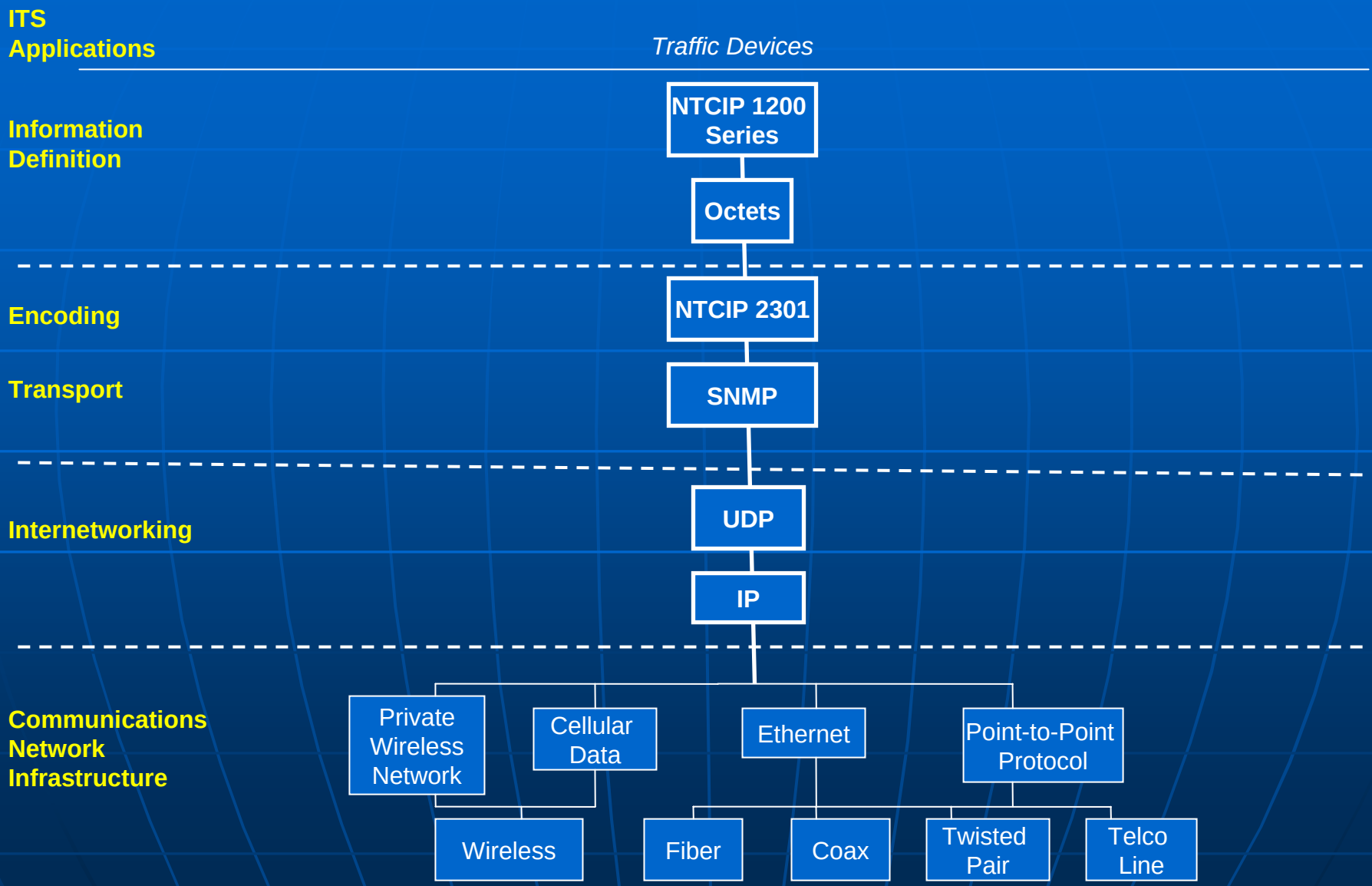


Where To Find The Standards?

- TMDD
  - From the ITE web site at http://www.ite.org/standards/tmdd/
- NTCIP
  - From the NTCIP web site at http://www.ntcip.org
  - Once there, click on “Library” and then “Document Links” at the top of the page.
- TCIP
  - From the APTA web site at http://www.apta.com/about/committees/rsrchtec/tcip/index.cfm
- GTFS
  - https://developers.google.com/transit/gtfs/reference
- IEEE 1512
  - XML schemas are available from the ITS Standards Forum web site at http://www.itsstandards.org/bb/index.php
  - Once there, click on “XML Schemas” at the top of the page.
- SAE-J2354
  - Available for purchase from SAE at http://www.sae.org

