New York State Department of Transportation

Using ITS Standards for Deployment: Identification, Specification, and Testing

Version 2.0 – Introduction

Course Instructors:
Consensus Systems Technologies

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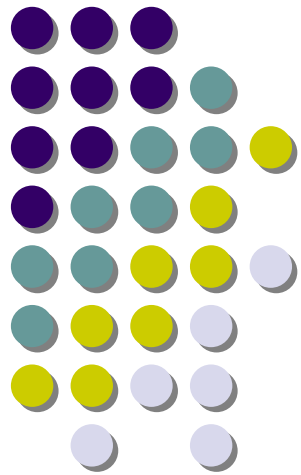


Last Updated: June 2, 2008

ConSysTec

Module 1:
Course Overview

Course Overview

- The focus of this course is on ITS system interfaces and standards: their identification, specification, and testing.
- Emphasis is given to *work products* and *process steps* needed for the deployment of ITS system interfaces, rather than the details of doing the work.
  - Knowing what work products, and necessary steps to develop them, will support your system acquisition, development, and deployment.

Why this Course

- Managing system development projects is challenging. Presented in this course is a structured methodology to help manage the challenges and risks of system development and deployment.
- You should be aware of nomenclature, information, and methodologies related to systems engineering and ITS standards that you and your contractors should use in your projects.

Intended Audience

- Day 1 is geared towards Managers, Planners, Operations and Maintenance staff. The focus is on user needs, requirements, and the business and operations drivers behind them. Design and Technical staff should also attend to understand the processes motivating a good technical solution.
- Day 1 covers ITS architecture and the principles of system engineering.
- Day 2 is for Technical Staff and Specification Developers who have an interest in the application of the techniques for ITS standards identification, specification, and testing.

Structure of Course Modules

- Learning Objectives
- Concise, Focused Lecture
- Hands-on Exercise / Q & A
- List of Useful Resources

Course Learning Objectives

- Standards identification methodology with examples
  - Help you answer the question: *what standards should I use in my project?*
- Standards specification and testing methodology
- Commercially available tools that can be used for specification and testing
- Case studies
- Lessons learned and tips for deployment

Course Outline

- Module 1 – Course Overview
- Module 2 – Systems Engineering Overview
- Module 3 – National and Regional ITS Architecture Overview
- Module 4 – Concept of Operations Development
- Module 5 – Requirements Development
- Module 6 – ITS Standards Overview and Key ITS Standards for New York State
- Module 7 – ITS Standard Framework for New York State
- Module 8 – ITS Standards Specification Development
- Module 9 – Standards Testing

Module 2:
Systems Engineering Overview

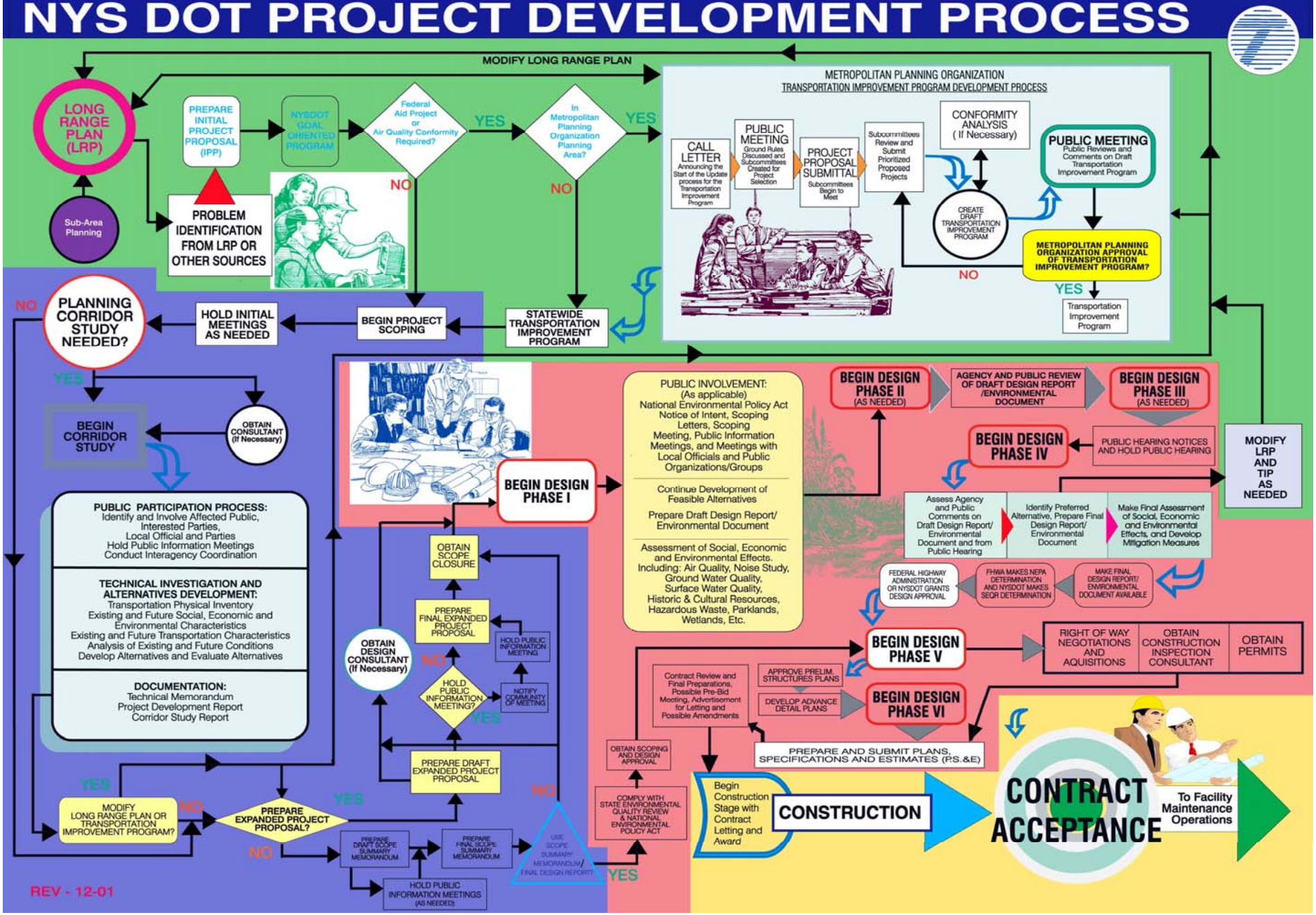
Module 2 – Systems Engineering Learning Objectives

- Understand What Systems Engineering Is
- Understand the Benefits and Challenges on Applying Systems Engineering in Projects

Systems Engineering Supports What You Do

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

NYS DOT PROJECT DEVELOPMENT PROCESS

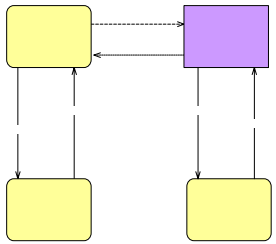


ITS System Journey from Plan to Deployment

Regional Transportation Plan

1

Regional ITS Architecture



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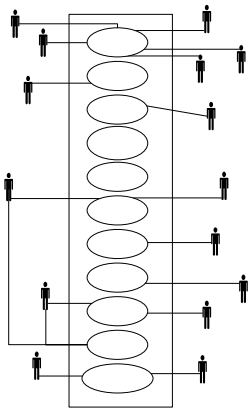
Concept of Operations



3

Requirements

Alternatives Analysis (High Level Design)

Use Cases & Requirements

Alternatives Analysis

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

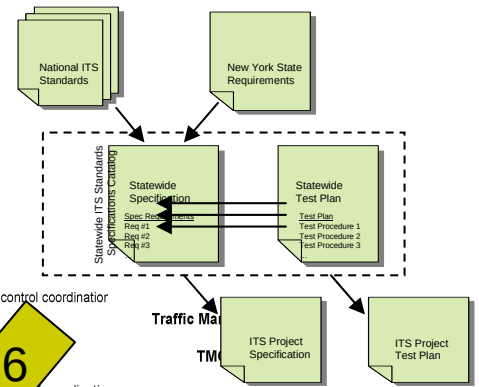
4

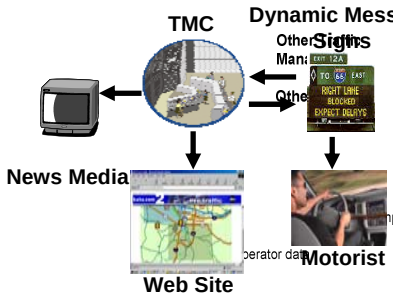
Data Storage Retrieval

$ $ $ $ $

5

Specifications and Test Plans





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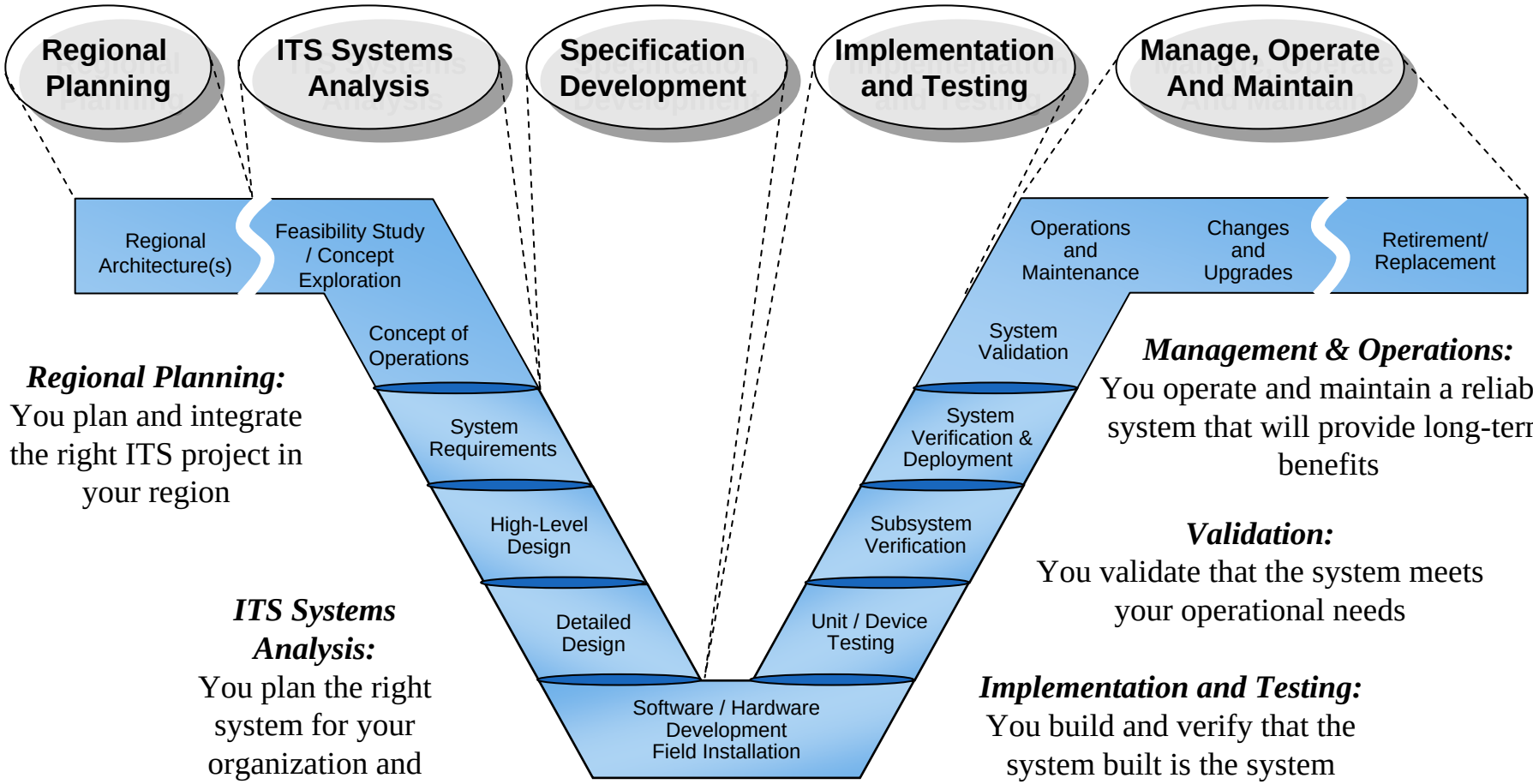
Implementation

Systems Engineering supports you through the ITS System Life Cycle



Regional Planning:
You plan and integrate the right ITS project in your region

ITS Systems Analysis:
You plan the right system for your organization and your customers

Specification Development:
You design a high quality, high value system for the least cost

Implementation and Testing:
You build and verify that the system built is the system specified

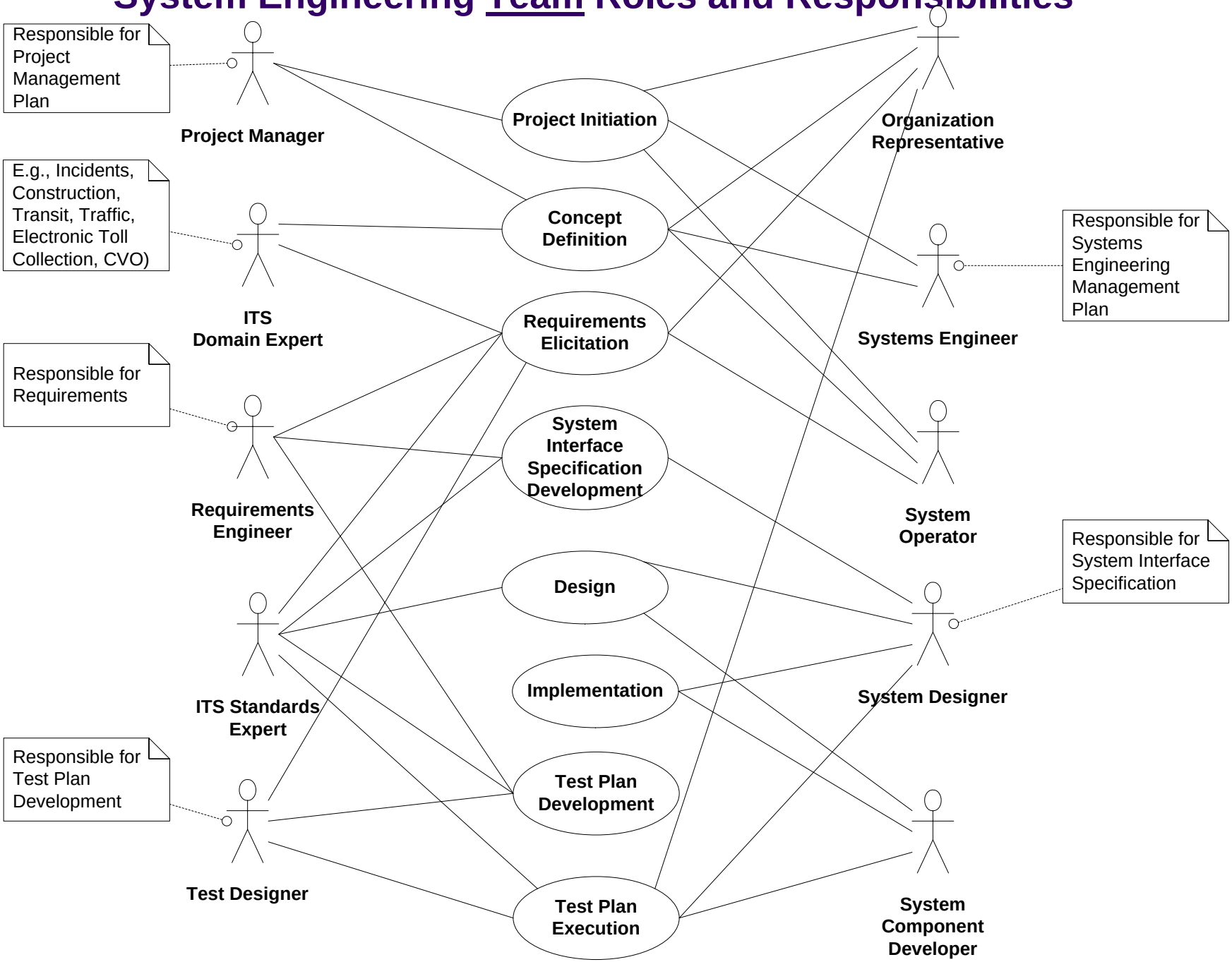
Validation:
You validate that the system meets your operational needs

Management & Operations:
You operate and maintain a reliable system that will provide long-term benefits

Key Systems Engineering Deliverables as relate to the NYSDOT Project Development Process

NYSDOT Project Development Process	Systems Engineering Deliverables
Transportation Planning	Regional ITS Architecture
Initial Project Proposal / Project Scoping	Concept of Operations
Design Report	Requirements
Advanced Detail Plans (ADP) & Plans, Specifications & Estimates (PS&E)	Specifications
Construction	Test Documentation

System Engineering Team Roles and Responsibilities



The Systems Engineering: Rationale

- Improves Coordination of Team during Project Phases
  - From ConOps to Requirements
  - From Requirements to Specification / Design
  - From Design to Implementation and Testing.
- Supports System Acquisition
  - Structured Methodology and Work Products
- Supports Quality Assurance and Control
  - Structured approach to Validation and Verification
  - Traceability of Requirements to Design and Test
- Process is oriented to identification of and removal of defects through the system development cycle

The Systems Engineering: Results

- Systems that work with your operations and satisfy user needs
- Improved reliability of systems translates into fewer maintenance problems and cost

The Systems Engineering: Challenges

- Application of Systems Engineering and Standards in ITS is relatively new
- Lack of in-house and consultants with experience
- Systems Engineering approach needs to be tailored to the project and project budget.
- Benefits of SE (and ITS) are hard to prove in the short-term
- Benefits of SE must be measured over the long-term
  - Metrics and data collection methods must be determined up-front

