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Module 24:

Transit Signal Priority in Connected Vehicle Environment

Instructor

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Learning Objectives

Describe how transit signal priority may be provided in a connected vehicle environment

Describe Transit Signal Priority (TSP) Standards in a Connected Vehicle Environment

Describe what agencies need to do to prepare for Connected Vehicle (CV) TSP implementation

Implementation Considerations

Learning Objective 1

Describe how transit signal priority may be provided in a connected vehicle environment

Describe how transit signal priority may be provided in a connected vehicle environment

- Define what is a **connected vehicle (CV) environment**
- Describe **how** Transit Signal Priority (TSP) is currently implemented and the role of **NTCIP 1211**
- Identify **what information** is exchanged for TSP in a connected vehicle environment
- Describe potential **advantages** of a CV implementation over traditional TSP implementations

What is a Connected Vehicle Environment ?

Transportation Challenges

Safety

37,113 motor vehicle deaths in 2017

6,452,000 crashes in 2017

Mobility

8.8 billion hours of travel delay

$166 billion cost of urban congestion

Environment

3.3 billion gallons of wasted fuel

Source: US Department of Transportation, 2019 Urban Mobility Report, TTI

What is a Connected Vehicle Environment

The CV Environment

Source: US Department of Transportation

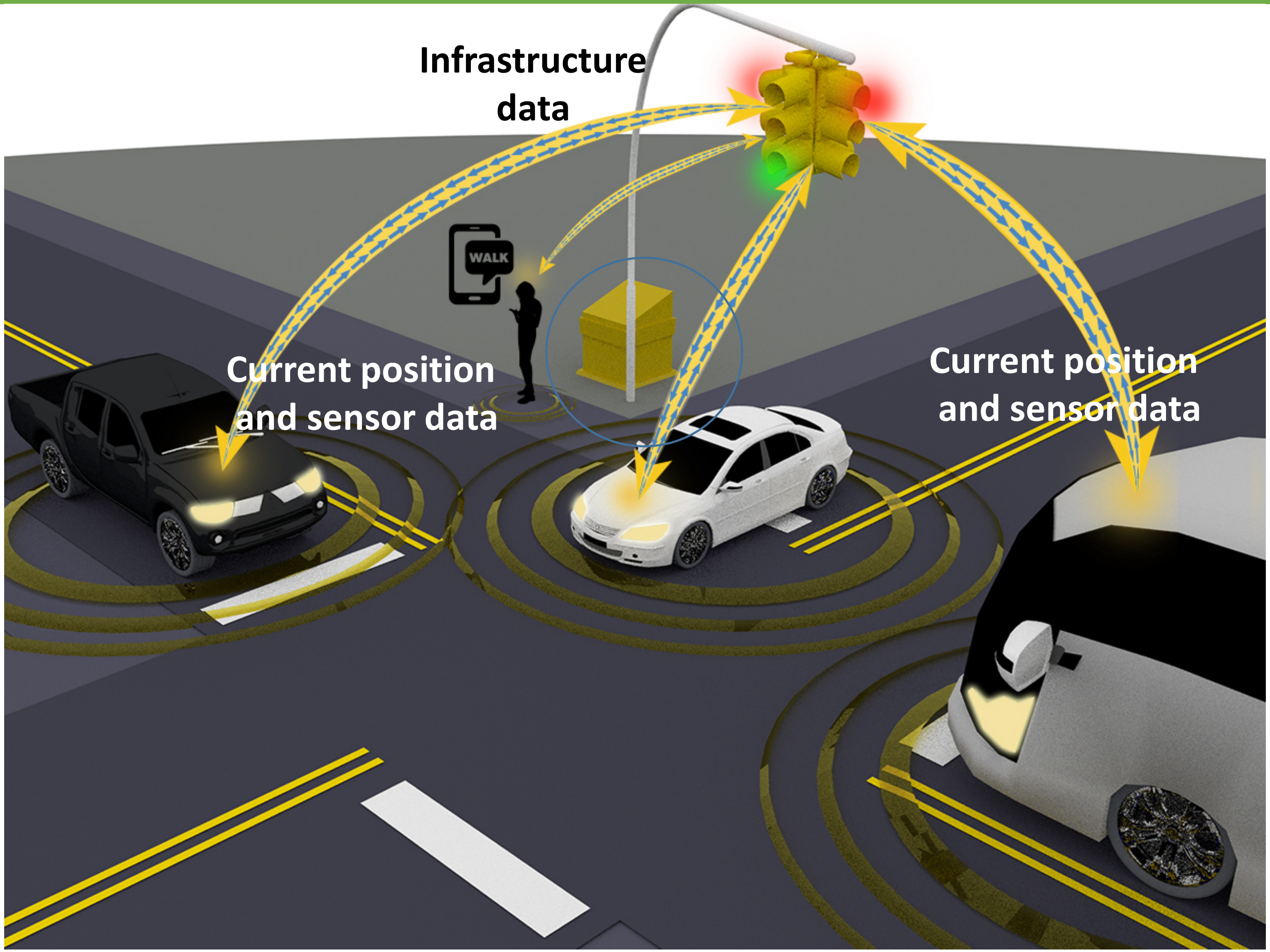
CV environment consists of:

- Connected vehicles
- Connected individuals (vulnerable road users)
- Connected infrastructure

CV Communications

- Wireless
- Mixture of
  - Short-range communications
  - Remote communications

What is a Connected Vehicle Environment?