Module 5.2:
Center-to-Field ITS Standards

Massachusetts ITS Standards Framework
Center-to-Field ITS Standards

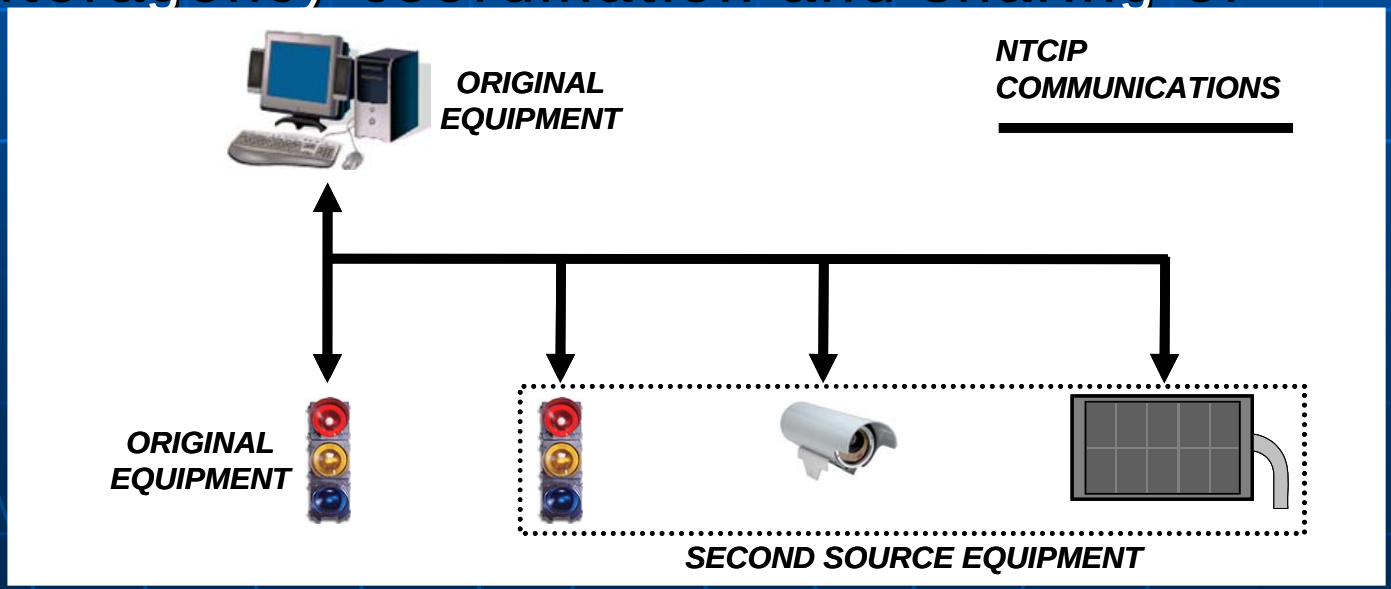


What is the NTCIP?

- National Transportation Communications for ITS Protocol (NTCIP)
  - *Where ITS = Intelligent Transportation Systems*
- The ***NTCIP*** is a family of **open** standards, defining common communications protocols and data definitions.
- NTCIP is a joint effort of the:
  - American Association of State and Highway Transportation Officials (AASHTO)
  - Institute of Transportation Engineers (ITE)
  - National Electrical Manufacturers Association (NEMA)
- Web Site: www.ntcip.org

NTCIP Concepts and Benefits

- Provides a choice of manufacturer
  - Supports interoperability of manufacturer's equipment when specifications are based on the NTCIP
- Phased procurement and deployment
- Different types of devices can communicate on a single communications network
- Enables interagency coordination and sharing of devices



"From NTCIP 9001 v04 – NTCIP Guide"

1200 Series Information Level Standards

Standard Number	Device
NTCIP 1201	Global Objects (GO)
NTCIP 1202	Actuated Signal Controller (ASC)
NTCIP 1203	Dynamic Message Signs (DMS)
NTCIP 1204	Environmental Sensor Station (ESS)
NTCIP 1205	Closed Circuit Television Camera (CCTV)
NTCIP 1206	Data Collection (DCM)
NTCIP 1207	Ramp Meters (RM)
NTCIP 1208	Video Switch (VS)
NTCIP 1209	Transportation Sensor Systems (TSS)
NTCIP 1210	Field Management Station (FMS)
NTCIP 1211	Signal Control and Prioritization (SCP)
NTCIP 1213	Electrical and Lighting Management Systems (ELMS)

2300 Series Application Profile Standards

Standard Number	C2F / C2C	Standard
NTCIP 2301	**C2F**	**Simple Network Management Protocol (SNMP)**
NTCIP 2301	C2F	Simple Transportation Management Protocol (STMP)
NTCIP 2302	C2F	Trivial File Transfer Protocol (TFTP)
NTCIP 2303	C2F & C2C	File Transfer Protocol (FTP)
NTCIP 2304	C2C	Data Exchange (DATEX)
NTCIP 2306	**C2C**	**XML-based Web Services (C2C XML)**