Systems Engineering: Resources & Where in the Guide

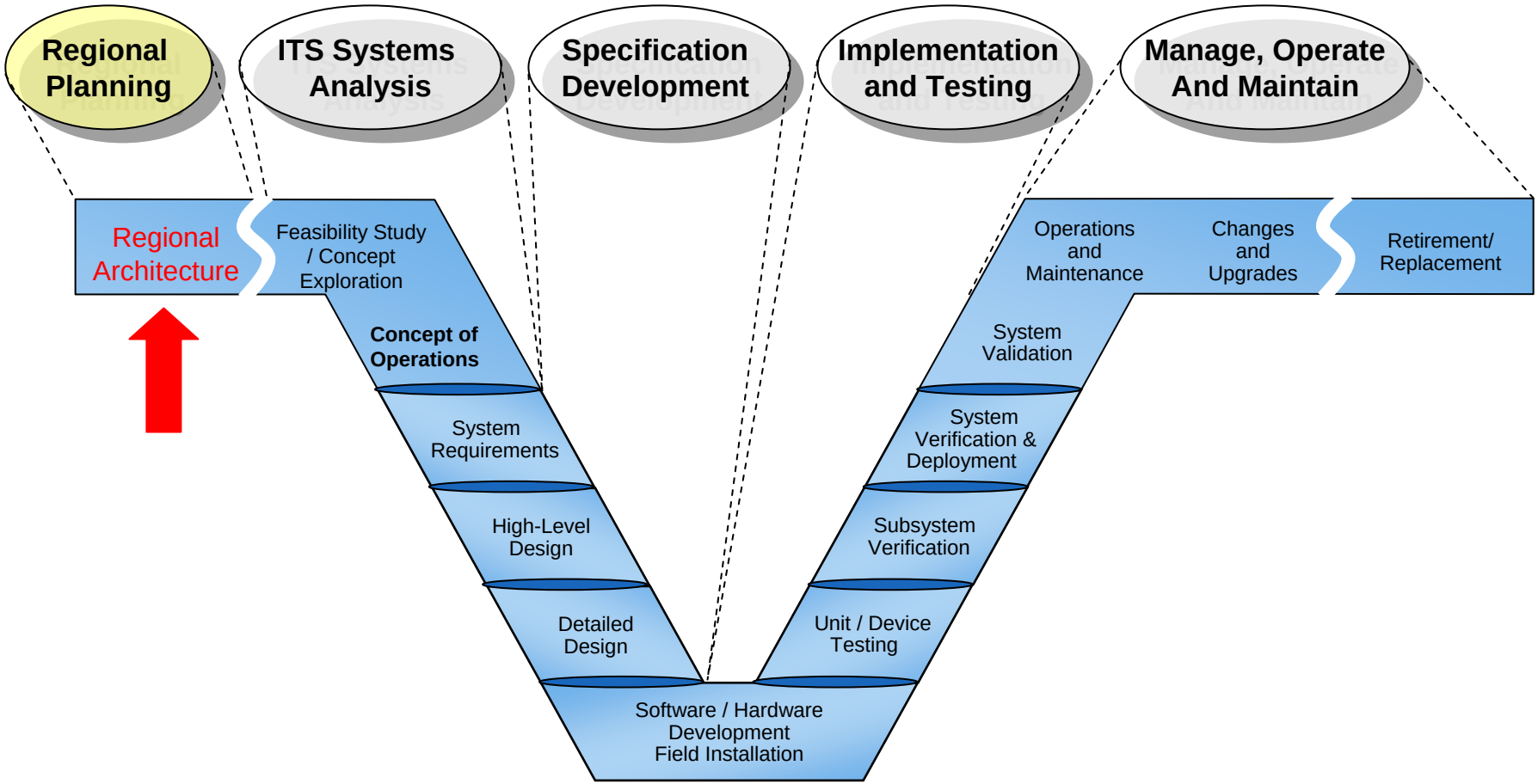
- Resources
  - FHWA Systems Engineering Guide
  - Caltrans Systems Engineering Guide
  - IEEE 1220 – Application and Management of the Systems Engineering Process

Module 3:
National and Regional ITS Architecture Overview

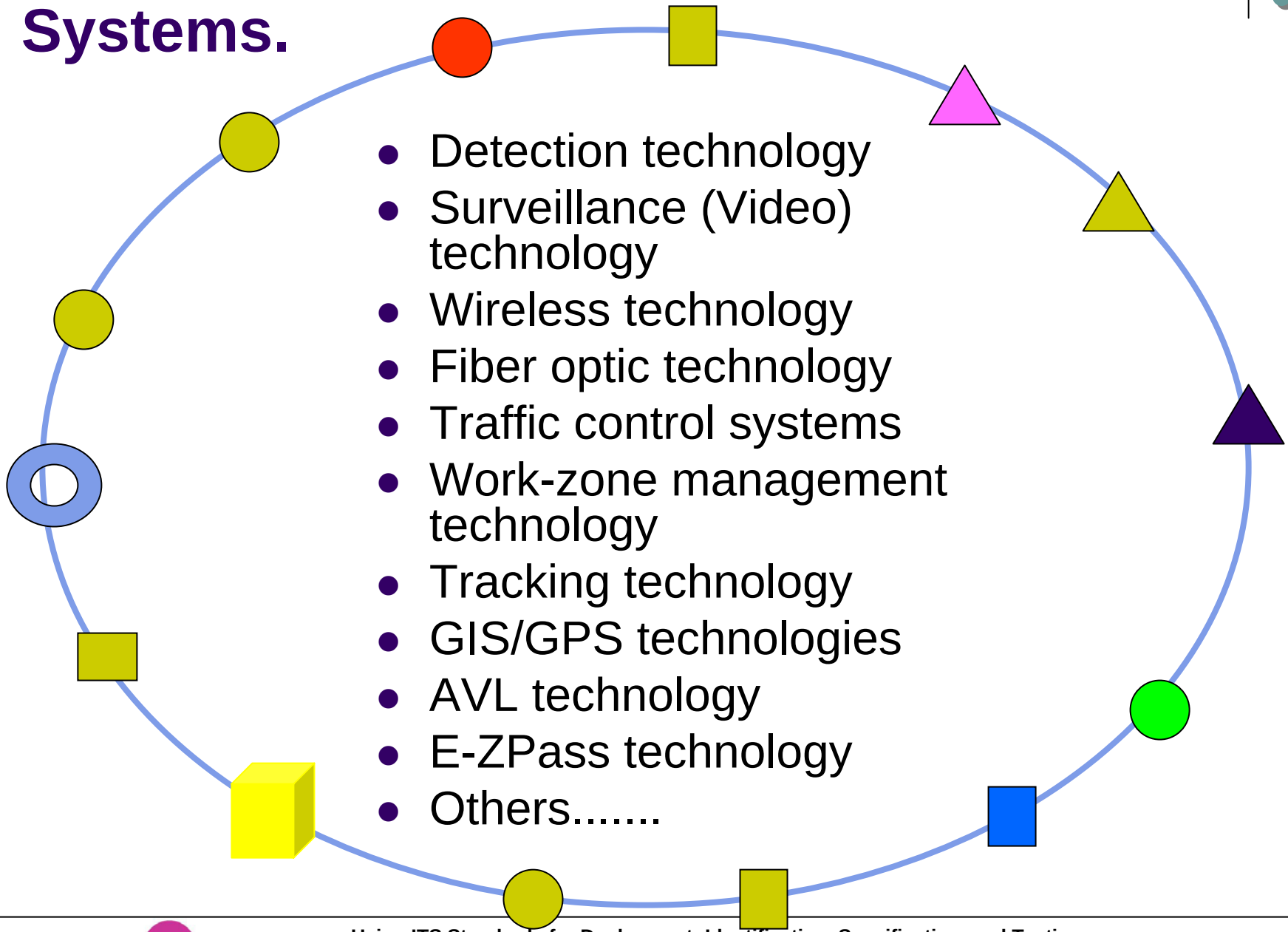
Module 3 – ITS Architecture Learning Objectives

- Regional ITS Architecture and how it is applied in the context of ITS Standards.
- ITS Services
  - A description of what ITS should do in a region to satisfy a transportation or transportation improvement need.
- Market Packages
  - A diagram that models ITS Services
  - Identifies major stakeholders and functions of ITS elements
- Architecture Flows
  - Information flows between ITS elements
  - High-level mapping to standard

Concept of Operations Development



There are many technologies used in ITS Systems.



- Detection technology
- Surveillance (Video) technology
- Wireless technology
- Fiber optic technology
- Traffic control systems
- Work-zone management technology
- Tracking technology
- GIS/GPS technologies
- AVL technology
- E-ZPass technology
- Others.....

How do we *PLAN* to use and integrate these technologies in ITS?

Vehicle-Based / Safety

Vehicle-to-Vehicle

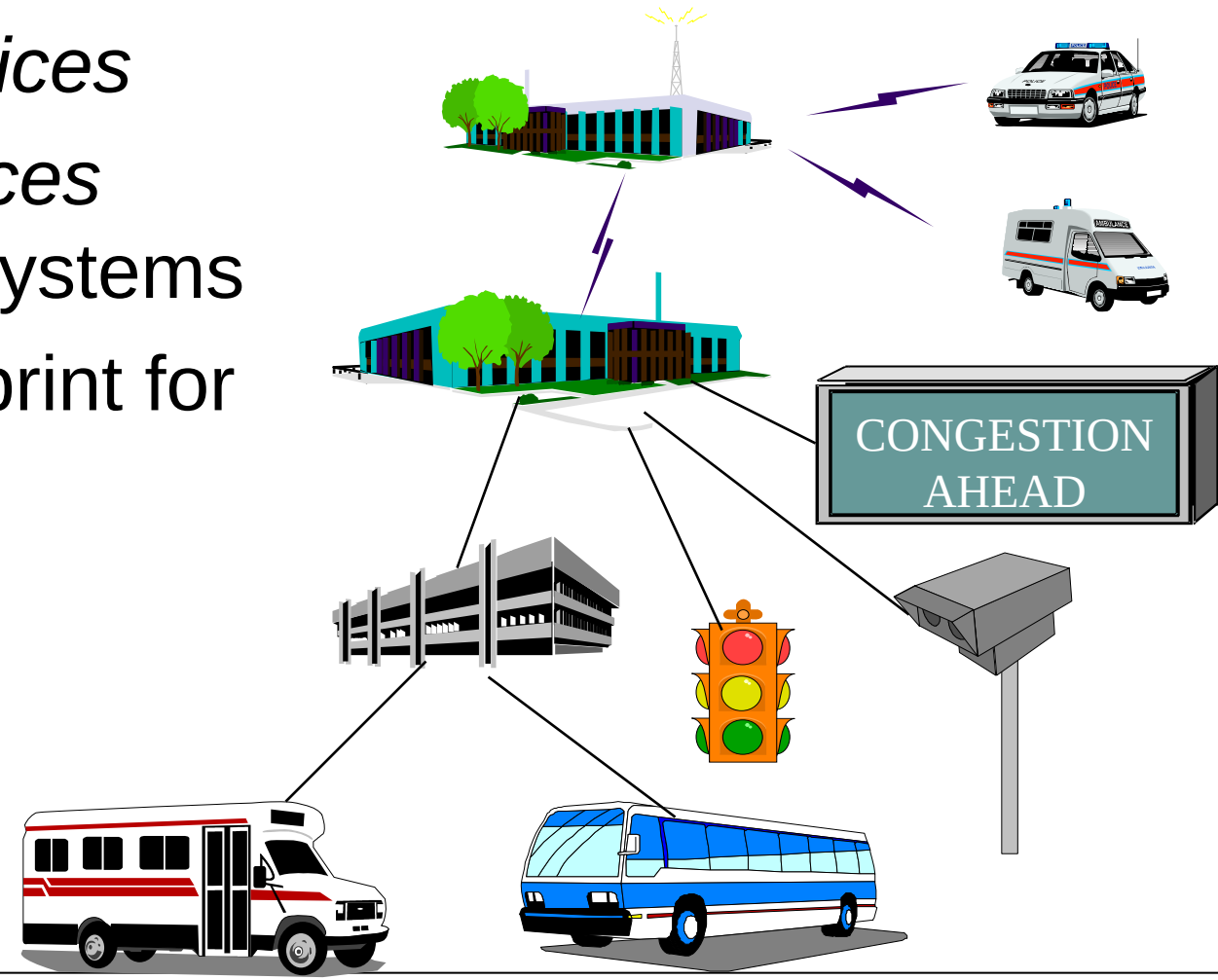
Operations Centers

Vehicle-to-Roadside

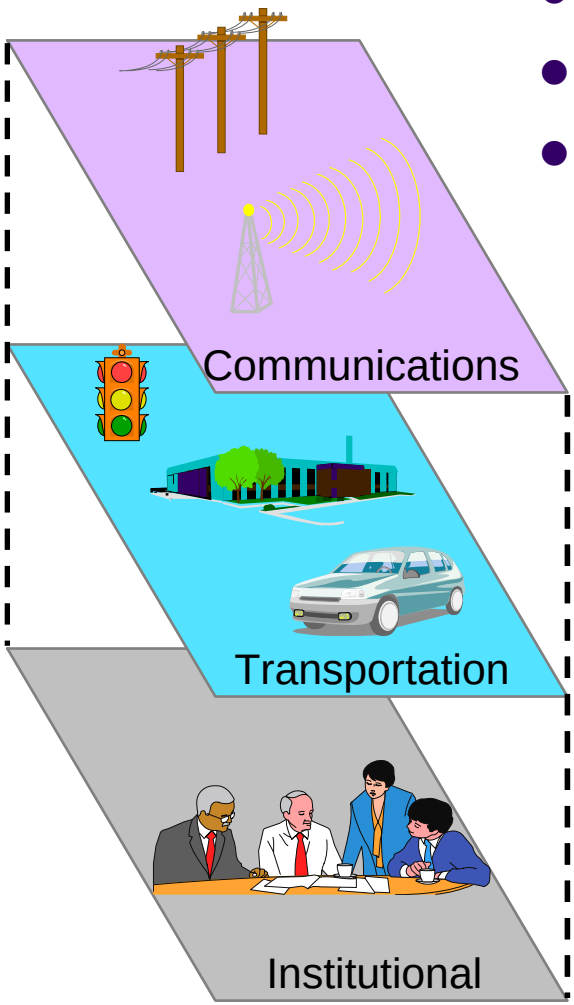
Vehicle-Based / Navigation

The National ITS Architecture is a Framework to Help:

- Describe *services*
- Define *interfaces* between subsystems
- Develop blueprint for *integration*



National ITS Architecture Layers



- Defines physical entity interfaces
- Distributes functionality
- 3 layers

Interfaces

Solutions

Objectives & Requirements

Communications Layer

- **How information is transferred between ITS elements**

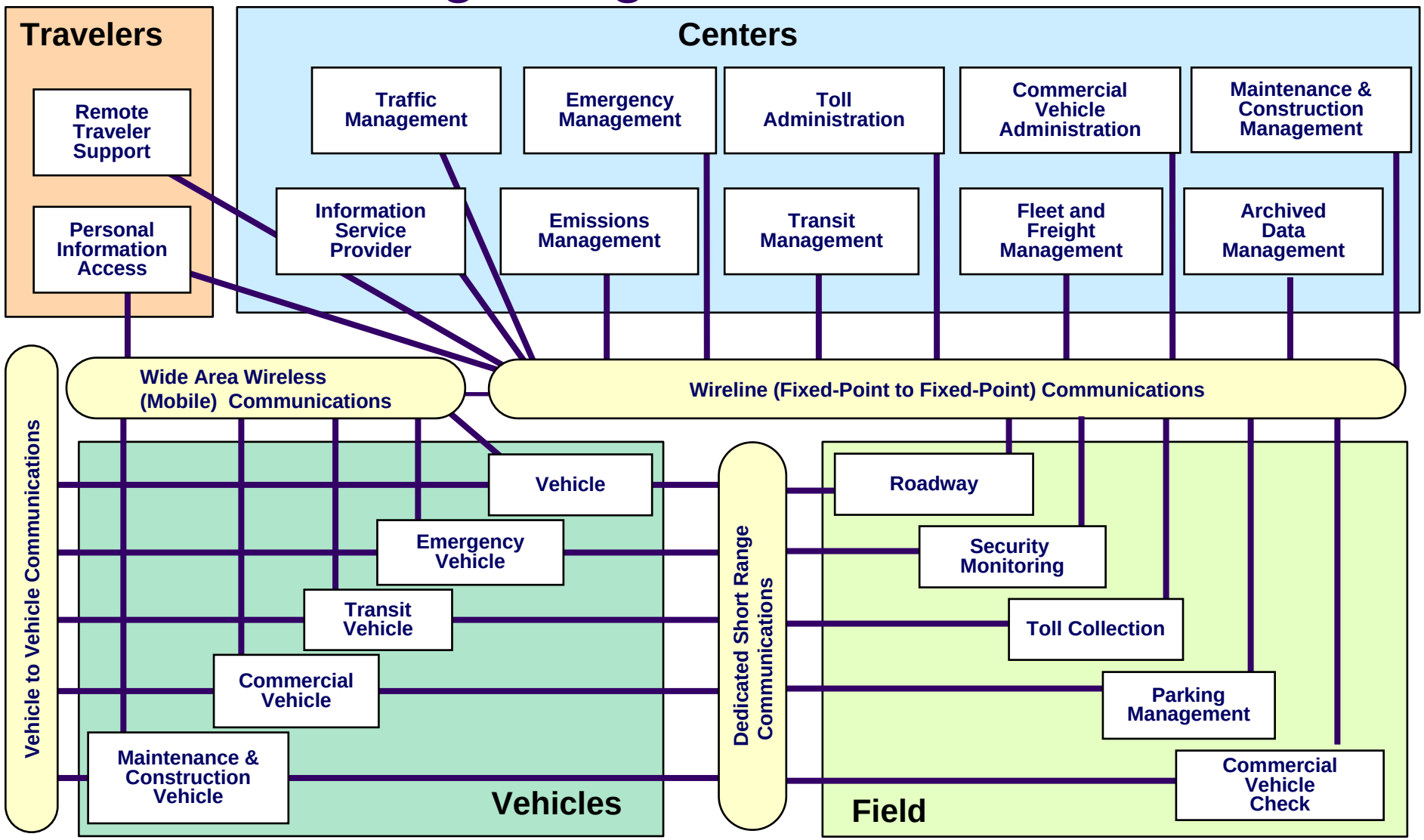
Transportation Layer

- **What ITS elements transfer what information**

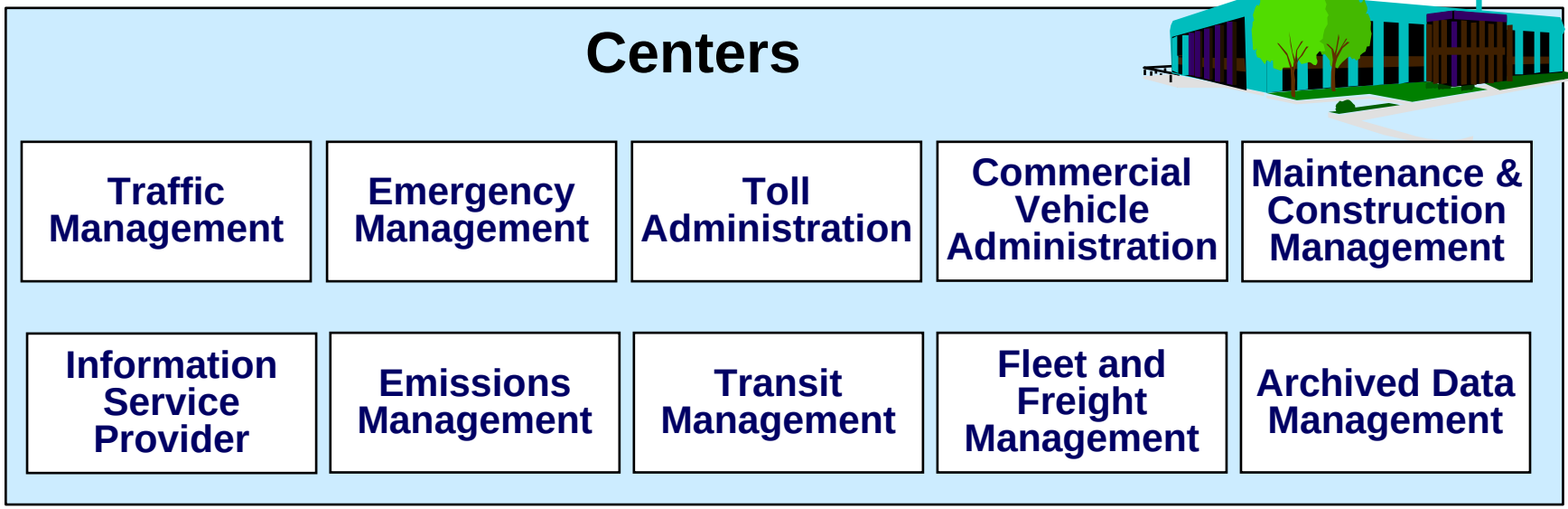
Institutional Layer

- **Supporting institutional structure, policy, and strategies**
- **<u>Stakeholder Driven</u>**