Source: US Department of Transportation

What is a Connected Vehicle Environment?

Source: US Department of Transportation

Transit Signal Priority

An **operational strategy** that provides preferential treatment (priority) to facilitate the movement of **transit** vehicles through signalized intersections

- Does not degrade the **overall performance** of the traffic network
- Provides more efficient use of the street network by **increasing the throughput of travelers**
- Improves **reliability** (on-time performance and scheduled adherence) of public transportation

Signal Priority applications can apply for emergency and freight vehicles also

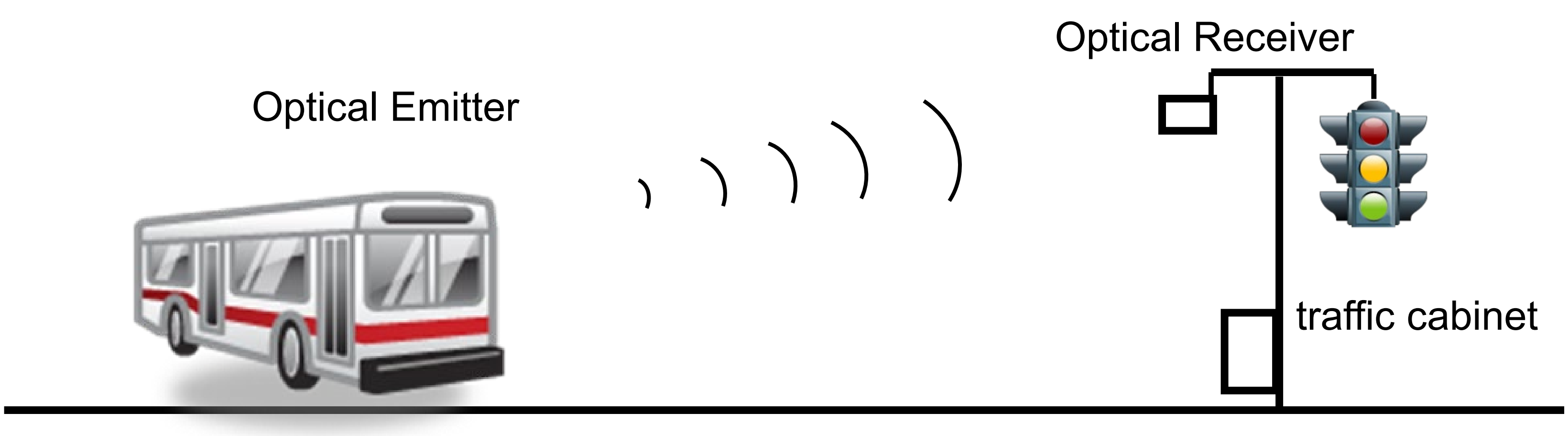
- Address **mobility** and **environmental** challenges

How Transit Signal Priority (TSP) is Currently Implemented

Current Systems

Optical Systems

- An optical emitter on the vehicle requests preemption/priority
  - Activated manually by the driver or based on location
- An optical detector near the traffic signal controller



How Transit Signal Priority (TSP) is Currently Implemented

Current Systems

Optical Systems – Limitations:

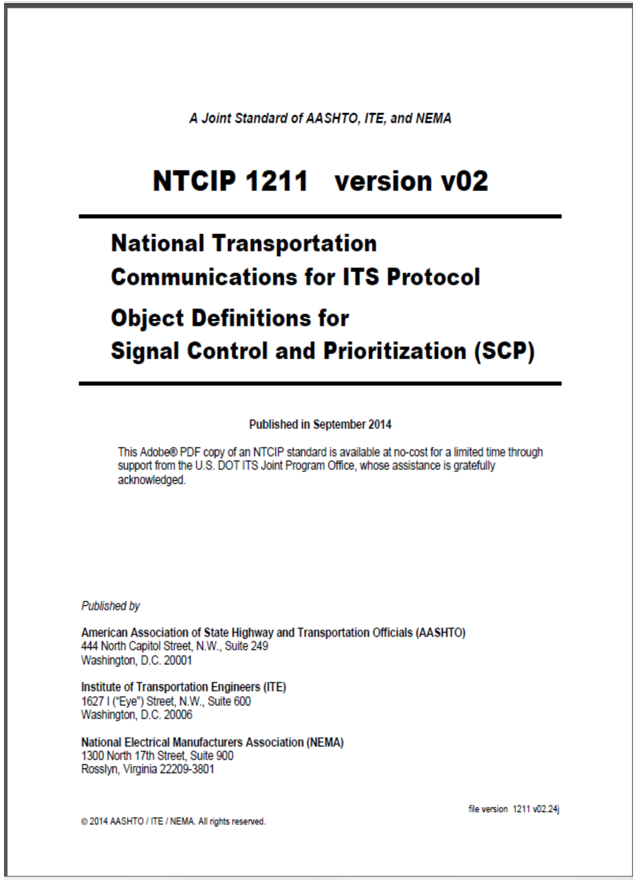
- **Requires line of sight.** The detector must be aligned in the direction of the emitter, optical emitters/receivers could get dirty or misaligned, limited range.
- **Limited information** transmitted (timestamp, vehicle id maybe)
- **Schedule** may need to be maintained on the vehicle
- **Proprietary.** Hinders extending / connecting TSP corridors.
- **Requires equipment** at each intersection and on each vehicle.
- Lack of **security**.