C2F = Center-to-Field
C2C = Center-to-Center

How the Device Standards Work

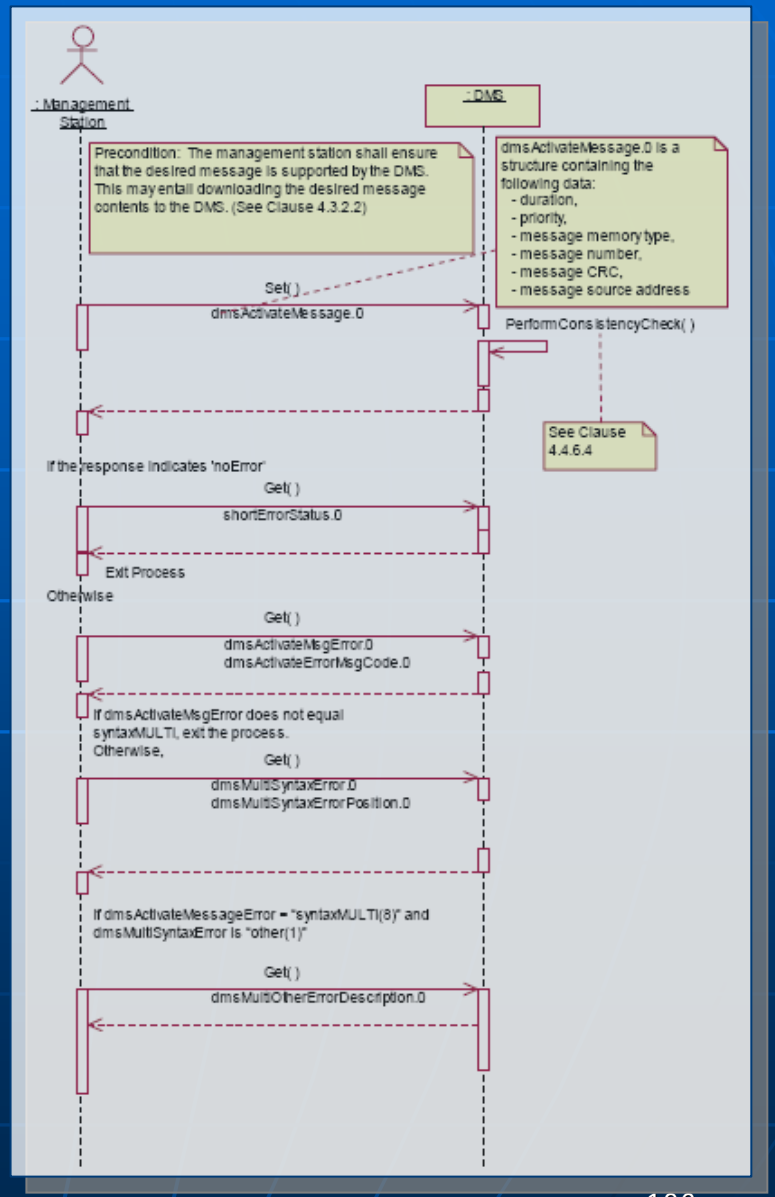
- The 1200 Series Standards Include:
  - Data Dictionary - defines the data elements (called “objects”), information type (e.g., string, numeric, or list), and value ranges.
  - Management Information Base (MIB) - that defines data elements for transfer over a SNMP network.
  - Dialogs – define the order of transfer of data elements. In the standard these are represented as a series of “get” and “set” object actions.

How the Device Standards Work

- The 2301 SNMP Standard:
  - SNMP is an Internet Engineering Task Force (IETF) standard created to help manage the Internet.
  - SNMP is the protocol used to communicate with networked devices such as routers, hubs, and printers.
  - The same software that will “talk” to your router will “talk” to a DMS
  - The MIB (included in the 1200 series standards) is a SNMP concept.
  - SNMP specifies a mechanism that allows a virtual description of networked device information and protocol for access to that information.

Example 1200 Series MIB Definition and Dialog for DMS

5.7.19 Position of MULTI Syntax Error Parameter
dmsMultiSyntaxErrorPosition OBJECT-TYPE
SYNTAX INTEGER (0..65535)
ACCESS read-only
STATUS mandatory
DESCRIPTION
"<Definition> This is the offset from the first character (e.g. first character has offset 0, second is 1, etc.) of the MULTI string where the SYNTAX error occurred.
<Unit>character
<Object Identifier>
1.3.6.1.4.1.1206.4.2.3.6.19"
::= { signControl 19 }