National ITS Architecture V 6.0 - "Sausage Diagram"

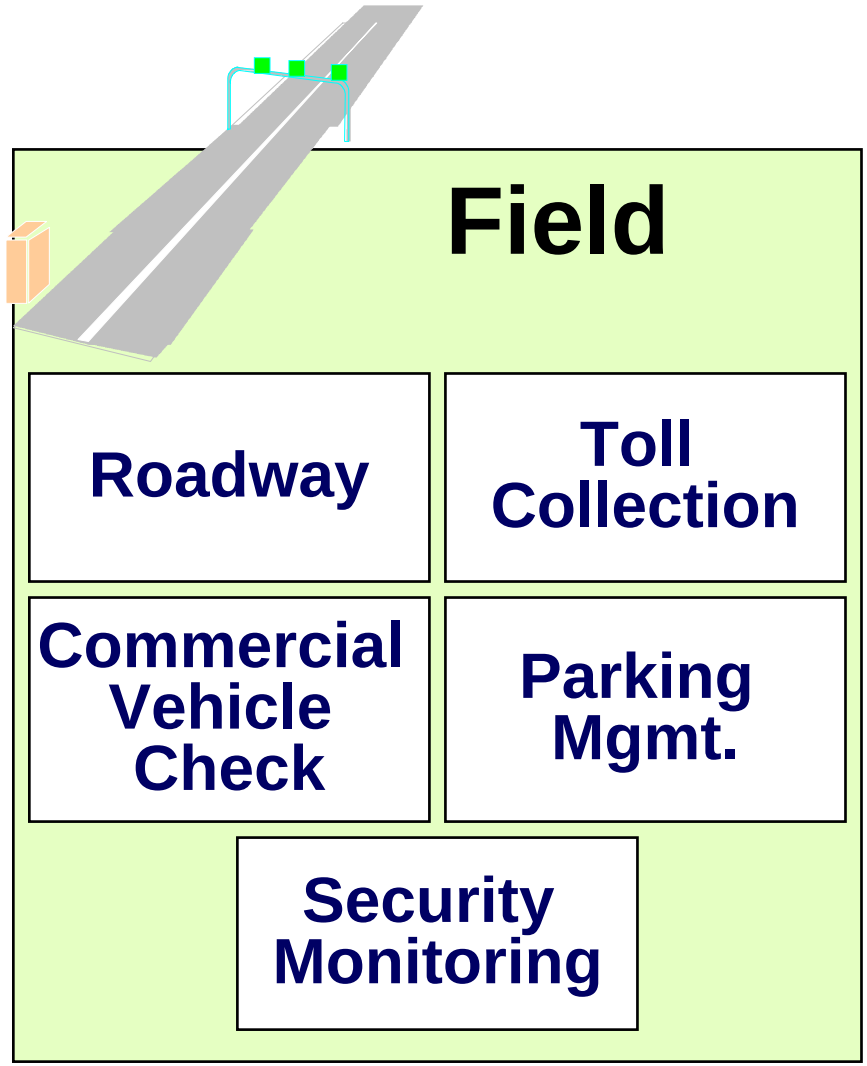


Center Subsystems



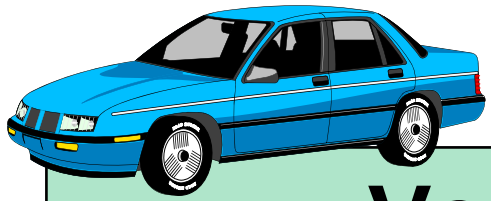
- Perform management and administration functions
- Coordinate with other Center Subsystems

Field Subsystems



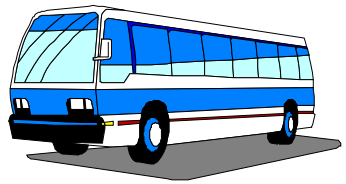
- *ITS* infrastructure
- *On* or *along* the transportation network
- Surveillance
- Control plans
- Supply information

Vehicle Subsystems

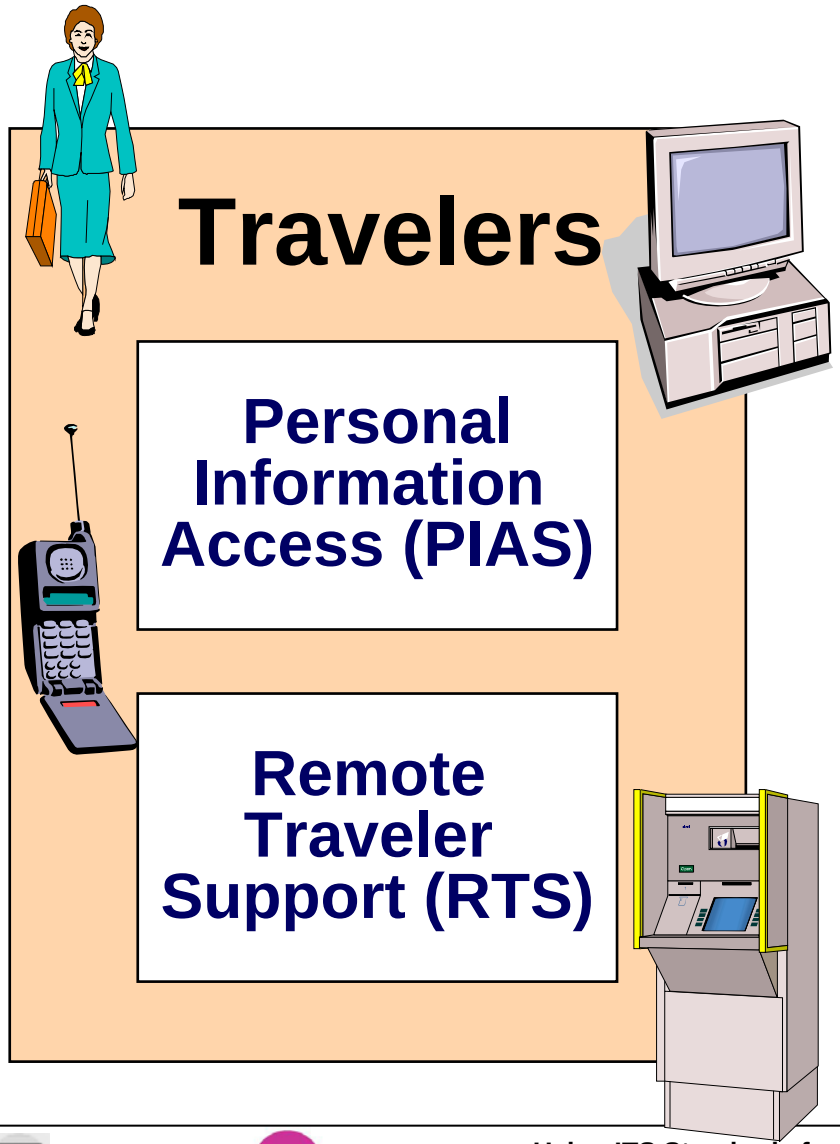


Vehicles

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



Traveler Subsystems



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

Regional ITS Architecture

- Is a planning tool for implementing ITS within a region
- Uses the National ITS Architecture as a template – borrowing concepts, functional requirements, information flows, etc.

… the National ITS Architecture is tailored to meet the needs of a region in the form of a Regional ITS Architecture

Regional ITS Architecture Scope

- Geographic Boundaries
- ITS Services to be provided
- Time Frame
  - Existing Today → 10 to 15 years in the future

ice and Associates

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LEGEND

National ITS Architecture Entity — No Regional Architecture Elements Map To National ITS Architecture

National ITS Architecture Entity — Regional Architecture Elements Map To National ITS Architecture

Information Service Provider Subsystem
CDTA Traveler Information System*
CDTA Webpage
NYSDOT Capital Region TMC Traveler Information System *
NYSDOT Web Page
NYSTA Web Page
Regional Cellular Telco Probe Service*
Thruway 800 number*
TRANSCOM RA Servers

Traffic Management Subsystem
City of Albany/City of Schenectady/Local TMC
NYSDOT Traffic Signal Control Servers
NYSDOT/ NYSP Capital Region TMC
NYSTA Division Traffic Office
NYSTA Thruway Statewide Operations Center (TSOC)
Other State/Regional TMCs*
Transmit Servers*

Emergency Management Subsystem
Capital State Police PSAP
County/City Emergency Operations Centers
Local Public Safety Dispatch
NYS Police Dispatch- COMSEC
NYSDOT HELP Program
NYSTA Thruway Statewide Operations Center (TSOC)
Private Mayday Providers Vehicle Emergency Systems
State Emergency Operations Center
Tow Dispatch

Transit Management Subsystem
CDTA Transit Dispatch
Local Transit Operations Centers
School Bus Dispatch-Private
School Bus Dispatch- Public

Maintenance & Construction Management
Local Dept of Public Works
NYSDOT Maintenance Residency
NYSDOT Regional Transportation Maintenance
NYSTA Lane Closure Reporting System*
NYSTA Operations and Maintenance Dispatch

Archived Data Management Subsystem
CDTA Transit Archive
Local Government Planning Department Archive
NYS DMV Accident Reporting System
NYSDOT Region 1 TMC Archive
NYSTA Traffic Data Systems Archive*

Toll Administration
NYSTA E-ZPass Customer Service Center
NYSTA E-ZPass Service Center

Remote Traveler Support Subsystem
CDTA Transit Kiosks*
TRANSCOM Kiosks*

Personal Information Access Subsystem
Private Traveler Personal Computing Devices

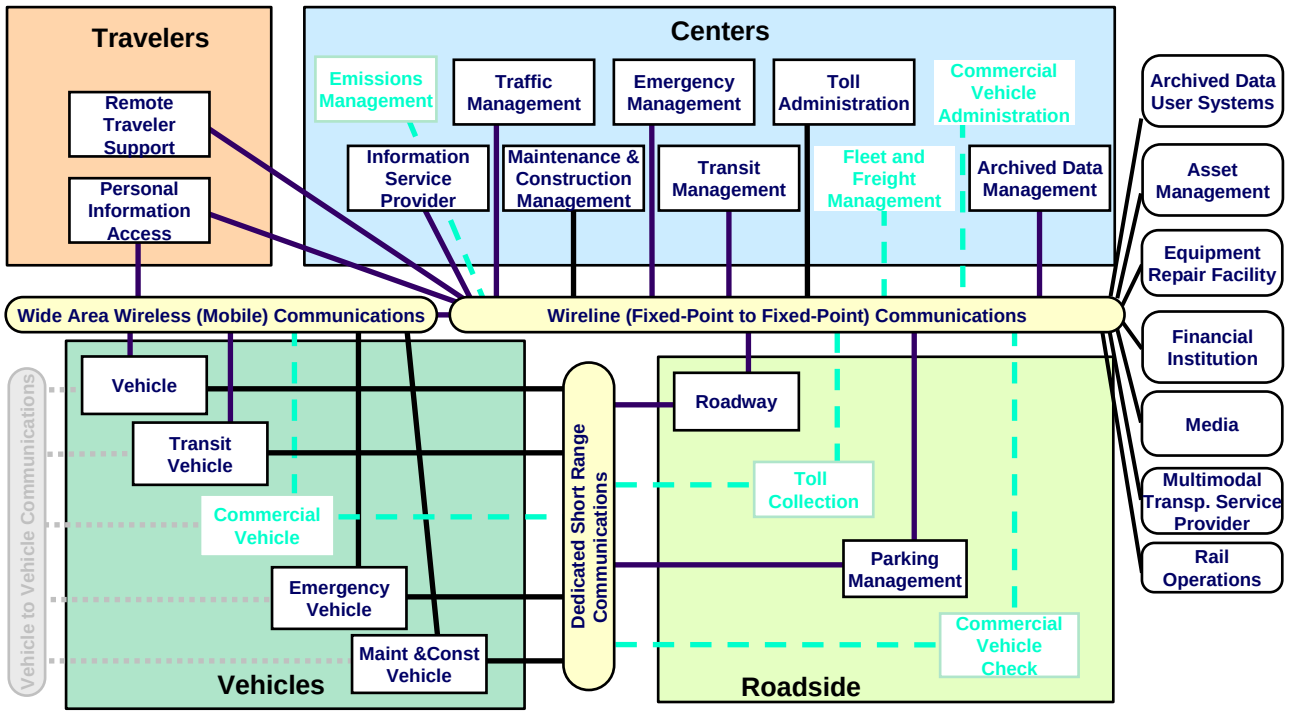
Traveler Card
E-ZPass II Tag*
E-ZPass Tag

Emergency Vehicle Subsystem
Local Public Safety Vehicles
MedFlight Helicopters
NYS Police Vehicles
NYSDOT HELP Truck

Maint & Const Vehicle Subsystem
Local Maintenance and Construction Vehicles
NYSDOT Maintenance and Construction Vehicles
NYSTA Maintenance and Construction Vehicles

Vehicle Subsystem
Private Vehicles

Transit Vehicle Subsystem
CDTA Supervisor's Vehicles
CDTA Transit Vehicles
Local Transit Vehicles



Archived Data User Systems
RPI

Asset Management
NYSDOT Bridge Management System

Equipment Repair Facility
Local DPW Repair Facility

Financial Institution
Financial Institutions

Media
Newspapers, Radio, Television Stations

Multimodal Transp. Service Provider
Albany International Airport

Rail Operations
Amtrak Passenger Train Terminal

Capital District, NY
Regional ITS Architecture

"Sausage Diagram"

Roadway Subsystem
City of Albany/City of Schenectady/Local Field Equipment
NYSDOT Field Equipment
NYSTA Field Equipment

Parking Management Subsystem
Albany International Airport Parking Management System
CDTA Parking Management System*

* Elements are *planned*, not *existing*.

June 28, 2002

FHWA Rule 940/FTA Policy

Regional ITS Architecture Requirements

1. Description of the region
2. Identification of participating agencies and other stakeholders
3. Operational concept
4. Agreements required for implementation
5. System functional requirements
6. Interface requirements
7. **Identification of ITS standards**
8. Sequence of projects required for implementation
9. Process for maintaining your Regional ITS Architecture

FHWA Rule 940/FTA Policy

Systems Engineering Analysis Report

- Any ITS project that moves into design is required to follow a *systems engineering analysis*
- An ITS project is defined as an ITS project or program that receives federal-aid
- If the ITS project moves into design prior to the completion of a regional ITS architecture, a project architecture is required to support the systems engineering analysis

FHWA Rule 940

Systems Engineering Analysis

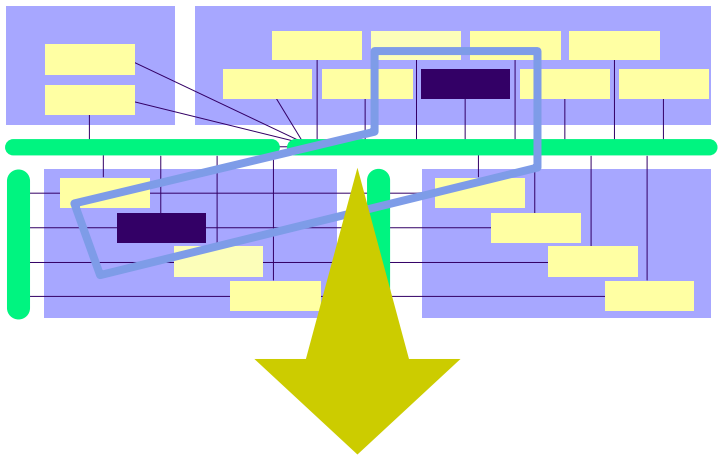
1. Identification of portions of the regional architecture being implemented
2. Identification of participating agencies roles and responsibilities
3. Requirements definition
4. Analysis of alternate system configurations and technology options to meet requirements
5. Procurement options
6. Identification of applicable standards and testing procedures, and
7. Procedures and resources necessary for operations and management of the

Module 3.1:
Introduction to ITS Architecture Market Packages

Modeling ITS Architecture Solutions: *Market Packages*

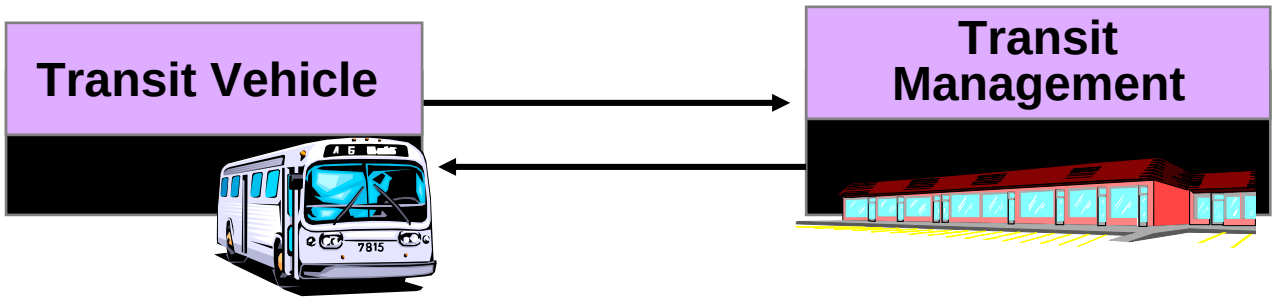
- The National ITS Architecture introduced the term *Market Package*
- Market Packages illustrate ITS elements that can be grouped to provide ITS services to transportation system users.