Role of NTCIP 1211 in Transit Signal Priority (TSP)

NTCIP 1211

An information content standard that defines aspects of a communications interface standard for a **Signal Control Priority** (SCP) system

- Defines data elements (**object definitions**) used to monitor, configure and control a SCP system
- References NTCIP 1201 for generic data elements



A Joint Standard of AASHTO, ITE, and NEMA

NTCIP 1211 version v02

National Transportation Communications for ITS Protocol

Object Definitions for Signal Control and Prioritization (SCP)

Published in September 2014

This Adobe® PDF copy of an NTCIP standard is available at no-cost for a limited time through support from the U.S. DOT ITS Joint Program Office, whose assistance is gratefully acknowledged.

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National Electrical Manufacturers Association (NEMA)
1300 North 17th Street, Suite 900
Rosslyn, Virginia 22209-3801

file version 1211 v02.24j

How Transit Signal Priority (TSP) is Currently Implemented

NTCIP 1211

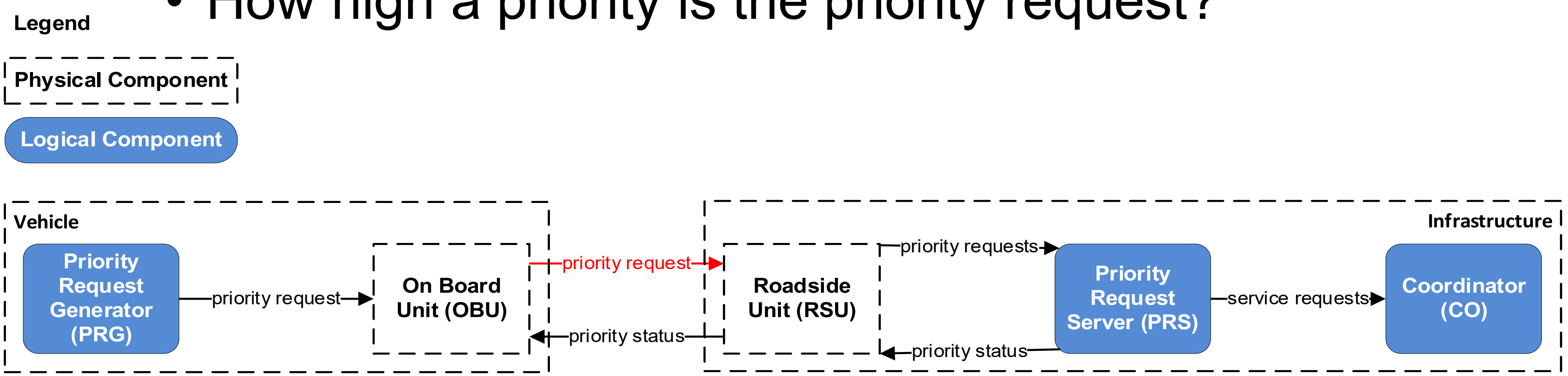
- **Priority Request Generator (PRG).** Generates the priority requests for signal priority
- **Priority Request Server (PRS).** Receives the priority requests and processes the requests to determine the optimal signal timing to service the priority requests, then transmits service requests to the CO
- **Coordinator (CO).** Receives the service requests from the PRS and provides the signal priority

What Information is Exchanged for TSP in a Connected Vehicle Environment

Vehicle to Infrastructure

Priority Requests

- Requests for preferential treatment
  - When is priority needed (i.e., when does the vehicle expects to arrive at the intersection)?
  - Where is the vehicle going (i.e., What direction is the vehicle moving and will it turn)?
  - How high a priority is the priority request?