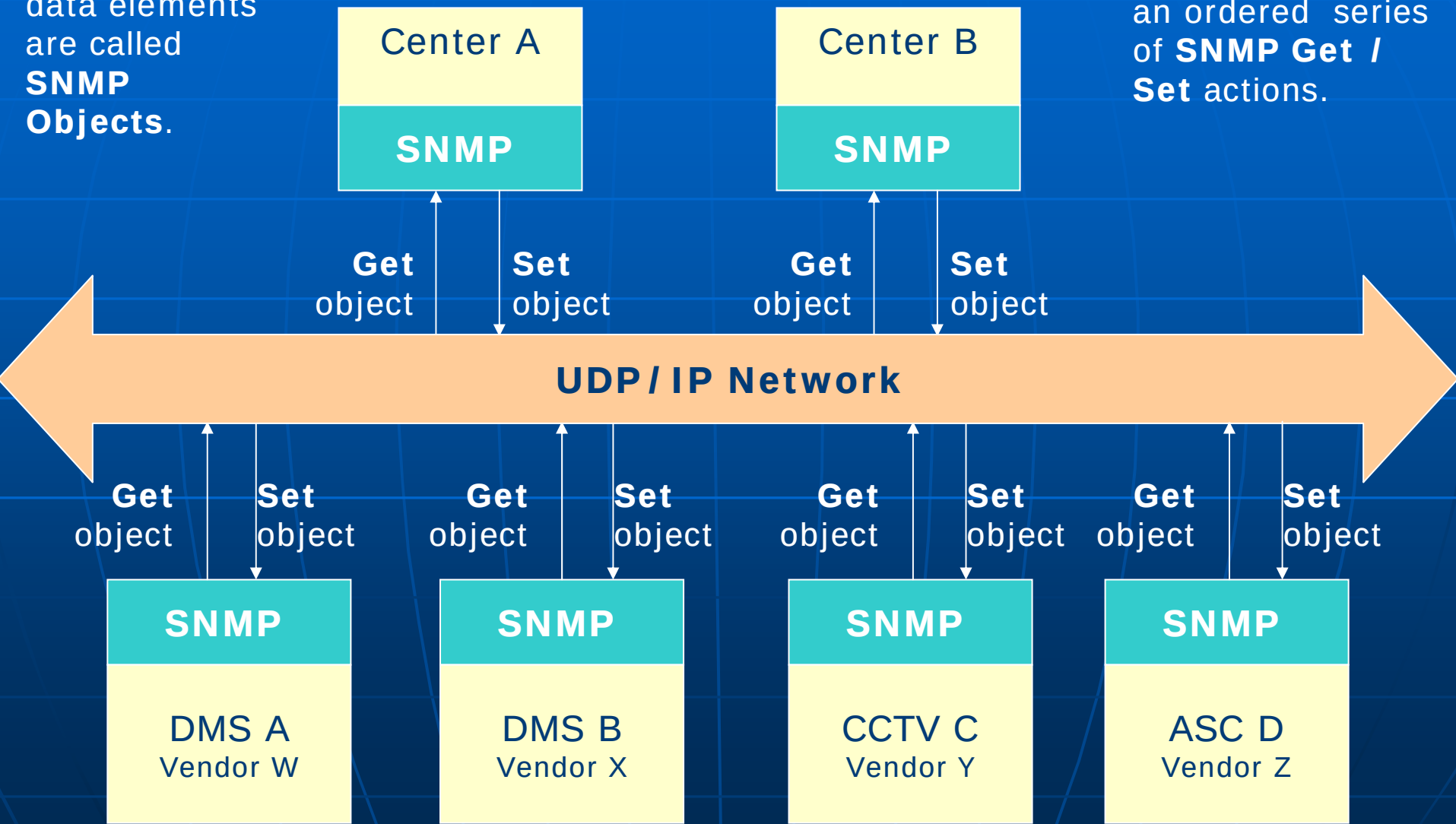


"From NTCIP 9001 v04 – NTCIP Guide"

The NTCIP is implemented as SNMP Interfaces

The **Data Dictionary** data elements are called **SNMP Objects**.

The **Dialogs** are implemented as an ordered series of **SNMP Get / Set** actions.



The DMS, CCTV, and ASC Devices are "SNMP Network Devices."[107]

Module 6:
Specification of ITS Standards

Typical Outline for ITS Standards

- Section 1: General
- Section 2: Concept of Operations
- Section 3: Functional Requirements
  - Includes Profile Requirements List (PRL)
- Section 4: Dialogs and Sequences
- Section 5: Data Dictionary
- Annex A: Requirements Traceability Matrix
- Annex B: Test Cases and Procedures

Profile Requirements List (PRL)

- The Profile Requirements List (PRL) is a table that lists all of the User Needs and corresponding requirements.
- The PRL identifies mandatory and optional elements of the standards.
  - Mandatory elements are essential for conformance
- The PRL is like a decision tree in tabular form.