Market Packages



Architecture

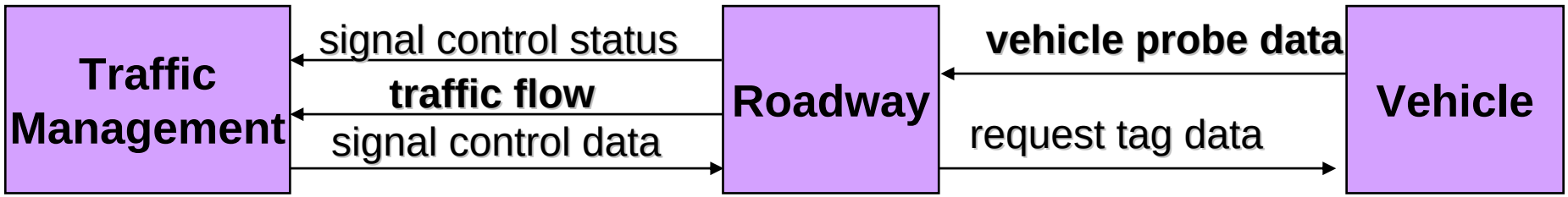
Framework spanning all of ITS



Market Packages

Pieces of the architecture that provide a particular transportation service.

Moving Standardized Information between ITS Elements: *Architecture Flows*



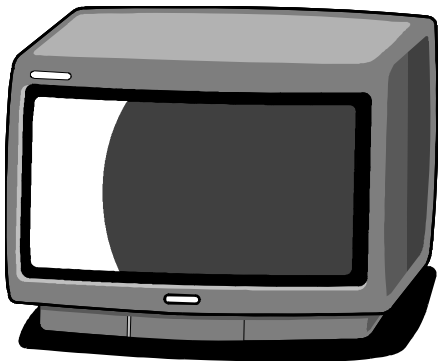
- *Architecture Flows*
  - Identify the expected types of information messages that flow between ITS elements
  - Provide a high-level mapping to ITS standards

… let's look at a few examples

Traffic Information Dissemination

Web Site

Motorist

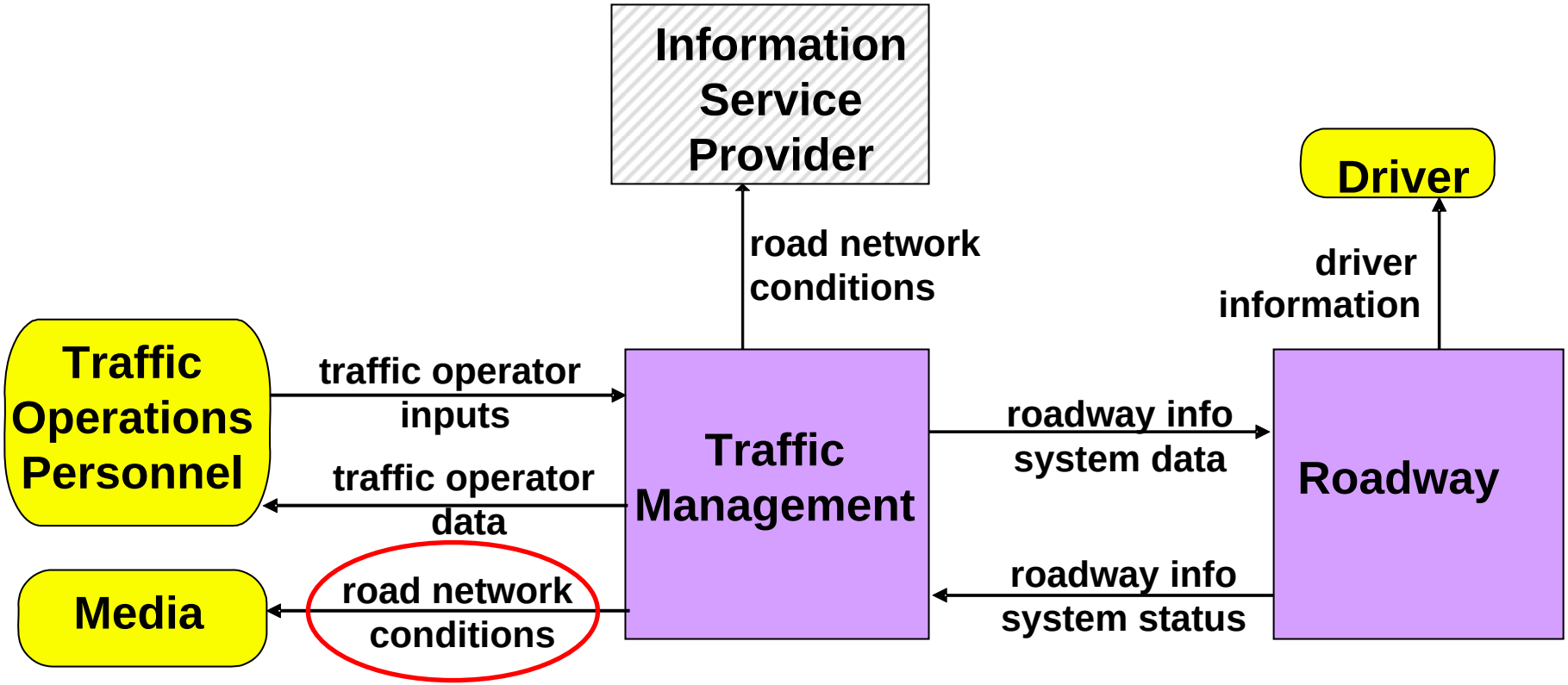


Television Station

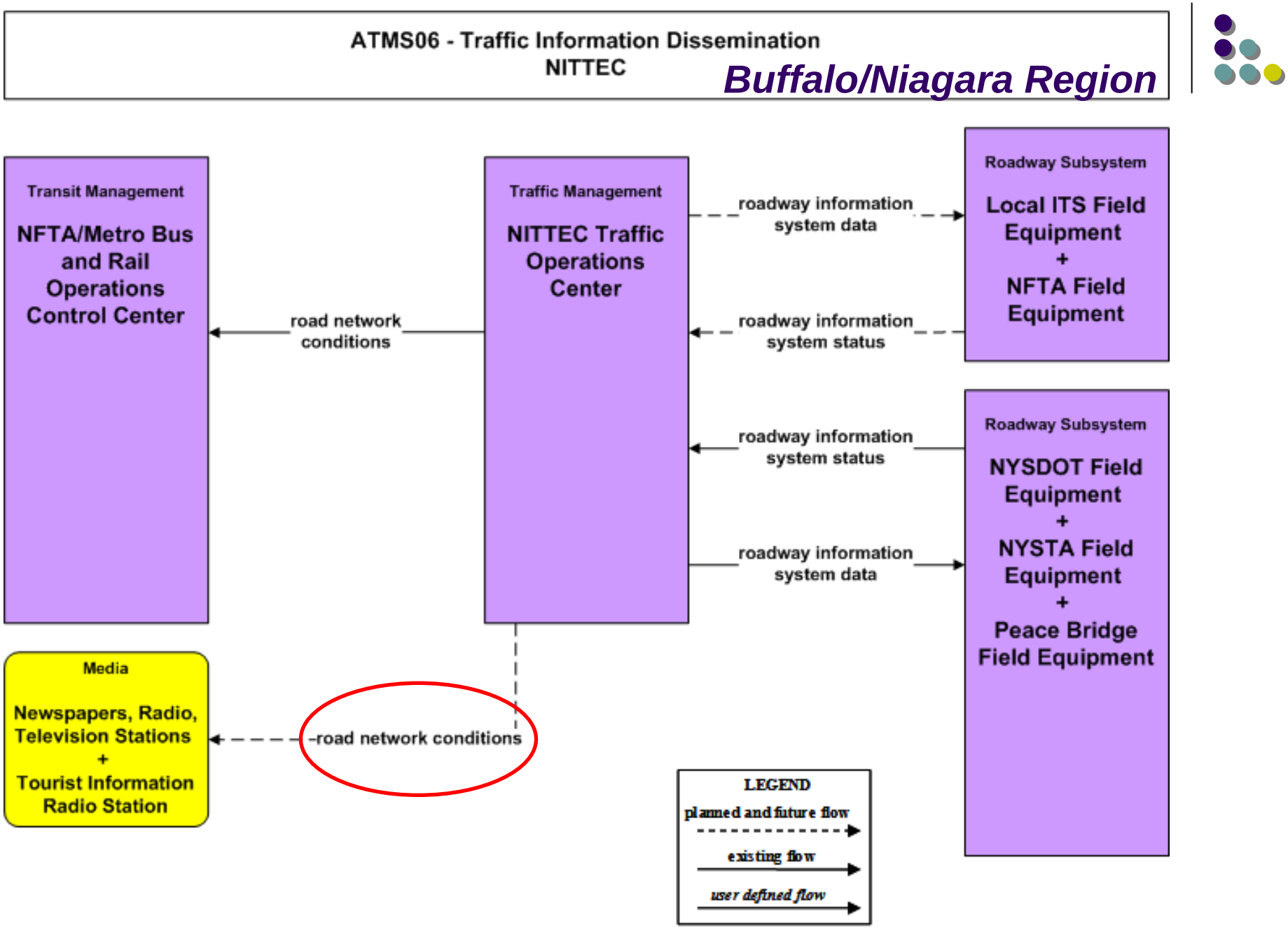
Traffic Management Center

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
NITTEC
Buffalo/Niagara Region
Transit Management
NFTA/Metro Bus and Rail Operations Control Center
Traffic Management
NITTEC Traffic Operations Center
Roadway Subsystem
Local ITS Field Equipment
+
NFTA Field Equipment
roadway information system data
roadway information system status
road network conditions
Roadway Subsystem
NYSDOT Field Equipment
+
NYSTA Field Equipment
+
Peace Bridge Field Equipment
roadway information system status
roadway information system data
Media
Newspapers, Radio, Television Stations
+
Tourist Information Radio Station
road network conditions
LEGEND
planned and future flow
existing flow
user defined flow

Example ITS Architecture Flow Mapping to ITS Standards [National ITS Architecture 6.0]

- road network conditions
  - NTCIP C2C: NTCIP Center-to-Center Standards Group
  - ITE TMDD 2.1: Traffic Management Data Dictionary and Message Sets for External TMC Communication (TMDD and MS/ETMCC)