What information is Exchanged for TSP in a Connected Vehicle Environment

Vehicle to Infrastructure

Vehicle Information

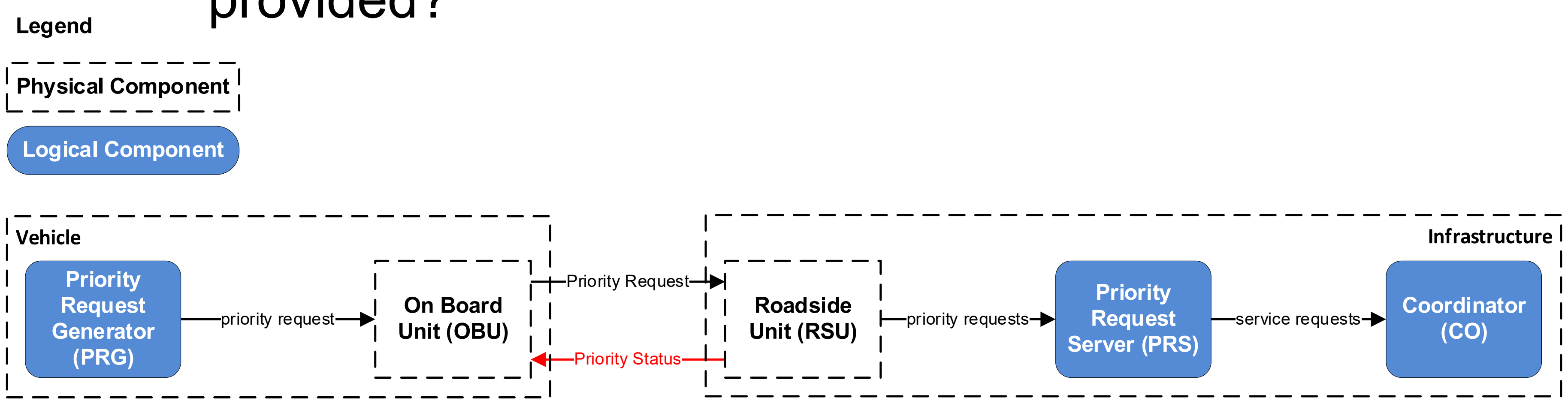
- Broadcasts their location and kinematics

What Information is Exchanged for TSP in a Connected Vehicle Environment

Infrastructure to Vehicle

Priority Status

- Acknowledges that the priority request was received
  - Indicates the status of the priority request
  - Indicates what priority treatment is being provided (if any)?
  - Indicates when will priority treatment will be provided?



What Information is Exchanged for TSP in a Connected Vehicle Environment?

Infrastructure to Vehicle

- **Signal Phase and Timing (SPaT)** information, which provides **dynamic** signal phase and timing data from one or more traffic signal controllers
  - What movements (by lane) are currently allowed and when will the movement state is likely to end
- **MAP (roadway geometry)** provides **static** roadway geometric information (e.g., lane information)
  - May be required from the infrastructure to support TSP
- Both messages are defined in SAE J2735
- For additional information, see **CV273, Introduction to SPaT/MAP Messages**

Potential Advantages of a CV Implementation over Traditional TSP Implementations

- **Low initial costs** if vehicles and infrastructure is already connected
  - V2V safety applications
  - Signalized intersection applications
  - See **Module 11, Transit and the Connected Vehicle Environment/Emerging Technologies, Applications, and Future Platforms** for other transit applications
  - Just need to add support for TSP application

Potential Advantages of a CV Implementation over Traditional TSP Implementations

- **Standardized messages**
  - Also supports emergency vehicles and freight vehicles
- **Standardized security measures** among all vehicle types and services
- Additional performance metric information
- Line of sight not required

ACTIVITY

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Question

What is a disadvantage of using a traditional optical TSP system?

Answer Choices

a) Special equipment is required for each intersection
b) Line of sight is required
c) Limited amount of information can be transferred
d) All of the above

Review of Answers

a) Special equipment required for each intersection

Incorrect. Optical equipment is required on each intersection and vehicle.

b) Line of sight is required

Incorrect. The required line of sight has a relatively high possibility of being obstructed.

c) Limited amount of information can be transferred

Incorrect. Relatively little information about the vehicle can be obtained.

d) All of the above

Correct! All of the above are disadvantages.

Learning Objective

Describe TSP Standards in a Connected Vehicle Environment

TSP Standards in a Connected Vehicle Environment

- Previously described **what** data is needed to support TSP in a Connected Vehicle Environment
- The next several slides describe how the standards **define** this data

Relevant Standards and the Maturity of the Standards

SAE J2735 Standard

- **Dedicated Short Range Communications (DSRC) Message Set Dictionary**
- A data dictionary for the CV environment.
  - Defines messages and data elements
  - Includes vehicle kinematic information, position correction information, traveler information

SURFACE VEHICLE STANDARD	J2735™	MAR2016
	Issued 2015-09 Revised 2016-03 Superseding J2735 JAN2016	
Dedicated Short Range Communications (DSRC) Message Set Dictionary		

RATIONALE

This Standard is the fifth edition of the message set dictionary. The changes made from prior editions include revising the content to reflect a uniform use of unaligned packed coding rules, a common message framework, the further refinement of several existing messages due to deployment experience, and the addition of a preliminary Personal Safety Message for use with vulnerable road users. This amendment to the standard was issued in March of 2016 to clarify how positional offsets were calculated in some data frames. Two typographical errors were also corrected at that time.