Using the PRL in Specification Development

- In Specification Development:
  1. Select the User Needs that apply to your project
  2. Use the PRL to select the corresponding functional requirements
  3. Include all of the Mandatory requirements
  4. Select Optional requirements
  5. Create additional project requirements, such as performance requirements.

Example Profile Requirements List (PRL)

User Need Section Number	User Need	FR Section Number	Functional Requirement	Conformance	Support / Project Requirement	Additional Project Requirements
		3.5.2.2	Reset the Sign Controller	M	Yes	
2.5.2.3	Control the Sign Face			M	Yes	
2.5.2.3.1	Activate and Display a Message			M	Yes	
		3.5.2.3.1	Activate a Message	M	Yes	
		3.5.2.3.3.5	Retrieve Message	M	Yes	
		3.5.2.3.6	Activate a Message with Status	Drum:M	Yes / NA	
		3.6.5 †	Supplemental Requirements for Message Activation Request	M	Yes	
		3.6.7 †	Supplemental Requirements for Locally Stored Messages	M	Yes	
2.5.2.3.2	Prioritize Messages			M	Yes	
		3.5.2.3.1	Activate a Message	M	Yes	
		3.5.2.3.3.3	Define a Message	VMS:M	Yes / NA	
				M	Yes / NA	
					Yes	
		3.6.6.4 †	Priority to Maintain a Message	M	Yes	
2.5.2.3.3	Define a Message			VMS:M	Yes / NA	
		3.5.1.2.1.3	Determine Beacon Type	M	Yes	
		3.5.1.2.3.1	Determine Maximum Number of Pages	M		
		3.5.1.2.3.2	Determine Maximum Message Length	M		
		3.5.1.2.3.3	Determine Supported Color Schemes	M		

1. Identify your User Need

2. Select the Dependent Project Requirements

3. Use the Completed Document as your Project Specification

Example PRL

M = Mandatory
O = Optional

User Need Section Number	User Need	FR Section Number	Functional Requirement	Conformance	Support / Project Requirement	Additional Project Requirements
2.5.3.1.5 (Environment)	Monitor Sign Environment			O	Yes / No	
		3.5.3.1.4.7	Monitor Sign Housing Temperatures	M	Yes	
		3.5.3.1.4.8	Monitor Sign Housing Humidity	O	Yes / No	
		3.5.3.1.4.9	Monitor Control Cabinet Temperatures	O	Yes / No	
		3.5.3.1.4.10	Monitor Control Cabinet Humidity	O	Yes / No	
		3.5.3.1.7	Monitor Ambient Environment	Temp:M	Yes / NA	
2.5.3.1.6	Monitor the Sign Control Source			M	Yes	
		3.5.3.1.5	Monitor the Sign's Control Source	M	Yes	
2.5.3.1.7	Monitor Attached Speed Detectors			O	Yes / No	
		3.5.3.1.9 (Speed)	Monitor Speed Detector Reading	O	Yes / No	
2.5.3.1.8 (Door)	Monitor Door Status			O	Yes / No	
		3.5.3.1.3.10	Monitor Door Status	M	Yes	
2.5.3.1.9 (ControllerOp)	Monitor Controller Software Operations			O	Yes / No	
		3.5.3.1.3.5	Monitor Controller Software Operations	M	Yes	
2.5.3.1.10	Monitor Automatic Blanking of Sign			O	Yes / No	
		3.5.3.1.1.1 (LampTest)	Execute Lamp Testing	Lamp OR Fiber:M	Yes / NA	
		3.5.3.1.1.2 (PixelTest)	Execute Pixel Testing	Matrix:M	Yes / NA	
		3.5.3.1.2	Provide General DMS Error	M	Yes	

Create a Project-Specific Data Dictionary During Design Phase

- The Requirement Traceability Matrix (RTM) traces each data dictionary element (data element or dialog) that fulfills one or more requirements.
- Specification Development:
  - Use the RTM to select the corresponding data dictionary elements suitable for design
  - You may create a tailored data dictionary and MIB that includes the mandatory elements for your project.

Example Requirement Traceability Matrix (RTM)

FR Clause Number	Functional Requirement	Dialog ID	Object Clause Number	Object	Additional Specifications
			5.8.7	dmsIllumBrightnessValues	
			5.8.8	dmsIllumBrightnessValuesError	
3.5.1.6	Configure Current Speed Limit	G.3			
			5.11.1.4	dmsCurrentSpeedLimit	
3.5.1.7	Configure Low Fuel Threshold Value	G.3			
			5.11.3.2	lowFuelThreshold	
3.5.2	Control the DMS				
3.5.2.1	Manage Control Source	G.3			
			5.7.1	dmsControlMode	
3.5.2.2	Reset the Sign Controller	G.3			
			5.7.2	dmsSWReset	
3.5.2.3	Control the Sign Face				
3.5.2.3.1	Activate a Message	4.2.3.1			
			5.7.3	dmsActivateMessage	
			5.7.17	dmsActivateMsgError	
			5.7.24	dmsActivateErrorMsgCode	
			5.7.18	dmsMultiSyntaxError	
			5.7.19	dmsMultiSyntaxErrorPosition	
			5.7.20	dmsMultiOtherErrorDescription	