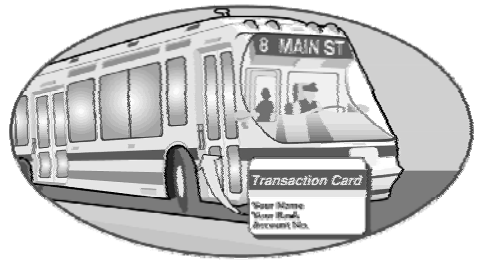
Automated Transit Fare Payment

Financial Institution

Enforcement

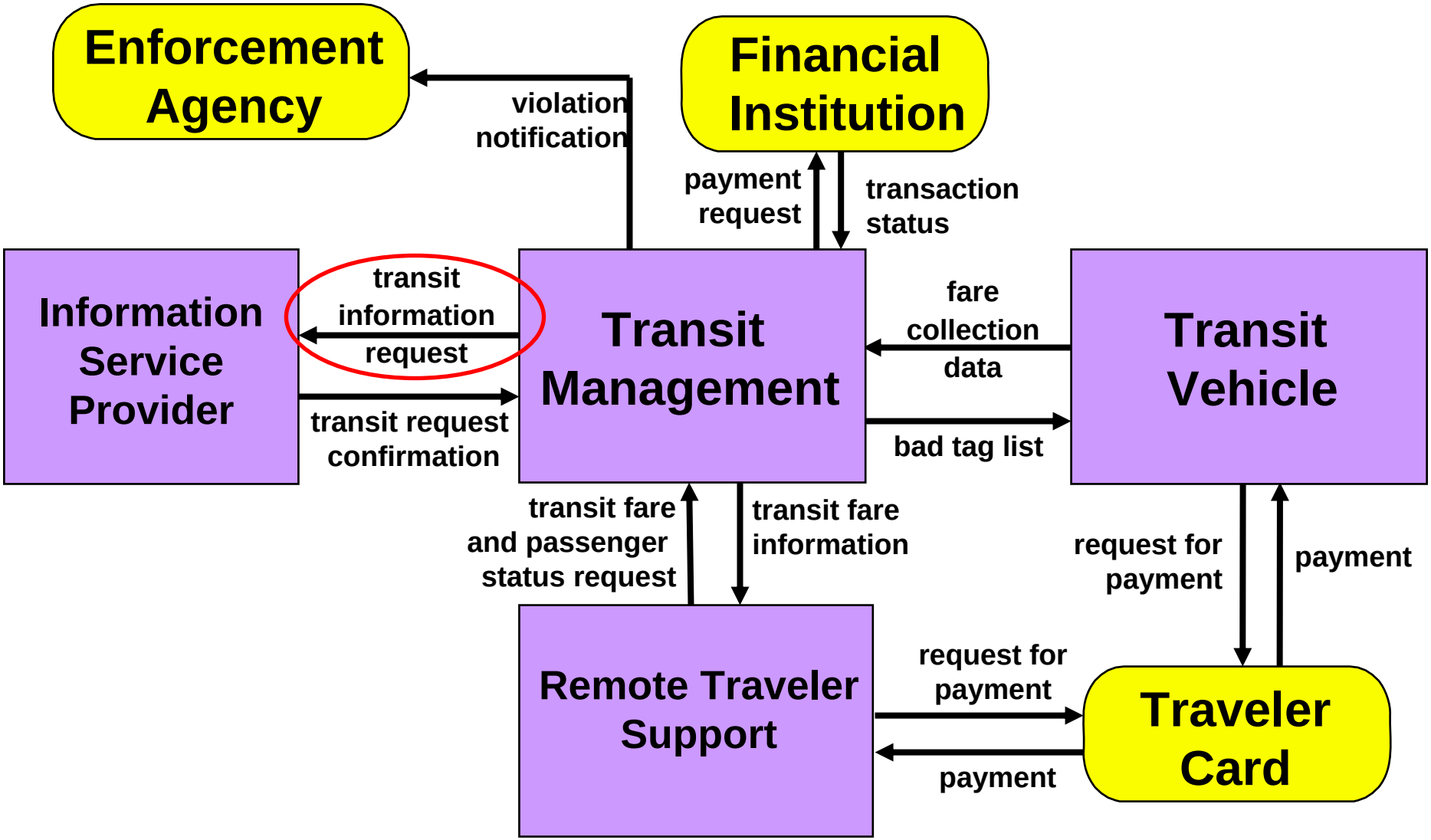
Transit Vehicle

Transit Management Center



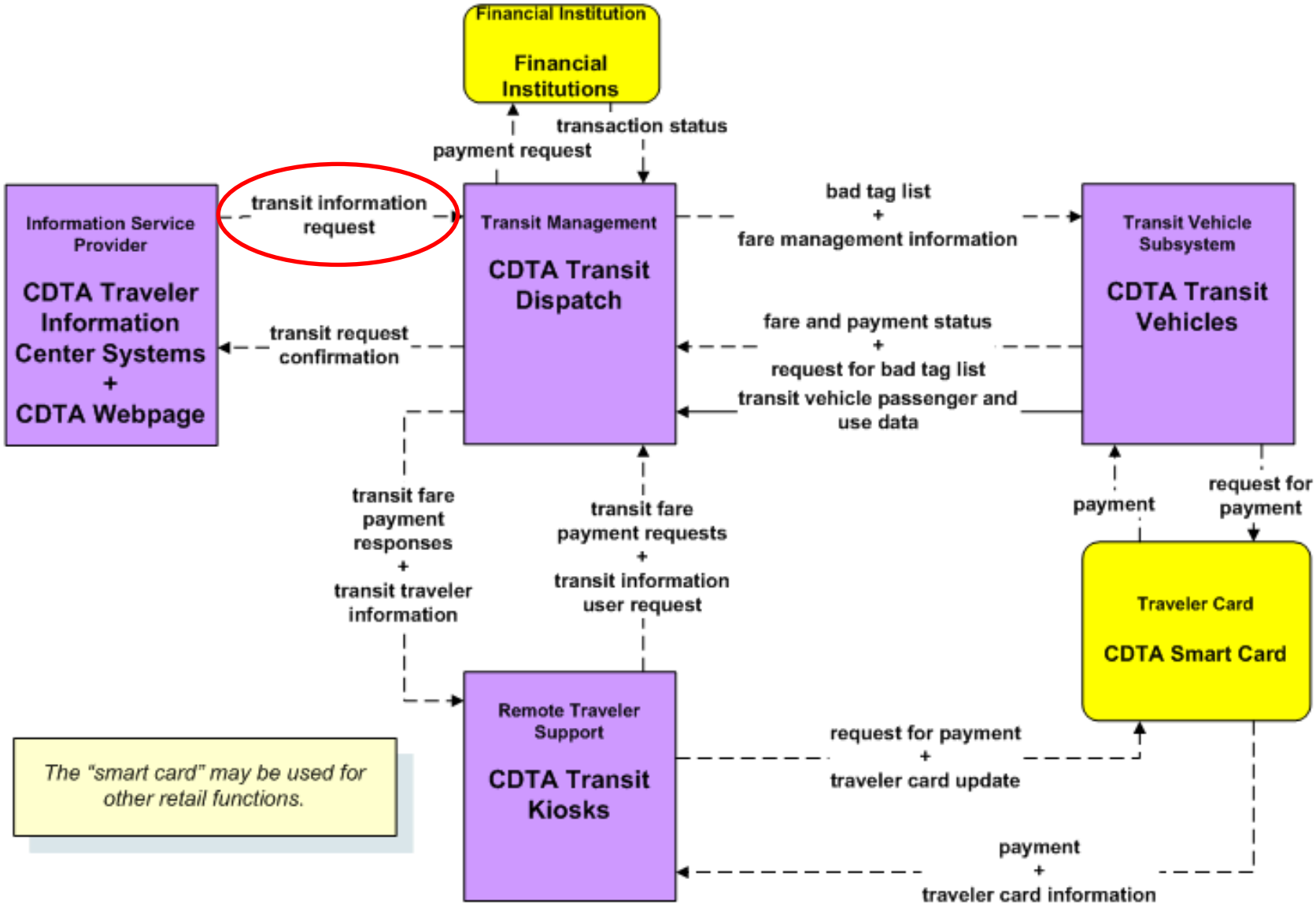
Point of Sale / Kiosk

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



APTS4 - Transit Passenger and Fare Payment
CDTA

Capital District Region

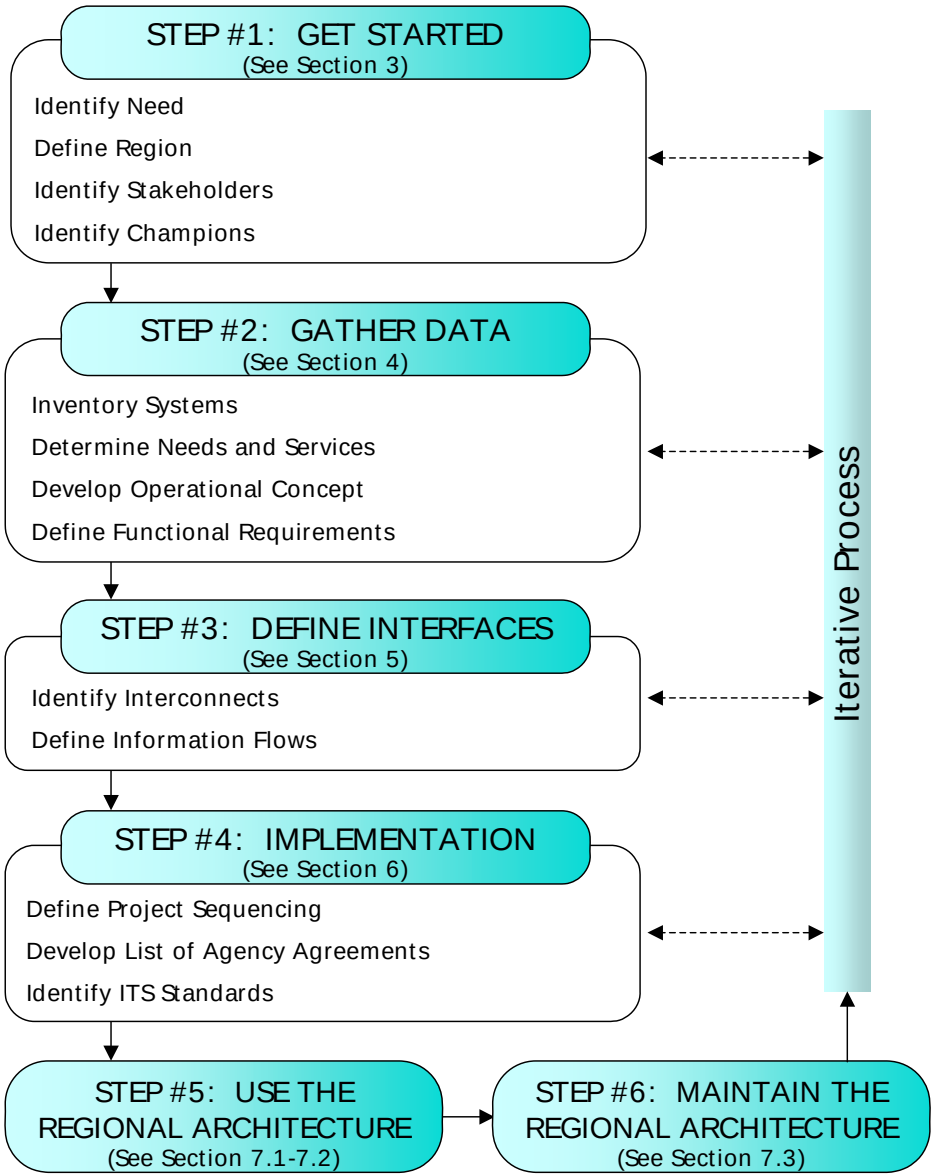


Example ITS Architecture Flow Mapping to ITS Standards [National ITS Architecture 6.0]

- transit information request
  - ATIS General Use: Advanced Traveler Information Systems (ATIS) General Use Standards Group
  - NTCIP C2C: NTCIP Center-to-Center Standards Group

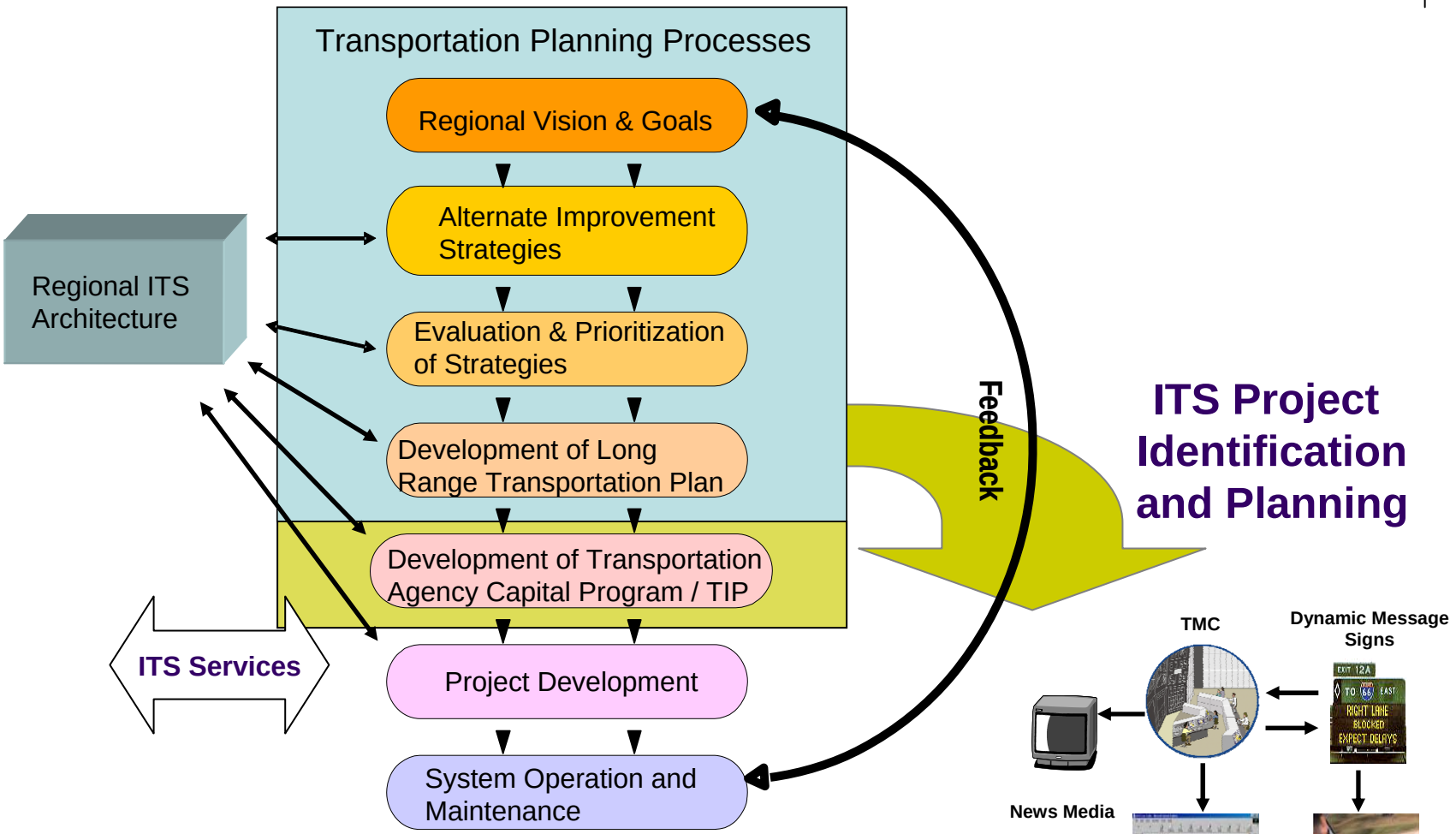
Module 3.2: Developing and Using Regional ITS Architecture

Developing Regional ITS Architecture



From the FHWA Regional ITS Architecture Guidance

Using Regional ITS Architecture



ITS Architectures help answer the question:
Are there ITS services that will help realize my region's transportation improvement strategies?

Development of Transportation Capital Program / TIP

A small subset of these projects, called *Regionally Significant Projects*, are highlighted below. A Regionally Significant Project is one with a short timeframe, AND affecting multiple institutions AND/OR having regional or extra-regional impact. The Regionally Significant Projects for all three architectures are shown in Table 5.

Project	Architecture	Description	Market Package Diagrams
NJDOT STOC - Statewide Transportation Operations Center	Statewide	Where multiple regions or institutional facilities are affected, the STOC coordinates: • incident/emergency planning and response; • timing of maintenance, construction and workzones • statewide early warning, disaster response and recovery, and evacuation.	ATMS07-07, ATMS08-01, EM01-1, EM01-2, EM01-3, EM07-1, EM07-2, EM08-1, EM08-2, EM09-2, EM09-3, MC08-1, MC08-2
Statewide Evacuation and Coordination Program	Statewide	STOC coordination with the NJ State Office of Emergency Management and major traffic Management centers; major public safety dispatch centers and major transit management centers.	EM09-1
Transit Smart Card	Statewide	A single payment instrument enabling payment reciprocity between the offering agencies coordinated under DVRPC, NJTPA and SJTPO Fare Reciprocity Networks which will include all transit properties operating in New Jersey.	APTS4-2
NJDOT Traveler Information System (includes 511)	Statewide	Enables the dissemination of traffic information between traffic management centers, including NJDOT TOC North/South/Central and potential travelers. Traveler	ATIS2-02

Example: New Jersey Statewide ITS Architecture and Deployment Plan

Development of Transportation Capital Program / TIP

			Capital Cost						Annual Cost		
			low end			high end			low end		high end
Center Subsystems			unit cost	quantities	extension	quantities	extension		unit cost	extension	extension
Transit Center Hardware[2]	TR001		$ 30.0	0	$ -	1	$ 30.0		$ -	$ -	$ -
Transit Center Software, Integration[2]	TR002		$ 1,720.0	0	$ -	1	$ 1,720.0		$ 12.0	$ -	$ 12.0
Systems Integration[3]	IS017		$ 110.0	4	$ 440.0	6	$ 660.0		$ -	$ -	$ -
Staff											
Transit Center Labor	TR004		$ -	0		1			$ 250.0	$ -	$ 250.0
Communications											
DS0 Communication Line[4]	TC001		$ 1.0	2	$ 2.0	3	$ 3.0		$ 1.2	$ 2.4	$ 3.6
DS1 Communications line[5]	TC002		$ 1.0	2	$ 2.0	3	$ 3.0		$ 8.4	$ 16.8	$ 25.2
		Subtotal			$ 444.0		$ 2,416.0			$ 19.2	$ 290.8
Design Development Allowance		25% Subtotal			$ 111.0		$ 604.0			$ 4.8	$ 72.7
		Total			$ 555.0		$ 3,020.0			$ 24.0	$ 363.5

Notes:

1 Costs are shown in thousands of dollars

2 Low end assume Transit Center Equipment cost borne by other projects; High end assume one new TR subsystem reqd

Example: New Jersey Statewide ITS Architecture and Deployment Plan

Regional ITS Architecture: Rationale

- Brings stakeholder together to develop a regional view of what ITS services are needed for the region across institutional boundaries.
- Helps break down institutional boundaries and provides a forum for discussion of regional ITS
- A plan for the regional, institutional, integration of ITS
- Defines systems and their interfaces
- Supports Transportation Planning

Regional ITS Architecture: Resources & Where in the Guide

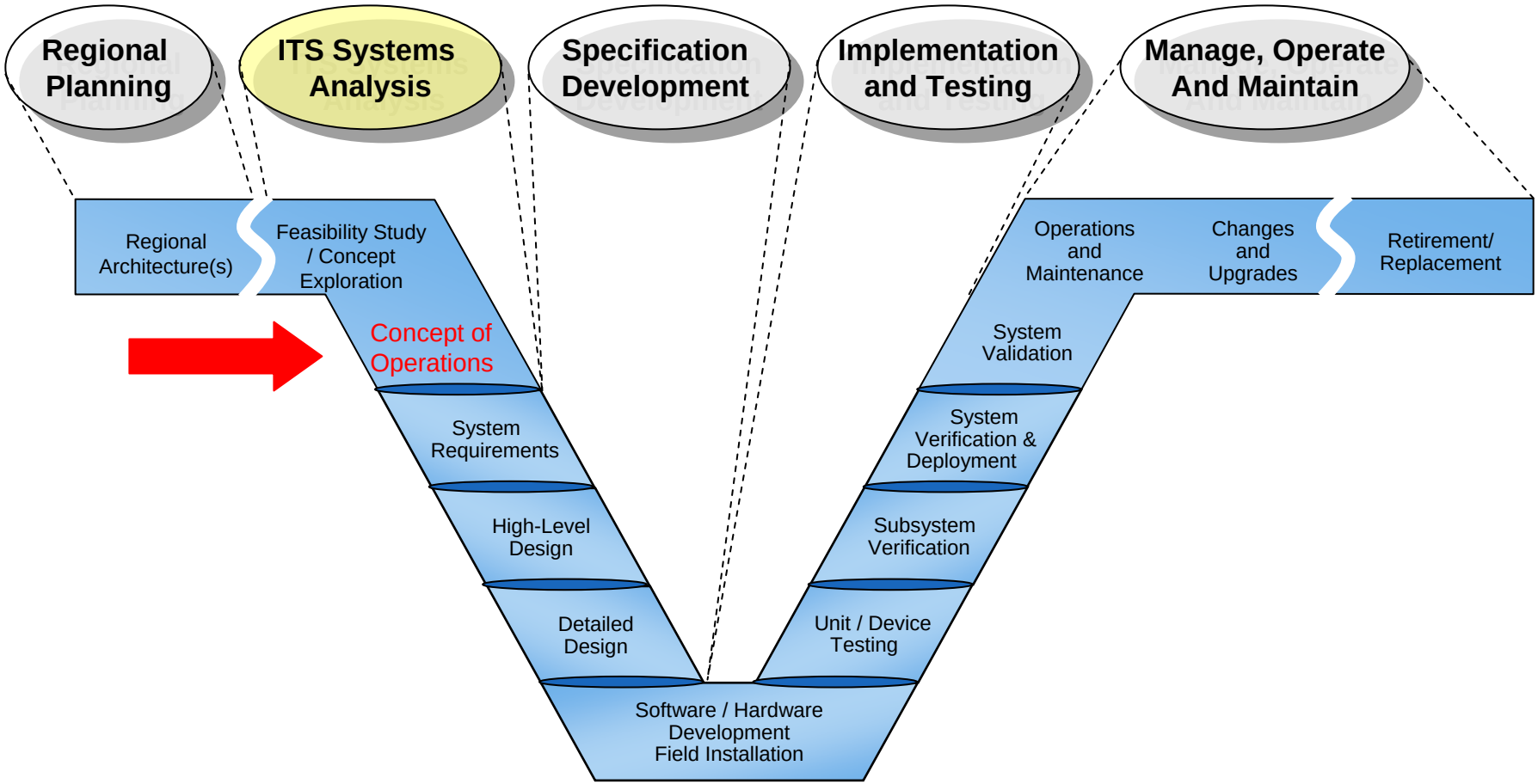
- Resources
  - FHWA Regional ITS Architecture Development Guidance

Module 4:
Concept of Operations Development

Module 4 – Concept of Operations Learning Objectives

- Understand that user / operational needs bound the requirements of a system
- Concept of Operations (ConOps)
  - What is a ConOps
  - Relationship to Regional ITS Architecture
- Operational Scenarios
  - How to document the user benefits and expectations of the system
  - Techniques for operational scenarios development
- User Needs
  - What is a user need
  - User Needs Wording

Concept of Operations Development



Module 4.1:
Relationship to Regional ITS Architecture

What is a Concept of Operations?

- What is a ConOps document? **[IEEE 1362]**
  - Communicates the user's needs for and expectations for the proposed system
  - Communicates an understanding of the users' need and how the system shall operate to fulfill those needs
  - Scopes the system boundary

IEEE 1362: Guide to ConOps Documents]

Relationship of ITS Architecture and ConOps?

- Regional ITS Architecture
  - Focus is on region
  - Long range time frame – it is a plan
  - A framework for ensuring institutional agreement and technical integration of ITS projects or groups of projects.
  - The ITS Architecture documents the system interfaces
  - *May* be a good starting point for ConOps development – depending on the level of detail in your regional ITS architecture.
- ConOps
  - Focus is on a system and its users
  - Time frame is the life cycle of the system – development plus time you will operate and maintain the system
  - Provides an operational context for the system elements of an ITS project

What's in a ConOps? [IEEE 1362]

1. System Scope
2. Referenced Documents
3. Current System or Situation
4. Justification for and Nature of Changes
5. Concepts for the Proposed System (System Description)
6. Operational Scenarios
7. Summary of Impacts (on Operations)
8. Analysis of the Proposed System (Alternatives)

Description of the Proposed System

- Operational Environment (modes of operation, locations, hours of operations, users, staff, support and maintenance)
- Major System Components and Interconnections among these components
- Interfaces to External Systems and Procedures
- Capabilities and functions of the proposed system
- Cost of system operations
- Operational Risk Factors
- Performance characteristics
- Quality
- Safety and Security

Consider using Regional ITS Architecture as a starting point

Module 4.2:
Identifying System Users

Identifying Users

- Identifying the User
  - Only people have needs
    - Traveler
    - TMC Operator
  - Things do not have needs
    - A system does not have needs
    - A transportation system does not have needs
    - A TMC does not have needs
  - An organization has a responsibility and agreements to provide a service or perform a mission

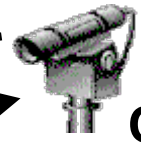
These are elements of the solution that satisfy needs

Techniques for Identifying Users

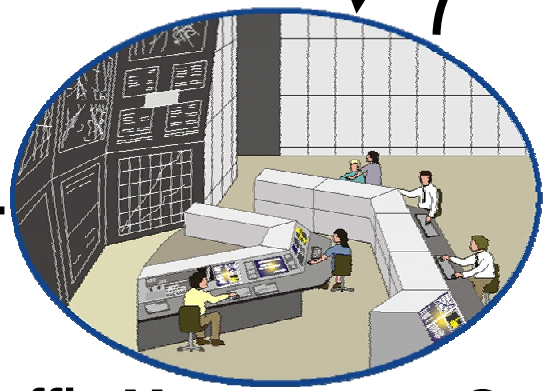
- Use or Develop a System Overview Diagram. Ask:
  - Who will control the ITS devices in the system
  - Who will use information the system creates or provides
  - Who will provide information to the system
  - Who will maintain the system
- Use the Regional ITS Architecture
  - Market Package Diagrams - What are the ITS services described?
  - Who receives the ITS service benefits?
  - Who provides the ITS service benefits?

Who are the users?