The document areas affected by this limited scope revision are as follows:

Section 6.82 Data Frame: DF_PathHistory,	Page 79	In the Use section,
Section 6.84 Data Frame: DF_PathHistoryPoint,	Page 80	In the Use section
Section 6.84 Data Frame: DF_PathHistoryPoint,	Page 80	In the ASN.1 Representation section
Section 7.127 Data Element: DE_OffsetLL-B18,	Page 171	In the Use section,
Section 7.195 Data Element: DE_TimeOffset,	Page 202	In the Use section
Section 7.224 Data Element: DE_VertOffset-B12,	Page 214	In the Use section
Section 8.58 Data Element: EXT_ITIS_Codes [ITIS],	Page 240	In the ASN.1
Section 11.8 Lanes, Objects Defined in Intersections and Elsewhere,	Page 263	In the last paragraph on this page.

DEDICATION

This standard is dedicated to the Memory of Broady Cash, who provided leadership and guidance in the evolution of the DSRC standards. His research led to work on the original ASTM DSRC standards, for which Broady pulled together a team of industry stakeholders and subject matter experts. The ASTM standard (E-2213) addressed all of the DSRC communications layers. Mr. Cash was also very active in helping support the establishment of the DSRC spectrum. When the DSRC standards expanded to IEEE and SAE, Broady continued his leadership role in ensuring that the 1609 and 802.11p standards continued to meet the original requirements, and that they would work together to meet the evolving ITS applications requirements. He was often the glue that kept the standards activities on track, as he mediated differences of opinion and personalities among the various contributors to the standards. Broady Cash was born on October 7, 1948, in Amherst, Virginia. He passed away after battling a long illness on November 3, 2008. He is survived by his wife and two children. Many thanks to Broady for his invaluable contributions to DSRC and to the foundation of Connected Vehicle technologies.

FOREWORD

Prepared for use by the DSRC committee of the SAE by SubCarrier Systems Corp (SCSC).

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Create_time: 07:35:50 PM Tuesday, September 01, 2015
Extracted from:   J2735_r63.its      [Mod: 9/1/2015 7:30:56 PM]
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Relevant Standards and the Maturity of the Standards

SAE J2735 Standard

Message

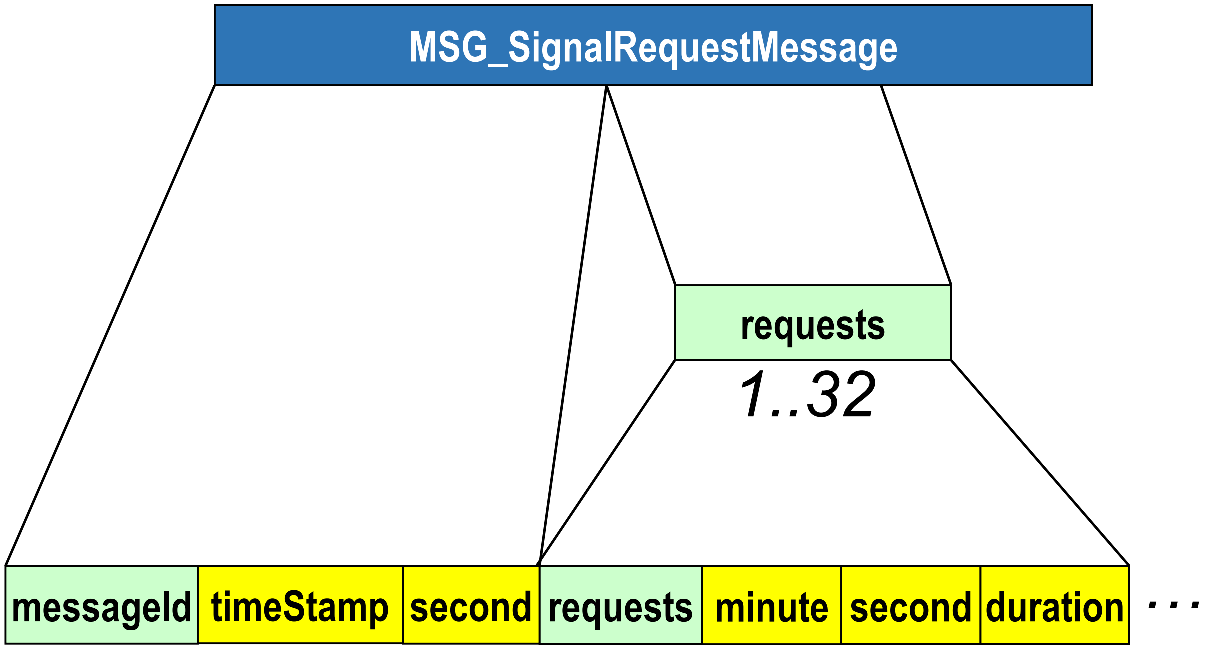
(sentence)