Example Requirement to Test Case Traceability Matrix (RTCTM)

Requirement		Test Case	
ID	Title	ID	Title
		C.3.5.6	Verify Light Sensor Error Detection
		C.3.5.8	Verify Temperature Warning - High
		C.3.5.9	Verify Temperature Warning - Low
		C.3.5.10	Verify Critical Temperature Alarm - High
		C.3.5.11	Verify Critical Temperature Alarm - Low
		C.3.5.12	Verify Humidity Sensor Operations
		C.3.5.13	Verify Door Open Status
3.5.3.1.3	Identify Problem Subsystem		
3.5.3.1.3.1	Monitor Power Errors		
		C.3.5.5	Verify Power Error Detection
3.5.3.1.3.2	Monitor Lamp Errors		
		C.3.5.21	Verify Lamp Test with No Errors
		C.3.5.22	Verify Lamp Test with Errors
3.5.3.1.3.3	Monitor Pixel Errors		
		C.3.5.1	Pixel Test - No Errors
		C.3.5.2	Pixel Test - Errors
3.5.3.1.3.4	Monitor Light Sensor Errors		
		C.3.5.6	Verify Light Sensor Error Detection
3.5.3.1.3.5	Monitor Controller Software Operations		
		C.3.5.7	Verify Controller Software Operation Status
3.5.3.1.3.6	Monitor Climate-Control System Errors		
		C.3.5.3	Climate-Control Equipment Test - No Errors
		C.3.5.4	Climate-Control Equipment Test - Errors
3.5.3.1.3.7	Monitor Temperature Warnings		
		C.3.5.8	Verify Temperature Warning - High
		C.3.5.9	Verify Temperature Warning - Low
		C.3.5.10	Verify Critical Temperature Alarm - High
		C.3.5.11	Verify Critical Temperature Alarm - Low
3.5.3.1.3.8	Monitor Humidity Warnings		
		C.3.5.12	Verify Humidity Sensor Operations
3.5.3.1.3.9	Monitor Drum Sign Rotor Errors		
		C.3.5.23	Verify Drum Sign Rotor Status - No Error
		C.3.5.24	Verify Drum Sign Rotor Status - Error
3.5.3.1.3.10	Monitor Door Status		
		C.3.5.13	Verify Door Open Status

Example Test Case

C.3 Test Procedures
C.3.1 Configuration Tests
C.3.1.1 Determine Sign Type and Technology

Test Case: 1.1	**Title:**	**Determine Sign Type and Technology**	
	Description:	This test case verifies that the DMS indicates that it is the sign type and uses the technology as required by the specification.	
	Variables:	Required_Sign_Type	PRL 2.3.2.1 and 2.3.2.3
		Required_Sign_Technology	PRL 2.3.2.2
	Pass/Fail Criteria:	The DUT shall pass every verification step included within the Test Case to pass the Test Case.	

Step	Test Procedure	Results	Additional References
1	CONFIGURE: Determine the enumerated value for the sign type required by the specification (PRL 2.3.2.1 and 2.3.2.3). RECORD this information as: »Required_Sign_Type NOTE--Valid enumerated values are defined in Section 5.2.2 (Sign Type Parameter).		
2	CONFIGURE: Determine the enumerated value for the sign technology required by the specification (PRL 2.3.2.2). RECORD this information as: »Required_Sign_Technology NOTE--Valid enumerated values are defined in Section 5.2.9 (Sign Technology Parameter).		
3	GET the following object(s): »dmsSignType.0 »dmsSignTechnology.0	Pass / Fail (Section 3.5.1.1.1)	
4	VERIFY that the RESPONSE VALUE for dmsSignType.0 is equal to Required_Sign_Type.	Pass / Fail (PRL 2.3.2.1 and 2.3.2.3)	
5	VERIFY that the RESPONSE VALUE for dmsSignTechnology.0 is equal to Required_Sign_Technology.	Pass / Fail (PRL 2.3.2.2)	

Test Case Results		
Tested By:	**Date Tested:**	**Pass / Fail**
Test Case Notes:		

Module 7:
ITS Standards Testing and Tools

Testing Concepts

- Purpose of Testing
  - To validate user needs are satisfied
  - To verify requirements are fulfilled in the deployed system
- Test all requirements
  - Functional Requirements
  - Performance Requirements
  - Hardware, Electrical, and Mechanical
- The NTCIP 8007 Standard defines the format of test cases and procedures

Testing Phases

Test Phase	Purpose	Number of Units	Test Location
Prototype Test and Inspection	Verify the electrical and mechanical design.	One prototype.	Test Laboratory
Design Approval Test and Inspection	Verify the final design.	Pre-production or a small percentage of the production units	Laboratory
Factory Acceptance Test	Verify production units are identical to the final design and production quality	A percentage of the production unit.	Production factory.
Incoming Device Test	Inspect for damage due to shipping and handling.	All delivered units, including spares	Agency.
Site Acceptance Test	Full functionality of the entire system.	All installed units.	Final location for operation.
Burn-in and Observation Test	Monitor proper operation of the installed unit.	All installed units.	Final location for operation.