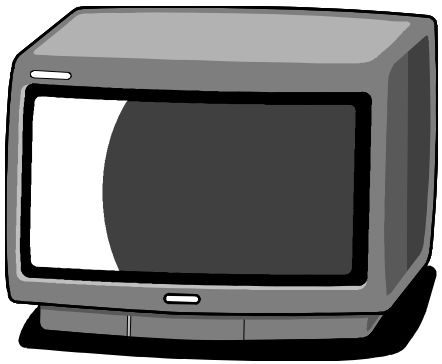
ITS Field Device / TMC Integration



CCTV



Traffic Management Center



Television Station

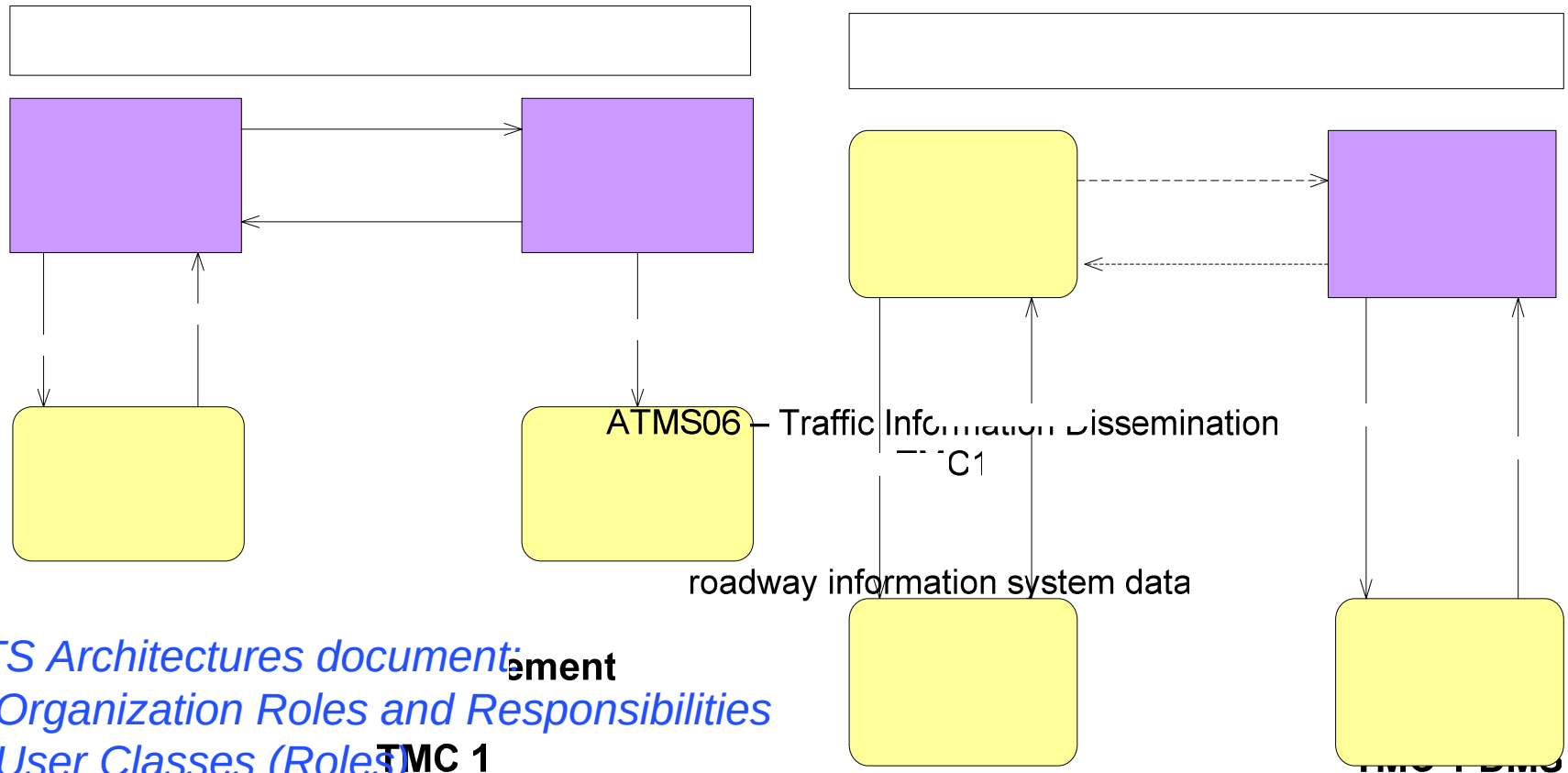
Dynamic Message Signs

Web Site

Motorist

Class Exercise: Identify who are the users?

Regional ITS Architecture
Market Package Diagrams



ITS Architectures document:
- *Organization Roles and Responsibilities*
- *User Classes (Roles)*
- *Users (Role Players)*

Market packages show the ITS elements that together provide ITS services to transportation system users.

Module 4.3:
Operational Scenarios

Describing Your Operations

- Your operations primarily exist to satisfy some users needs
  - Some users can be characterized as your customers
  - Some users can be characterized as your operations and maintenance staff
- Operational Scenarios describe the sequence of activities and help to identify user needs
- Operational Scenario Development is an iterative process
  - To get this crucial step right, allow for several drafts of the operational scenarios and needs to be developed

Operational Scenarios and User Needs

- The technique described here supports identification and development of well-state user needs, which bound the system scope.
- The key result is the documentation of the rationale for the user need consistent with your operations.
- You can use the technique described here or tailor it for your own purposes.

Steps for Operational Scenario Development

1. State the Current Situation / Problem
   - Can be derived from goals and objectives
2. Document User Classes and Roles
   - We describe a tabular technique for capturing this information
3. Develop Operational Scenarios

State the Current Situation / Problem

- Who (is having the problem)
  - Traveler
- What is lacking / problem
  - En-route information on congestion hot-spots
- When and where (Operational Context)
  - On their way to work, typically driving the same primary route, 5 days a week
- Why (is this a problem)
  - Traveler needs to make route driving decisions en-route upon being made aware of congestion or problems on primary route of travel

Document User Classes and Roles

Rationale: Helps capture desired operational capabilities and rationale for a user need.

User	User Class	User Class Description	Desired Operational Capability	Expected Benefit	Performance Measure
Motorist	Driver	Traveling public.	To plan timely routes. T be notified of problems on roadways to avoid them.	Improved Travel Time. Improved safety in terms of reduction of incidents.	Travel Time. Number of incidents reported.
TMC Operator	Traffic Operations Personnel	TMC operators control TMC ITS devices and monitor status of roadways. Coordinate with operators of adjacent areas.	To provide warning and alerts to Motorists. To provide warning and alerts to other TMCs.	More timely provision of information, warnings and alerts to Motorists so they may change travel plans.	Timeliness of Warnings and Alerts. Wider geographic scope of coverage of alerts and warnings.

Columns were adapted from Regional ITS Architecture Descriptions

Develop the Operational Scenarios

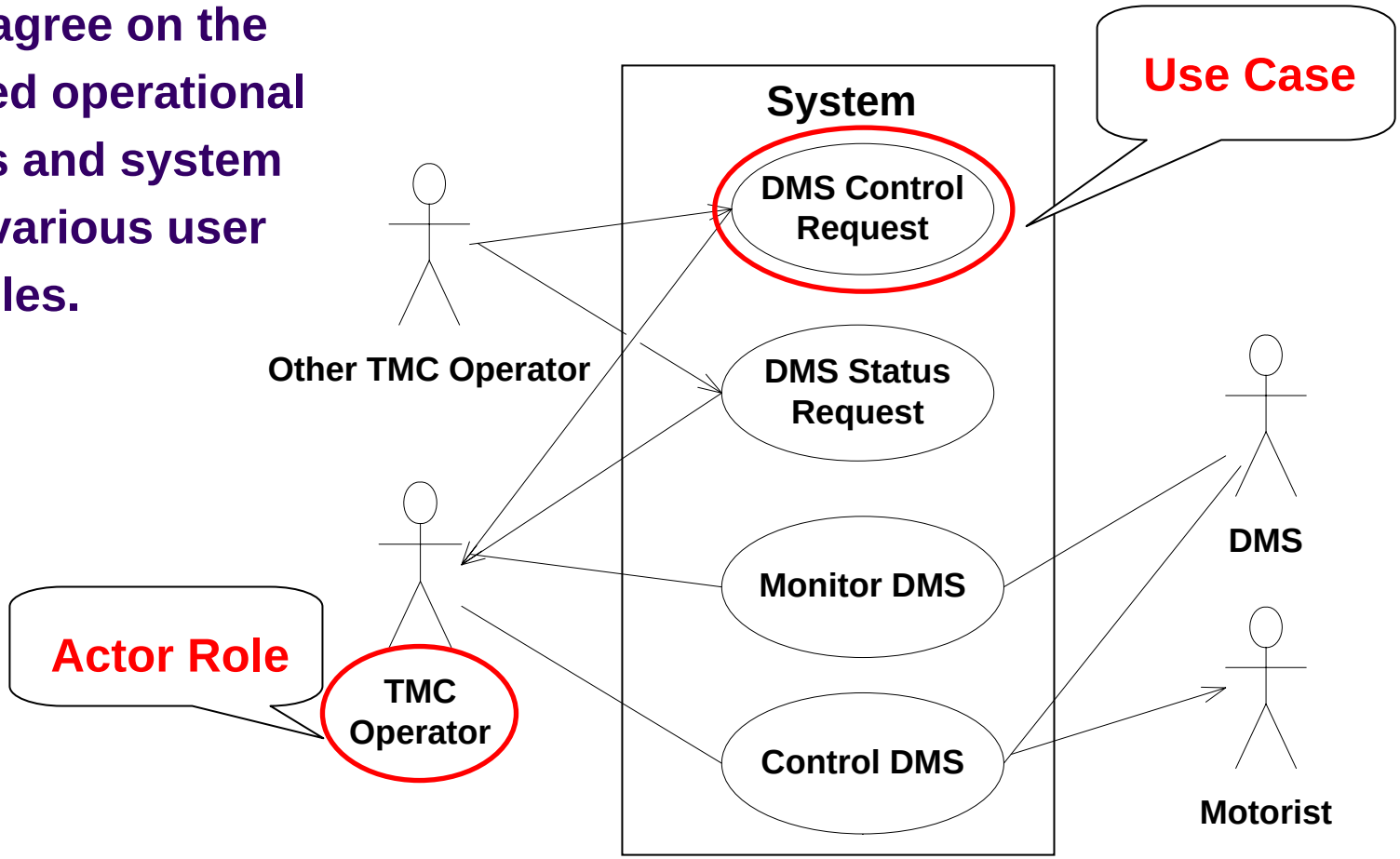
- Objective is to document the system behavior as seen by its users
- Make sure the system supports your organization's way of doing things.
  - You want to make sure that a system being introduced into your operations does things the way you need to do them.
- People in your organization have different points of view, vocabulary, and knowledge (level of detail) for the same function.
  - You want to prevent conflicting descriptions of operational capabilities

Develop the Operational Scenarios

- We will use two diagrams and a narrative to describe operational scenarios
  - Use Case Diagram – Shows a set of user roles and which use cases the role participates in.
  - Use Case – Is a description of a sequence of actions that the system performs that yields a result of observable value for a user role.
  - Activity Diagram – Is a flow chart that shows sequence of activities (paths) and alternates.
  - Activity Diagrams will be used to model a use case process in more detail.
  - Narrative – Captures the flow of activity as a textual description

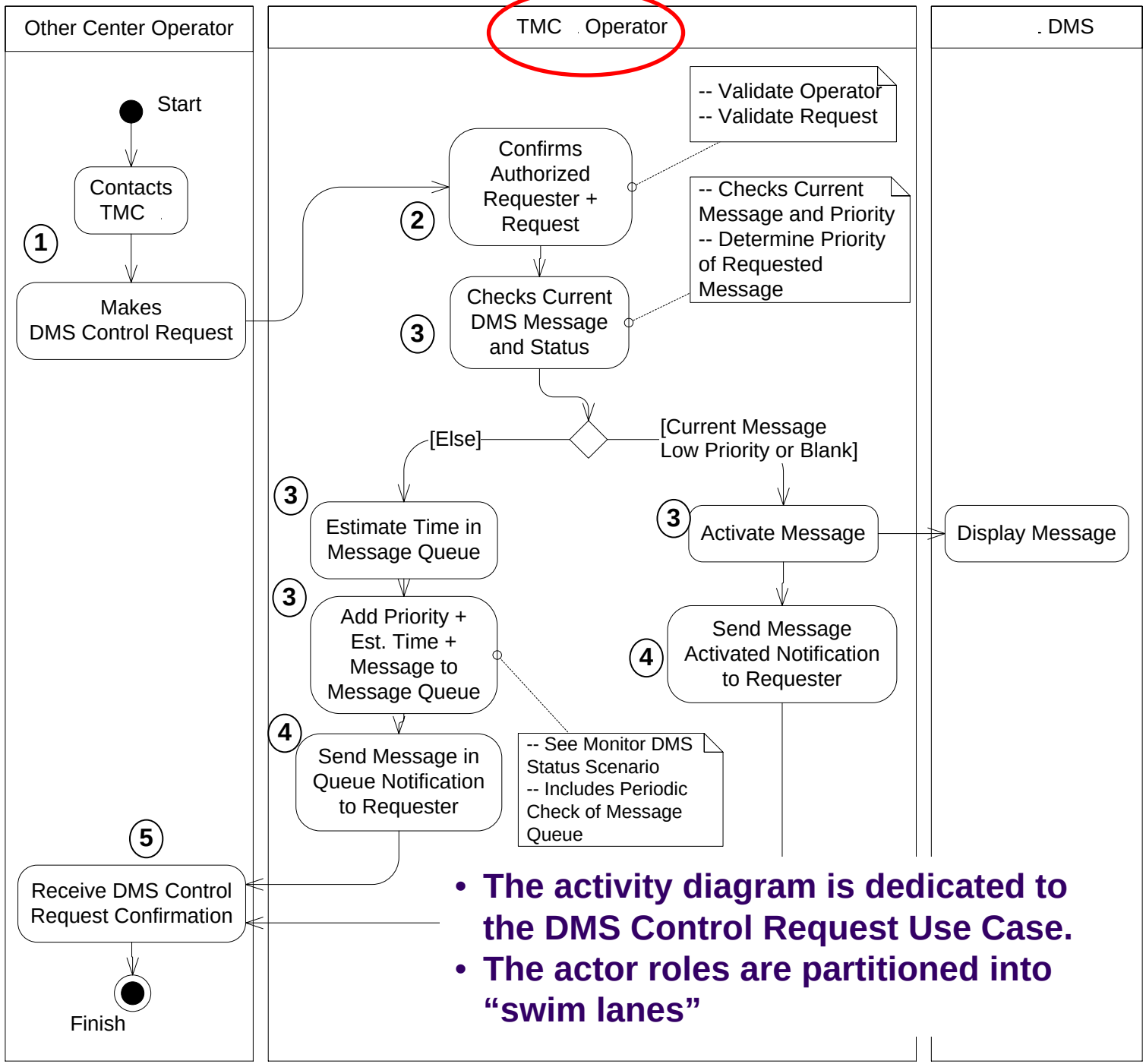
Example Use Case Diagram

Let's you agree on the major desired operational capabilities and system usage by various user roles.



Navigation to/from Activity Diagram (captures sequence of steps in the scenario - next page) is done through the Use Case (DMS Control Request) and Actor Role (TMC Operator)

DMS Control Request Activity Diagram



- **The activity diagram is dedicated to the DMS Control Request Use Case.**
- **The actor roles are partitioned into "swim lanes"**

Operational Scenario Narrative

1. This operational scenario begins when an operator from an external center provides a request to communicate with TMC to display a message on a DMS.
2. The TMC must validate that the requester and request are valid for control requests of dynamic message signs.
3. Upon validation of the requester and request, the TMC begins the process to activate a message. The TMC Operator may reject a control request.
4. The TMC provides control request status information and control acknowledgement / rejection to the Other TMC.
5. The Other TMC Operator is notified of message activation and/or request acknowledgement / rejection.

Module 4.3:
User Needs Wording

User Needs Wording

- Uniquely Identifiable
  - Each need is assigned a unique number and title
- Major Desired Capability
  - Expresses capability of the system, whether it exists in the current situation or is a gap
- Solution Free
  - Solution free, thus allows designers to explore alternatives
- Captures Intent and Rationale
  - Explains why the capability is needed

Example: User Needs

User Need ID	User Need Title	User Need
UN1.0	Motorist Information	Motorists need to receive information about roadway conditions (incidents and roadway closures) to improve safety and travel time while en-route to their destination.
UN1.1	Motorist Warnings and Alerts	Motorists need to receive warnings and alerts (pre-trip and en-route) so they may change their travel plans.
UN2.0	Provide Incident Information	TMC operators need to provide incident and roadway condition information to adjacent TMCs to allow adjacent areas to provide motorist information, including warnings and alerts.
UN2.1	Receive Incident Information	TMC operators need to receive incident and roadway condition information to allow warning motorists in the operators area of conditions in adjacent areas.
UN2.2	Share Incident Information for Dispatch	TMC operators need to provide and receive incident and roadway condition information to allow them to dispatch secondary responders to incident locations.

ConOps Summary

The Concept of Operations: Rationale

- You and your system requirements developers will need information about your operations must be improved.
- The system must help operators and maintainers do their job better and more efficiently (in terms of time and cost).
- User and operational needs bound the system.
- The result are systems that work with your operations and better meet your customer's needs!