Data frames

(Phrases)

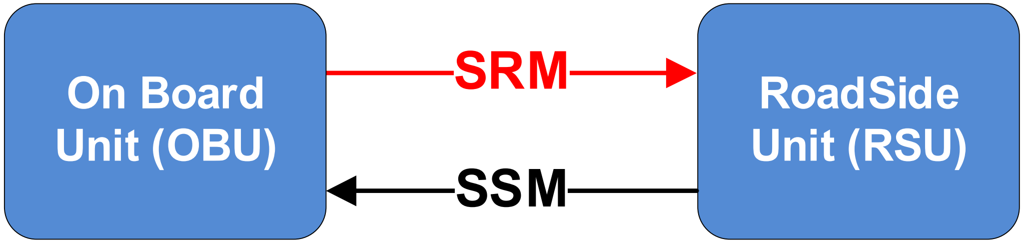
Data Elements

(words)

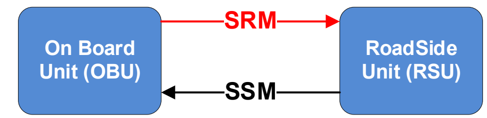


Signal Request Message (SRM)

- Broadcast by a vehicle (**On-Board Unit**) to infrastructure (**Roadside Unit**)
- Asks for **preferential** (preemption/priority) **treatment** for one or more signalized intersections
  - Includes approach and desired egress lane, and estimated times
- Must be configured to work reliably and with security protections



Signal Request Message (SRM)



MSG_SignalRequestMessage						
messageId	timeStamp	second	sequenceNumber	requests	requestor	regional
				1..32		

mandatory

optional

- **messageId.** DE_DSRCmsgID = 14
- **timestamp.** Number of elapsed minutes in the year
- **second.** Number of milliseconds within the minute
- **sequenceNumber.** Message counter
- **requests.** Data for the priority request (up to 32)
- **requestor.** Data about the requesting vehicle
- **regional.** Regional extensions