Test Documentation

- Test Plans. Describes the scope, approach, resources, and schedule of testing activities
- Test Designs. Describe which requirements are to be tested and which test cases cover which requirements. Pass-fail criteria.
- Test Cases. Describe the inputs, outputs, expected results, and procedures used to verify one or more requirements.
- Test Procedures. Sequence of steps in a test.

ITS Standards Testing

- What to Test
  - Hardware Tests
    - Electrical, Mechanical
  - Environmental Tests
    - Temperature, Humidity, Vibration
  - Functional Tests
    - Does it do what I expect it to do?
  - Performance Tests
    - Does it respond or function in a timely manner?
  - Standards Conformance Tests

ITS Standards Testing

- Conformance
  - To claim “Conformance” to a Standard, the vendor must minimally satisfy the mandatory requirements as identified in the Standard.
  - In addition, a conformant device may offer additional (optional) features, as long as they are conformant with the requirements of the Standard and the standards it references.

ITS Standards Testing

- Certification
  - ITS standards do not certify, nor provide a way to certify, a device or manufacturer
  - Certification is ideal for public sector, but there are issues:
    - Each unit is different
    - Who certifies the certifiers?
  - Considering Conformance Statements

Test Documentation Standards

- NTCIP 9012 - *Testing Guide for Center-to-Field Communications*
- NTCIP 8007 - *Testing and Conformity Assessment Documentation within NTCIP Standards Publications*
- NEMA TS 2-2003: *Traffic Controller Assemblies with NTCIP Requirements*
- NEMA TS 4-2005: *Hardware Standards for Dynamic Message Signs (DMS) with NTCIP Requirements*.
- IEEE 829-1998: *IEEE Standard for Software Test Documentation*.

Module 8:
Connected Vehicles and Emerging Standards

Connected Vehicle Overview

- **Objective is to integrate vehicles (computers) with the existing transportation system infrastructure**
- **We'll look at some applications**
- **New terminology**
  - V2V – Vehicle to Vehicle
  - V2I – Vehicle to Infrastructure
  - Roadside Equipment (RSE)
  - Roadside Unit (RSU)
  - Onboard Equipment (OBE)
- Emerging Standards

Connected Vehicle Applications

- **Vehicle-to-Vehicle (V2V) Communications for Safety:**
  - offers the opportunity for significant safety improvements.
- **Vehicle-to-Infrastructure (V2I) Communications for Safety**:
  - avoid or mitigate motor vehicle crashes but also to enable a wide range of other safety, mobility, and environmental benefits.
- **Real-Time Data Capture and Management**:
  - access to high-quality, real-time and archived, multi-modal transportation data that is captured from connected vehicles (automobiles, buses, trucks, fleets), mobile devices, and infrastructure.
- **Dynamic Mobility Applications:**
  - leverage the full potential of connected vehicles, travelers and infrastructure.
- **Road Weather Management**:
  - Road Weather connected vehicle applications that assess, forecast, and address the impacts that weather has on roads, vehicles, and travelers.
- **Applications for the Environment Real-Time Information Synthesis (AERIS)**:
  - support and facilitate “green” transportation choices by transportation system users and operators.

Onboard Equipment (OBE)

The Evolution of the Car: A Connected Vehicle

(a networked computer on wheels)

Data Sent from the Vehicle

Real-time location, speed, acceleration, emissions, fuel consumption, and vehicle diagnostics data

Data Provided to the Vehicle

Real-time traffic information, safety messages, traffic signal messages, eco-speed limits, eco-routes, parking information, etc.

Improved Powertrain

More fuel efficient powertain including; hybrids, electric vehicles, and other alternative power sources

Vehicle-to-Vehicle (V2V)

Safety Applications (V2V)

- **Blind Spot Warning/Lane Change Warning**, which warns drivers when they try to change lanes if there is a car in the blind spot or an overtaking vehicle.
- **Forward Collision Warning**, which alerts and then warns drivers if they fail to brake when a vehicle in their path is stopped or traveling slower.
- **Electronic Emergency Brake Lights**, which notifies drivers when a vehicle ahead that they can't see is braking hard for some reason.
- **Intersection Movement Assist**, which warns the driver when it is not safe to enter an intersection—for example, when something is blocking a driver's view of opposing traffic.
- **Do Not Pass Warning**, which warns drivers if they attempt to change lanes and pass when there is a vehicle in the opposing lane within the passing zone.
- **Control Loss Warning**, which warns the driver when another nearby vehicle has lost control.