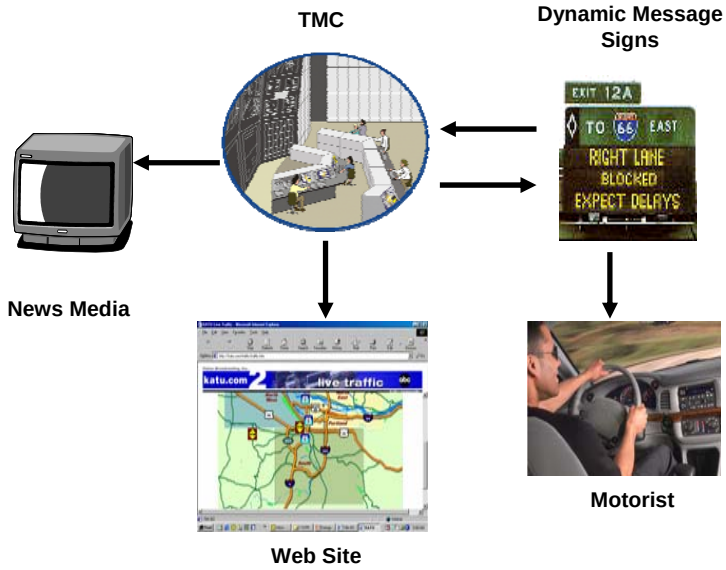
Module 4 – ConOps Exercise

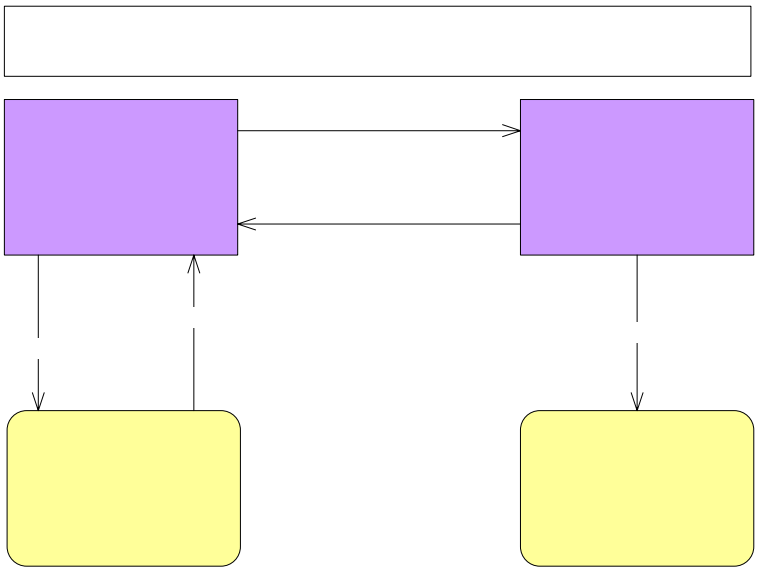
- Use the diagrams provided to:
  - Identify Users
  - Write an Operational Scenario
    - Sequence of Activities from your operations to meet those needs
    - Use a flow chart to help work through the operational scenario description
  - Identify User Needs

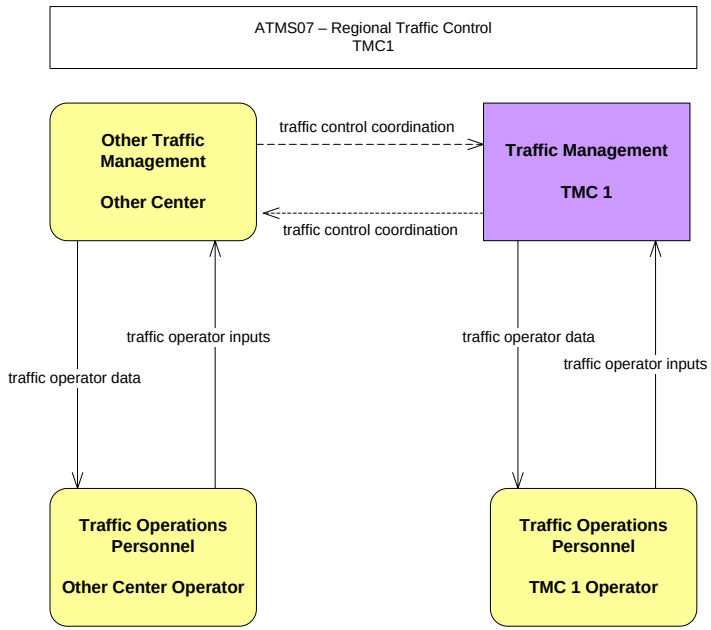
Concept of Operations: Resources & Where in the Guide

- Resources
  - IEEE 1362 - IEEE Guide for Information Technology and System Definition Concept of Operations (ConOps) Document
  - ANSI/AIAA-G-43 – Guide for the Preparation of Operational Concept Documents
  - International Council on Systems Engineering (INCOSE)
- Where in the Guide
  - Chapter 5 – Developing Concept of Operations and Requirements
  - Appendix C – Example Concept of Operations (Partial)

Module 4 – ConOps Exercise Diagrams





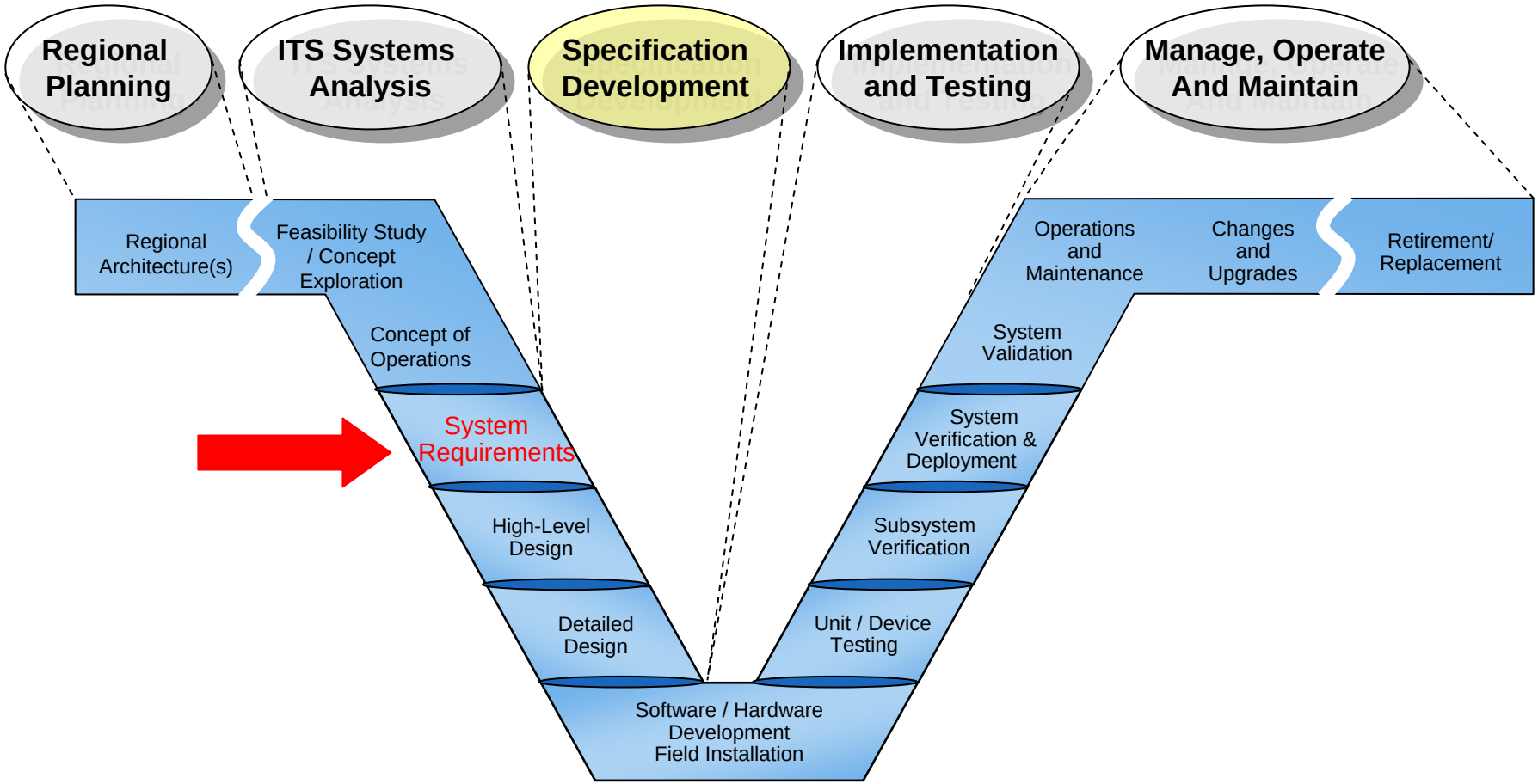


Module 5:
Requirements Development

Module 5 – Requirements Learning Objectives

- Requirements
  - What are requirements
  - Explain the difference between functional and non-functional requirements
  - What are the qualities of good requirements
  - How to use the operational scenario to derive system requirements
  - How to use a sequence diagram to help document information exchange requirements
  - How to write a requirement and applicable requirements wording
  - How do you test that requirements are fulfilled?
  - Tracing requirements to the ConOps user needs?

Requirements Development



Systems Analysis: Requirements Development

- **Use Cases** and Operational Scenarios support Requirements Development.
- Approach guarantees a **system that works with your operations**.

Project: ITE-AASHTO TMDD V3.0 Standard

3.3.9.5.3 Control Requests for Remote DMS Devices

The requirements to support DMS control requests from other authorized centers are as follows. Only control requests to display a specific message on a remote DMS device is supported.

3.3.9.5.3.1 Send DMS Control Response Upon Request

An owner center shall respond to an authorized EC requesting remote control of a DMS via an one-time control request with a message containing the status of the request.

3.3.9.5.3.2 Contents of DMS Control Request

The following are requirements for a DMS control request.

3.3.9.5.3.2.1 Required DMS Control Request Content

The DMS control request sent to an owner center shall include:

a. Unique identifier of the requesting organization;
b. Username and password of the requesting operator;
c. Unique identifier of the device;
d. Unique sequence number generated by the EC identifying the control request within the EC (this sequence number shall be returned to the requesting client in any response to the control request); and
e. Message requested in MULTI language; OR
f. Message number being requested.

3.3.9.5.3.2.2 Optional DMS Control Request Content

If the owner center supports it, the following are optional requirements that may be included in the DMS control request sent to an owner center.

3.3.9.5.3.2.2.1 Operator Identifier

The EC shall provide the unique identifier of the operator making the request for the

Project: WMATA Bus ITS Planning and Demonstration

5.3 Use Cases

R.1 Manage the data sets that are required by the Real time Bus Information

This use case defines the responsibilities of the data custodian and database administrator for several key data sets upon which the RTBI system depends. There are several data sets that are necessary for the proper operation of the real time bus information system. The major data set is the Metrobus schedule extrapolated to the scheduled time of arrival at each bus stop along each trip. The regional partner bus schedule is also a mandatory data set.

Additional data sets may be used depending on the predictive algorithm. These data sets will need to be collected, normalized, integrated and managed.

R.1.1 Load schedule (at stop level) data into the RTBI [mandatory]

This use case defines the responsibilities for extrapolating, transforming and loading the schedule data projected to the stop level (from the timepoint level) to the RTBI system.

Basic Flow:

1. Generate scheduling data from Trapeze Scheduling application (FX)
2. Extrapolate the data to scheduled arrival times at the stop level. (FX output does not produce scheduled arrival times at a stop level; three alternatives are listed below.)
3. Load the data into the data store.
4. Log events

Requirements are written as "shall" statements and are **traceable to Operational Needs**

What are requirements

- A description of ***what*** the system will do
- A statement that identifies a necessary attribute, capability, characteristic, or quality of a system in order for the system to have value and utility to a user.

Types of Requirements

- Functional Requirements
  - Describe the functions that the system is to execute
  - Written in technology neutral terms
  - Written as shall statements to reflect a “contract” between stakeholders/users and system designers
  - In the national standards, some functional requirements are optional as they ***may*** be included in your project
- Non-functional Requirements
  - Act to constrain the solution
  - Examples:
    - performance requirements
    - maintainability requirements
    - reliability requirements

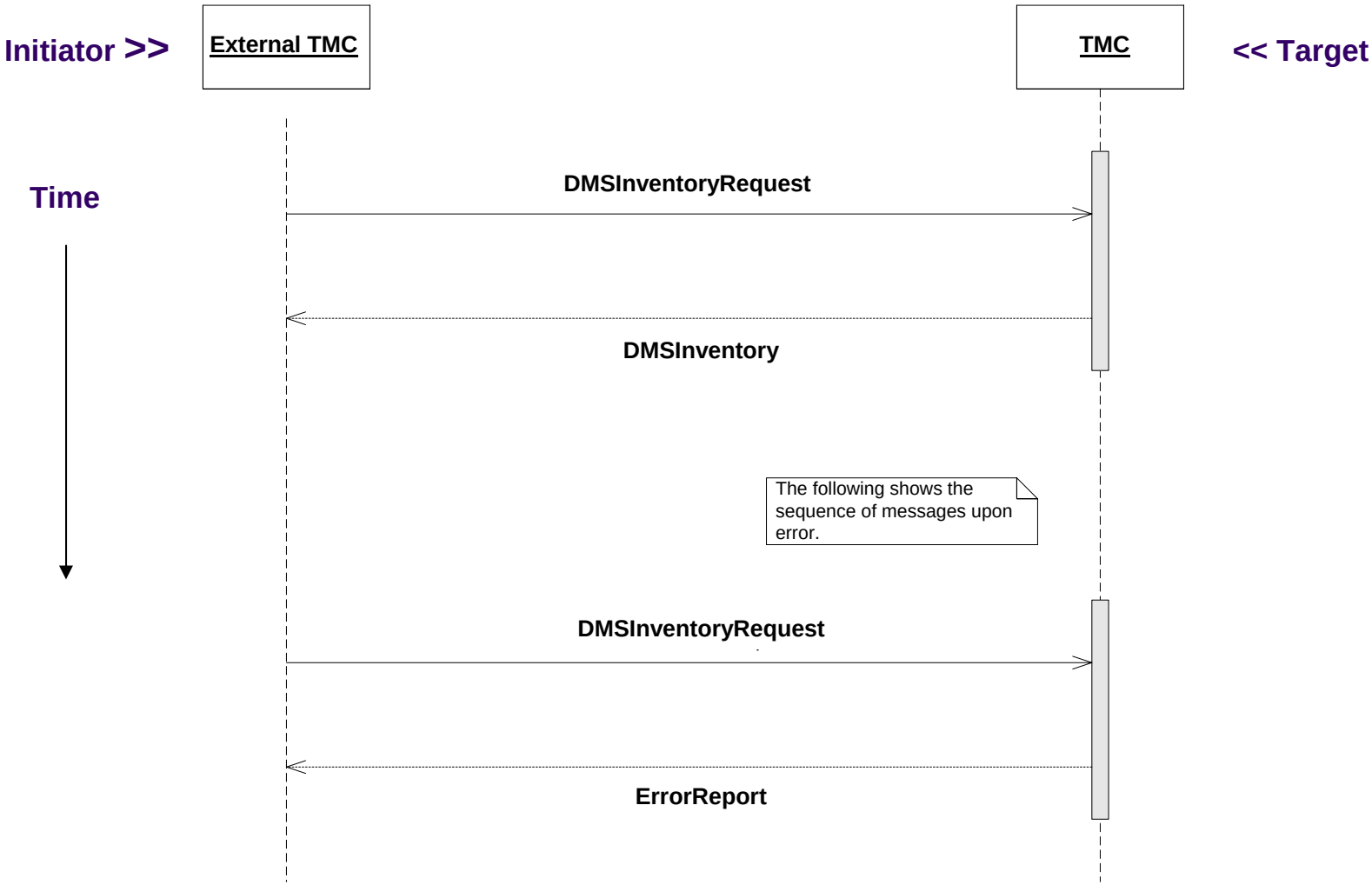
Qualities of Good Requirements

- Necessary – Must be useful (traceable to needs)
- Unambiguous – Susceptible to only one interpretation
- Concise – Stated in declarative language (“shall statements”)
- Consistent – Does not contradict itself, nor any other stated requirement
- Complete – The requirement is stated completely in one place. (Requirements may be grouped.)
- Attainable – Realistic to achieve within available resources and time
- Testable – Must be able to determine that the requirement has been met through one of four possible methods (inspection, analysis, demonstration, or test)

Using operational scenarios to derive requirements

- Analyze what parts of the scenario shall be automated
  - Ask: How does the system help the user accomplish a functions?
  - Technique: Fill in a table with these columns
    - User: What user and what need(s)
    - User Activity: What function the system will support
    - Automation: What the system will do
      - E.g., collect/disseminate information, verify information, perform a tedious error prone process
    - Is this (should this be) Part of Project?
  - This is an iterative process, so allow several drafts of requirements to be developed

Using a sequence diagram to derive and document information exchange requirements



Requirements Wording

- Requirements Wording
  - Initiator
    - External TMC
  - Target
    - TMC
  - Action to be Performed by Target
    - Send DMS Inventory
  - Conditions on the Action
    - Upon Request
- Example
  - The TMC shall send a DMS Inventory to an authorized External TMC upon request.
  - The contents of a DMS Inventory Request shall include:
    - Device request filter
    - …
  - The contents of a DMS Inventory shall include:
    - Device identifier
    - Device name
    - …

Requirements Traceability

- Refers to the ability to follow the life of a requirement from its origins, through its development and specification, to its subsequent deployment and use.
- Requirements Traceability Matrices
  - Trace Requirements to Needs: To ensure requirements are useful and necessary
  - Trace Requirement To Design: To ensure design fulfills all requirements
  - Trace Requirements to Tests: To ensures system has implemented the requirements as specified in the design

System Requirements: Rationale

- Describe what the system must do in technology neutral terms
  - This allows a wide range of possible design alternatives to be considered
- Have qualities that can be assessed/verified to ensure good requirements
- Requirements shape the rest of the system life cycle
- Poorly written requirements lead to:
  - Hard to design, hard to test, hard to operate, hard to maintain systems
  - Lead to re-work in phases downstream resulting from the need on the part of system designers and implementers to sort out ambiguities and guess-work about your intentions
- Requirements traceability is key tool of the verification and validation process

Module 5 – Requirements Development Exercise

- Using the results of the previous exercise, identify system features that support your operation's activities
- Write one or more requirements about the system features
- Optionally, draw a sequence diagram to support your requirements analysis

Requirements: Resources & Where in the Guide

- Resources
  - IEEE 1233 - Developing Systems Requirements Specifications
  - IEEE 830 - Recommended Practice for Software Requirements Specification

- Where in the Guide
  - Chapter 5 – Developing Concept of Operations and Requirements
  - Appendix J - Example DMS NTCIP Communications Specification
  - Appendix K - Example Center-to-Center Interface Specification

Module 6:
ITS Standards Overview and Key ITS Standards for New York State

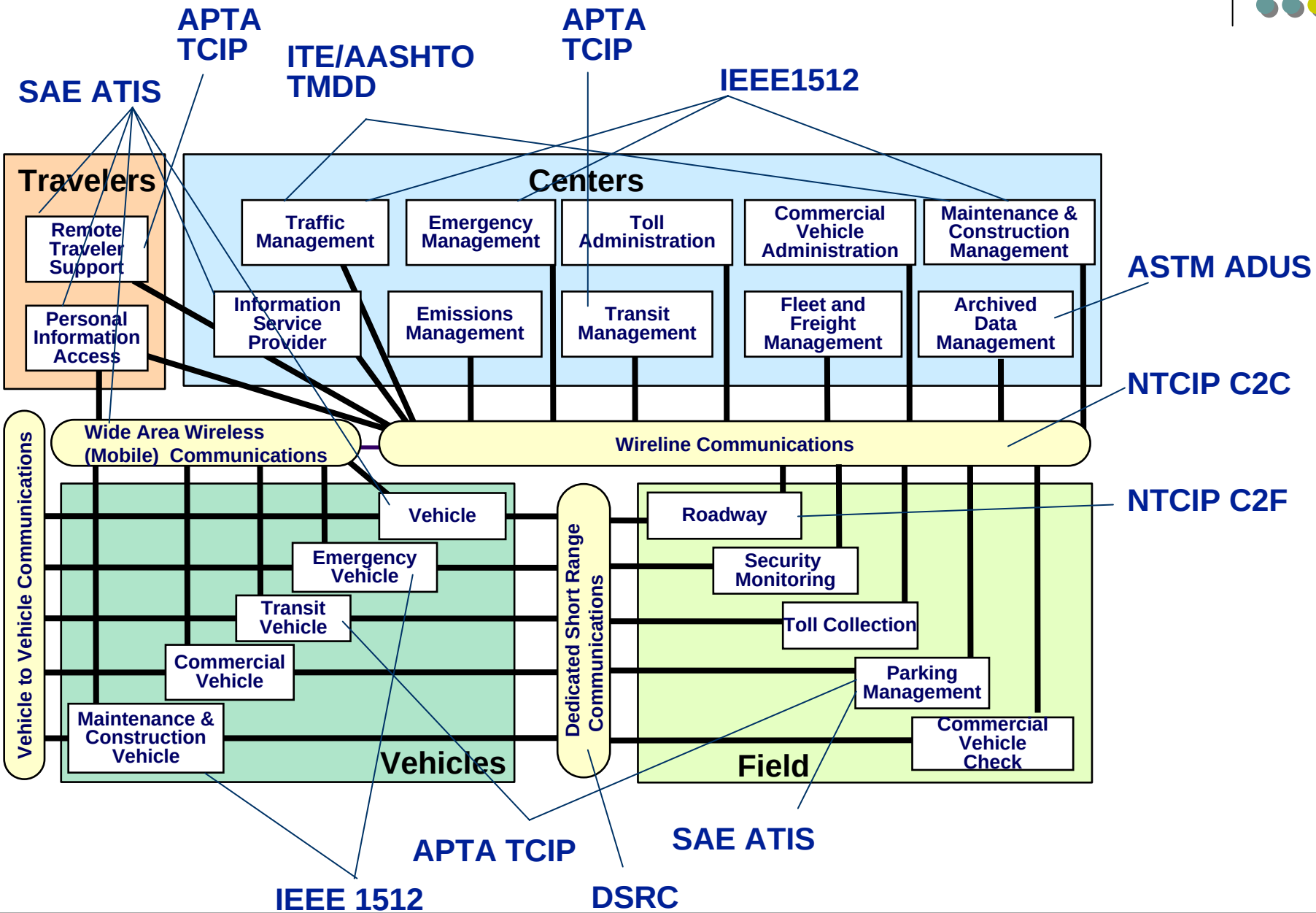
Module 6 – ITS Standards Overview and Key ITS Standards for New York State

- Understand What ITS Standards are and what organizations are developing them
- Understand Relationships to National ITS Architecture
- Understand What Key ITS Standards are and how they were determined.