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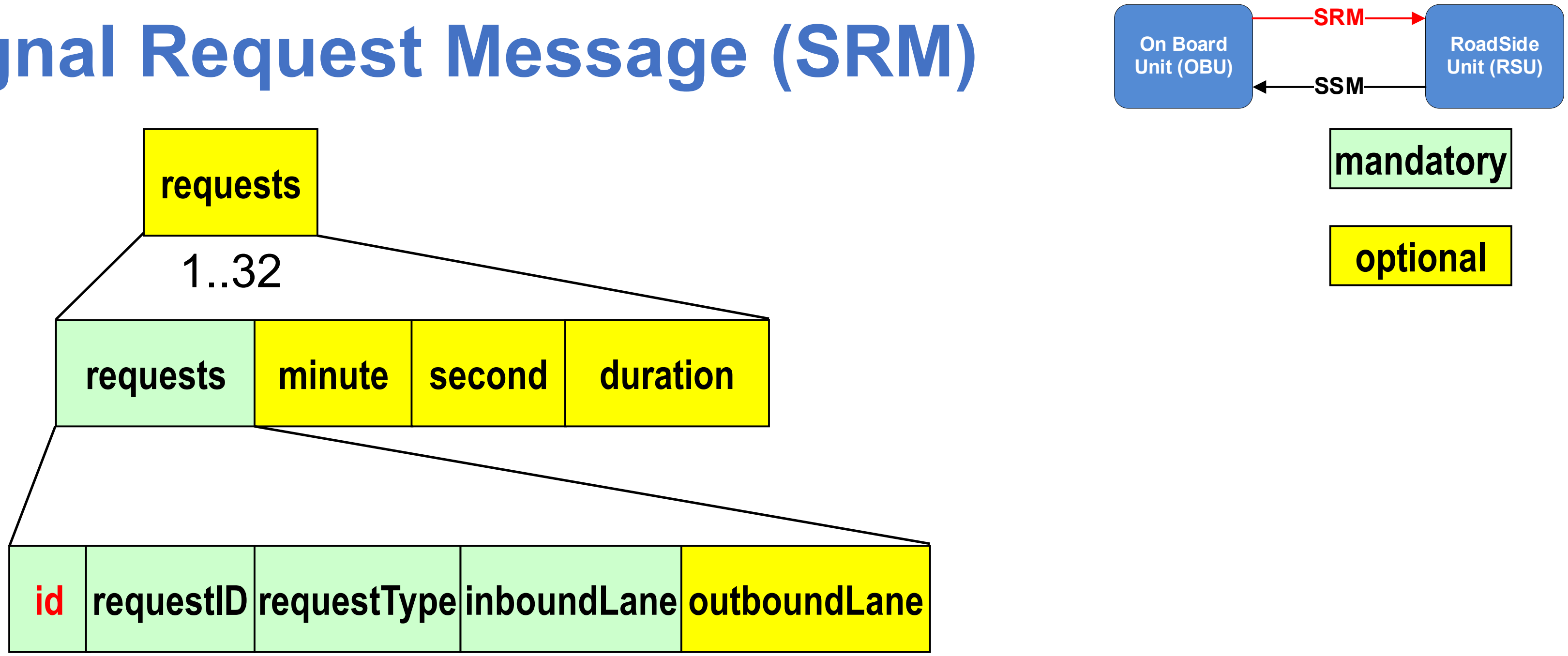
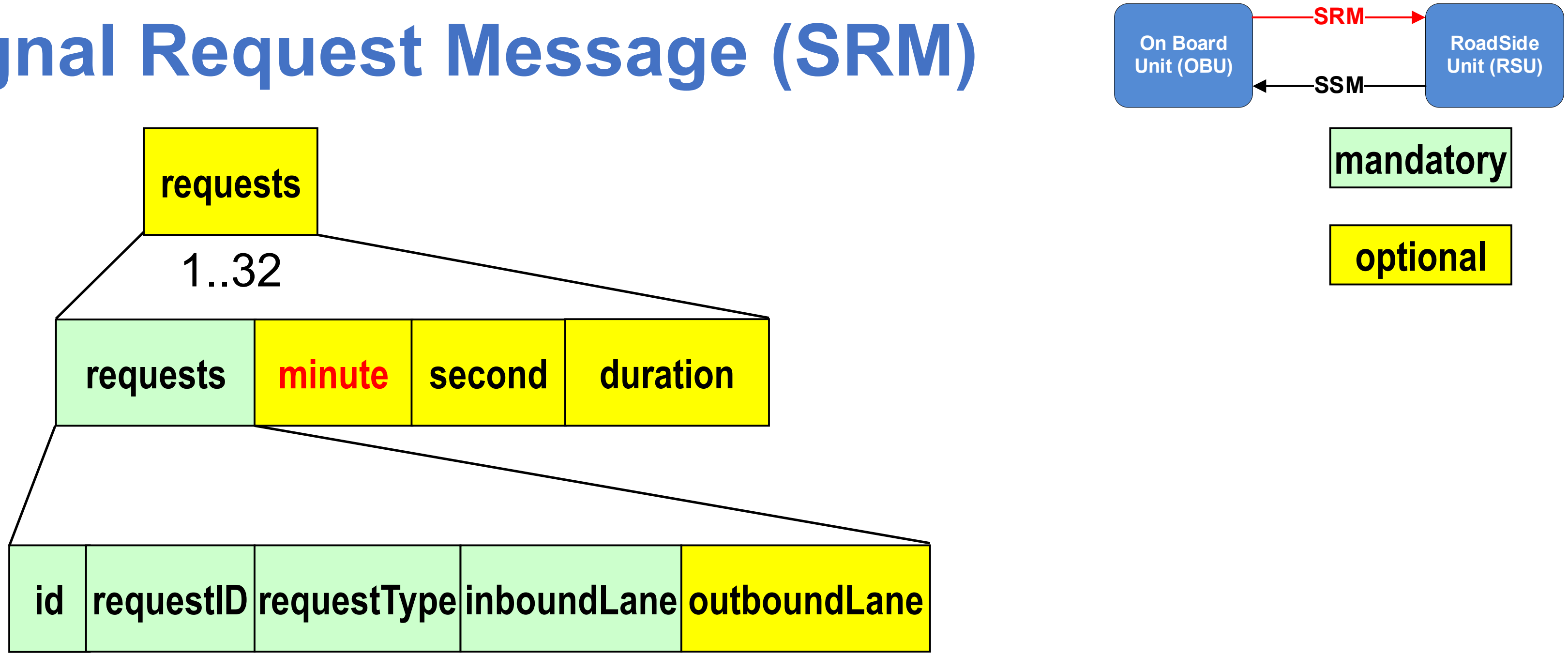
Signal Request Message (SRM)



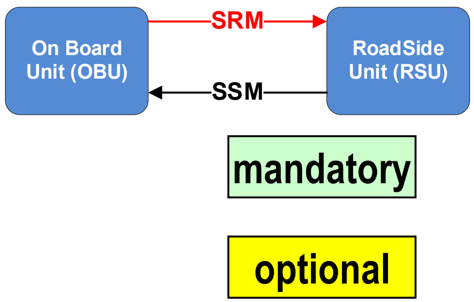
- **id.** Identifies the target intersection for the priority request
- **requestID.** An identifier for the priority request
- **requestType.** Request type (new, update, cancel)
- **inboundlane.** Identifier of the lane the requestor expects to enter the intersection