Roadside Equipment (RSE) also known as Roadside Unit (RSU)

Collects data from
Sensors onboard vehicles.

ield Devices

Road Weather Management

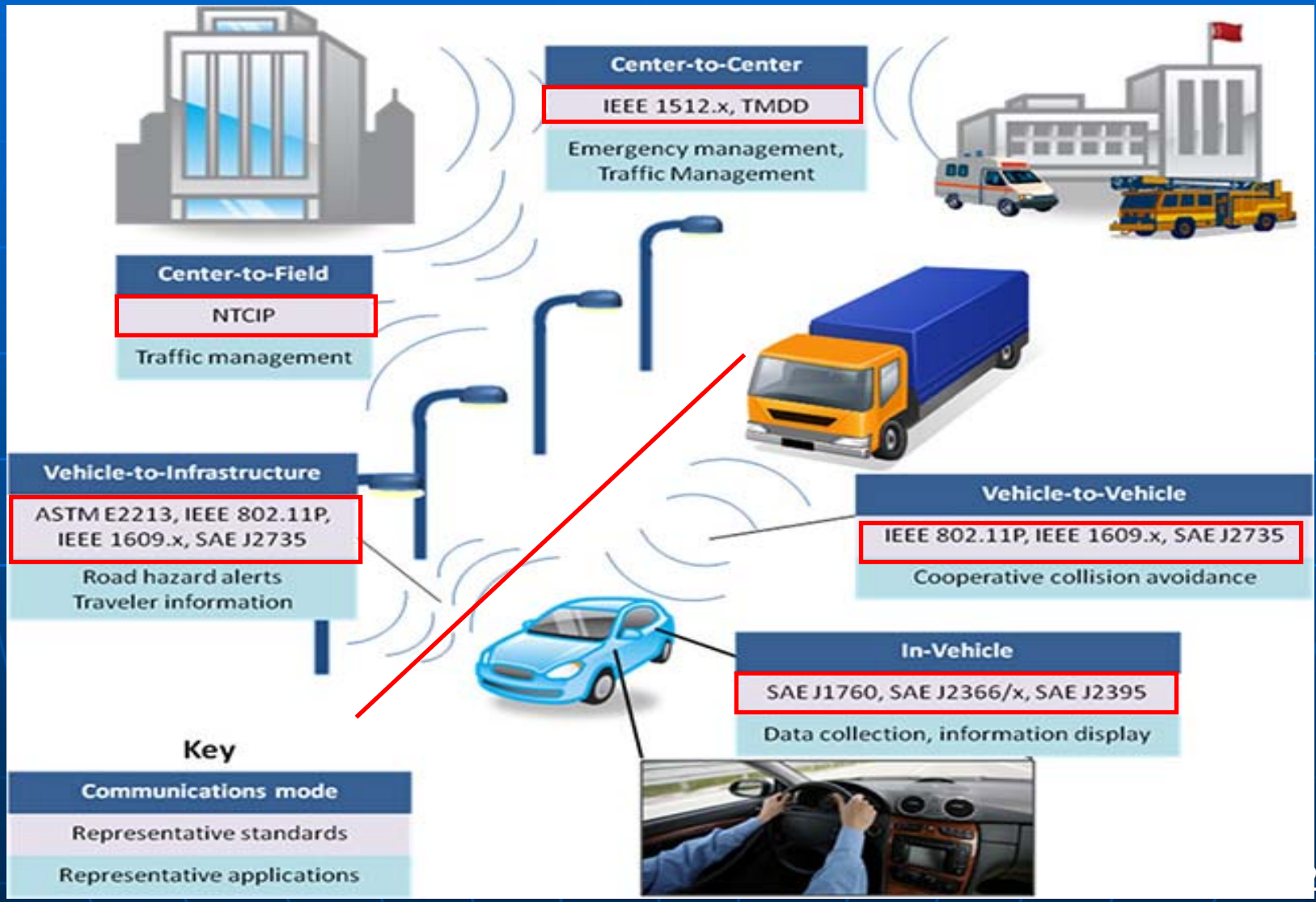
Speed and Heading
Adaptive Cruise Control
Location & Elevation
Hours of Operation

Sun/Rain Sensor
Windshield Wiper Setting
Headlight Status
Ambient Air Temperature

Anti-lock Braking System (ABS)
Brake Status
Stability Control
Traction Control

Snow plow as a mobile weather station.
Providing inputs for micro weather forecasts.

Standards to Integrate Vehicle Information



Thank-You!

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