Review of Criteria for Selecting Key ITS Standards

- Applicability to NYSDOT and NYS ITS systems, existing and planned
- Maturity of the standard
- National and NYS project experience with implementation of the ITS standards

NYSDOT Key ITS Standards in relation to the National ITS Architecture

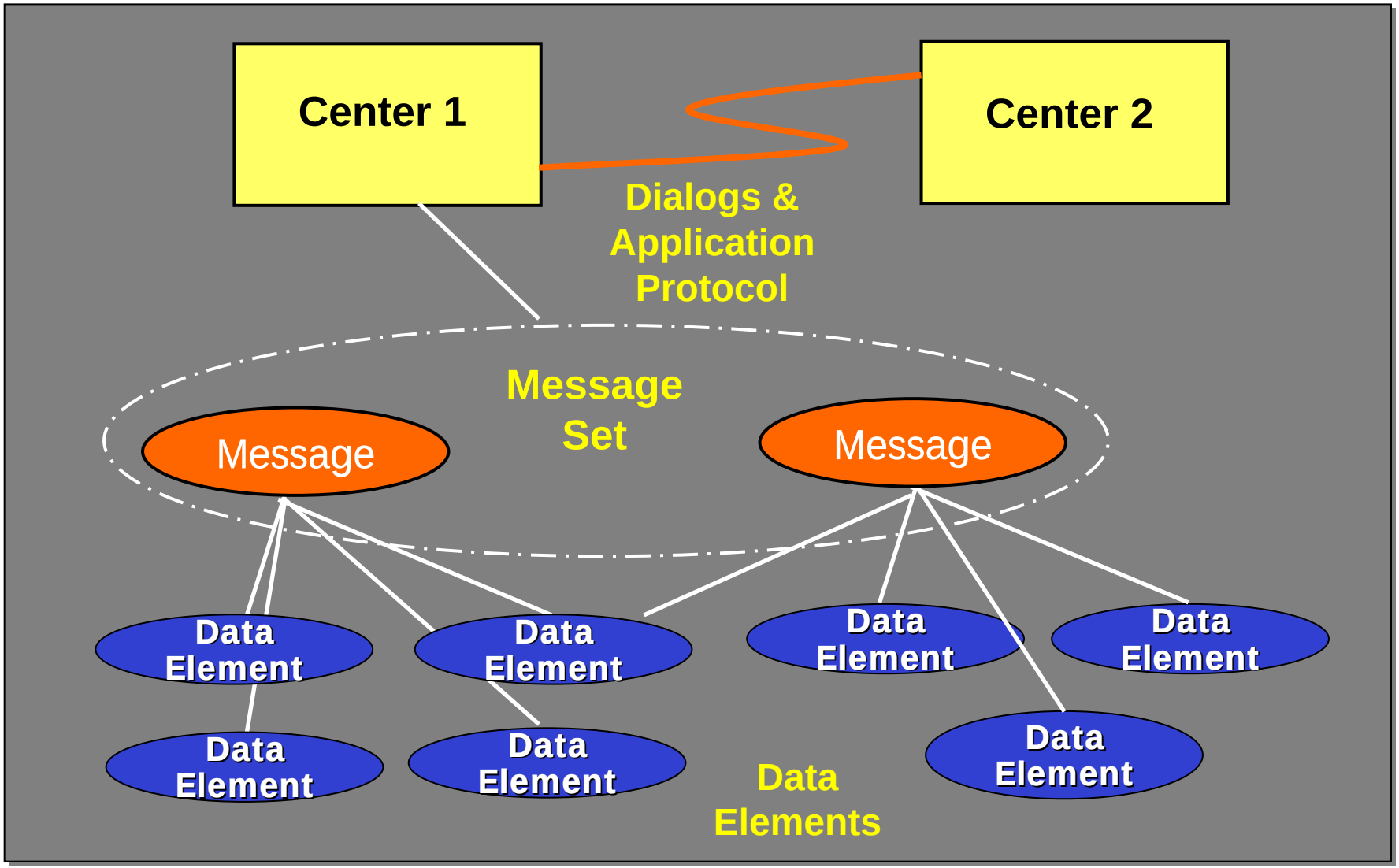


Acronyms used in Key ITS Standards

- SAE – Society of Automotive Engineers
  - ATIS - Advanced Traveler Information Systems
  - SAE J2354
- ITE - Institute of Transportation Engineers &

  AASHTO - American Association of State Highway Transportation Officials
  - TMDD – Advanced Traffic Management Systems Data Dictionary
- APTA - American Public Transportation Association
  - TCIP – Transit Communications Interface Profiles
- ASTM - American Society for Testing & Materials
  - ADUS – Archived Data Users Standard
- IEEE - Institute of Electrical and Electronics Engineers
  - IEEE 1512 Family of Standards for Incident Management
- NTCIP – National Transportation Communications for ITS Protocol
  - Joint NEMA - National Electrical Manufacturers Association, ITE, and AASHTO Standard
  - Center to Field Communications and Objects (Data Elements) for Traffic Control Devices
  - Center to Center Protocol

Introduction to the ITS Standards Structure



ITS Standards Reviewed

- Traffic Management (Center to Field)
  - NTCIP, Devices
  - NTCIP, Protocols
- Traffic Management (Center to Center)
  - TMDD
- Transit Management
  - APTA TCIP Family
- Travel Information
  - SAE-ATIS
- Incident Management
  - IEEE 1512 Family
- Center to Center Protocols
  - DATEX
  - XML
- Dedicated Short Range Communications (DSRC)
  - IEEE 1609
  - IEEE 802.11p

Data Elements

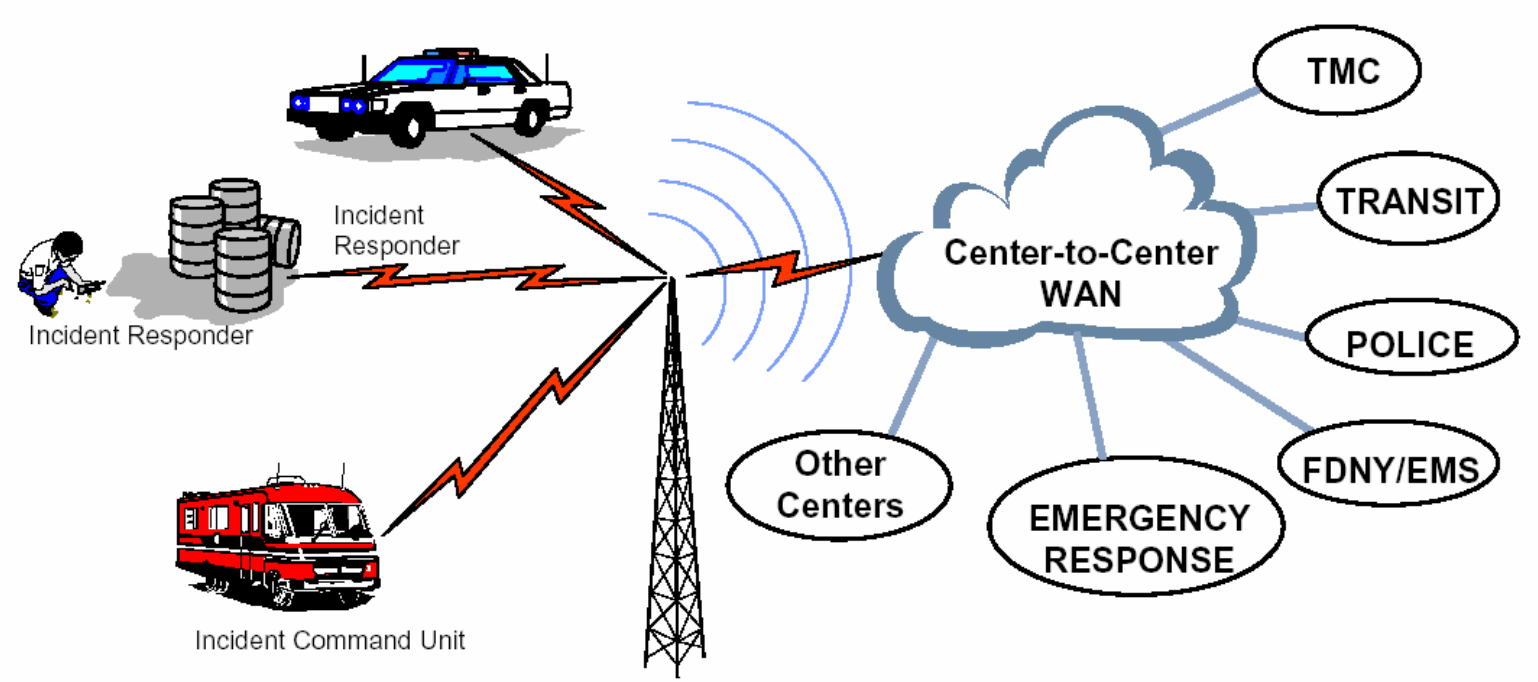
Messages

Protocols

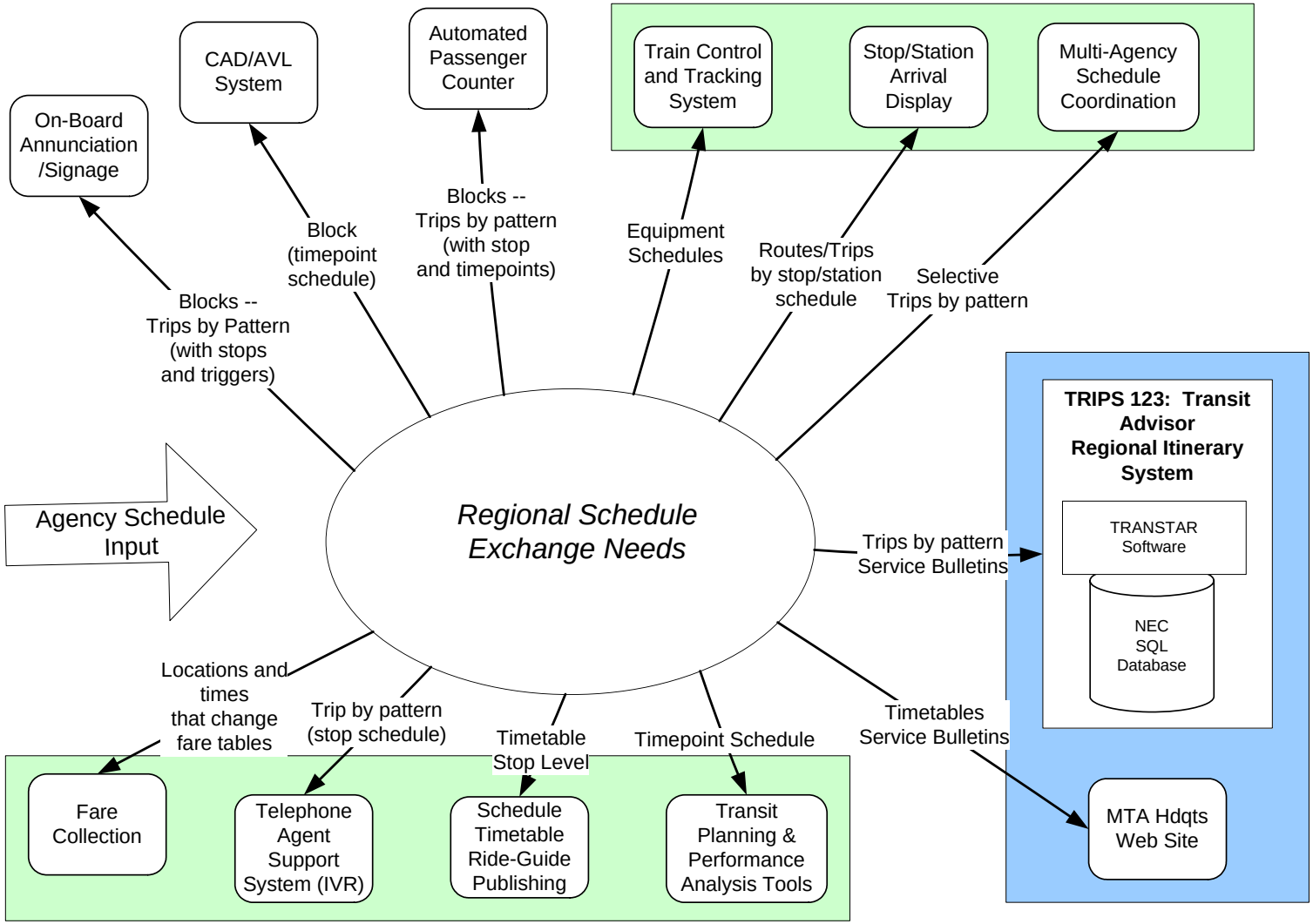
Select NYSDOT Projects Implementing ITS Standards

- IIMS – Integrated Incident Management System
- TSDEA – Transit Schedule Data Exchange Architecture
- NYSDOT IEN - Information Exchange Network
- NYSDOT Freeway Management Device Projects
- Atlantic Beach Bridge 5.9 GHz Demonstration Prototype

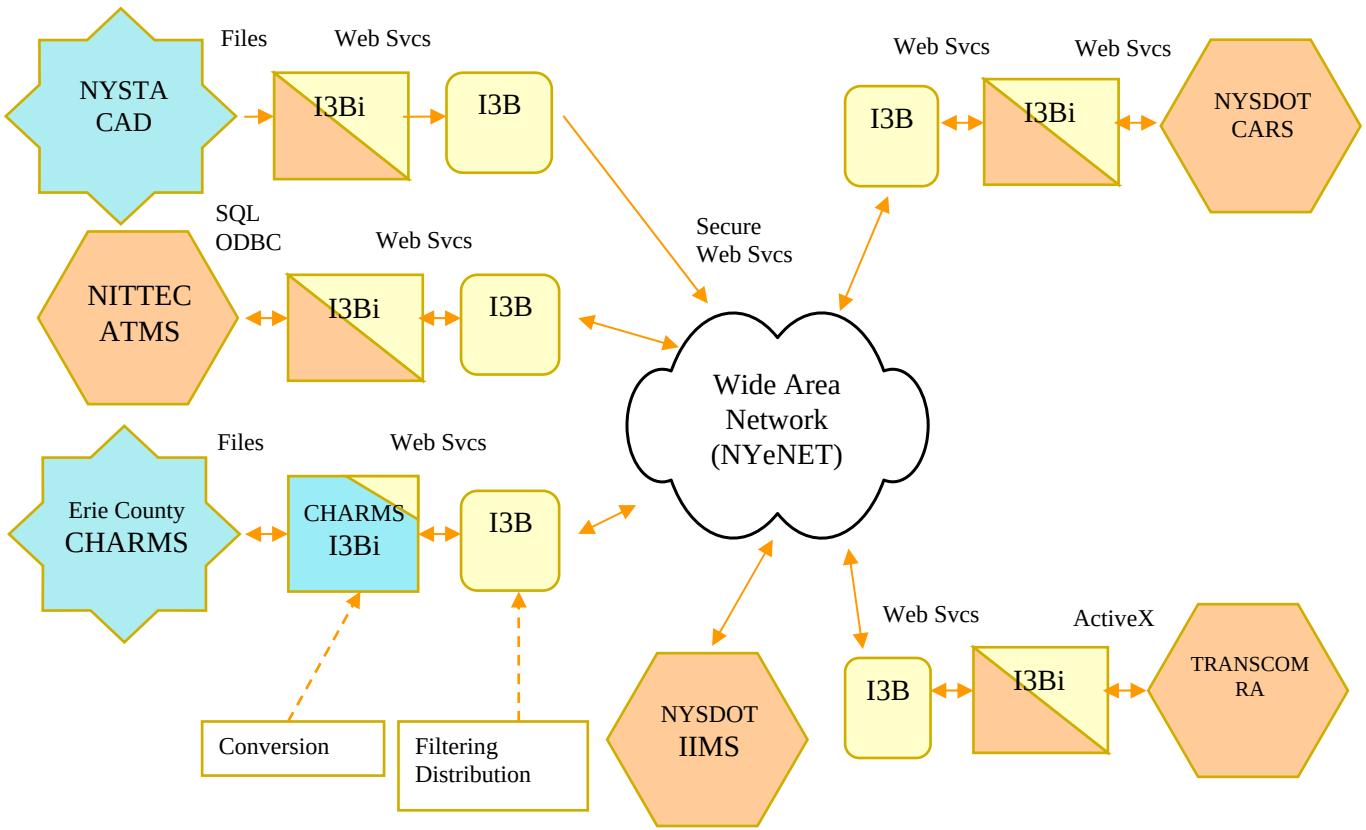
IIMS – Integrated Incident Management System



TSDEA – Transit Schedule Data Exchange Architecture



NYSDOT Information Exchange Network



END OF DAY 1