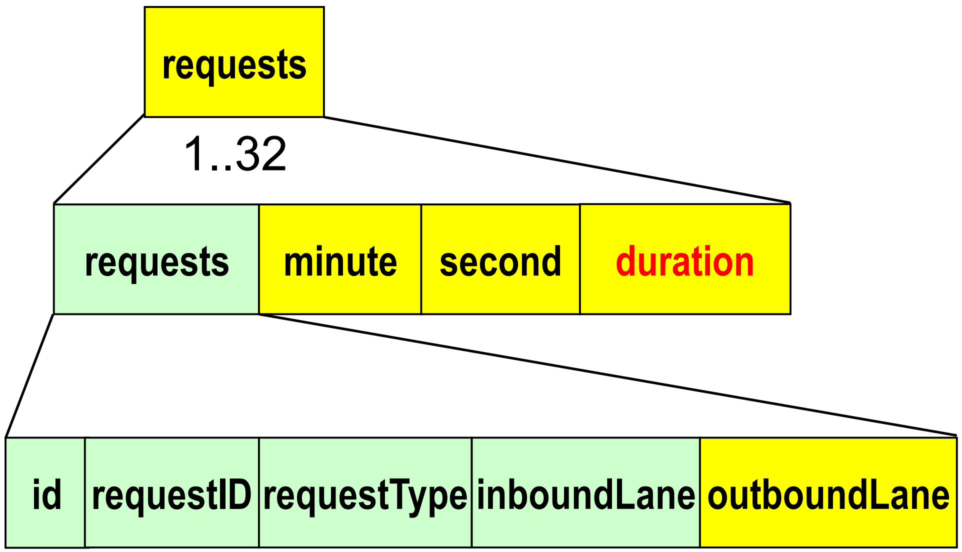
Signal Request Message (SRM)



- **minute.** Estimated time of arrival (ETA) in number of elapsed minutes in the year
- **second.** Estimated time of arrival (ETA) in number of elapsed seconds into the minute

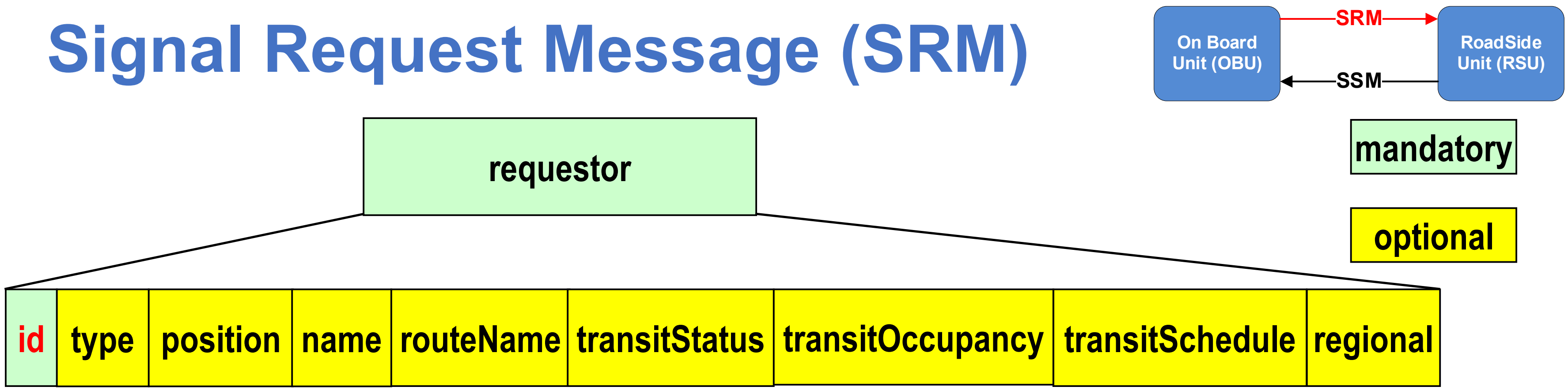
Signal Request Message (SRM)





- **duration.** Represents milliseconds after the ETA, to create a window that the requestor will arrive at the intersection
- **outboundLane.** Identifier of the lane the requestor expects to exit the intersection

Signal Request Message (SRM)



- **id.** Identifier of the requestor. Generally, a fixed id.
- **type.** Represents the type of requestor (emergency, public transit, truck, fire, police, cyclist, pedestrian, etc…)
  - May include regional subroles
  - Importance level
  - Highway Performance Monitoring System (HPMS) classification type

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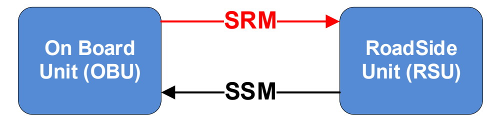
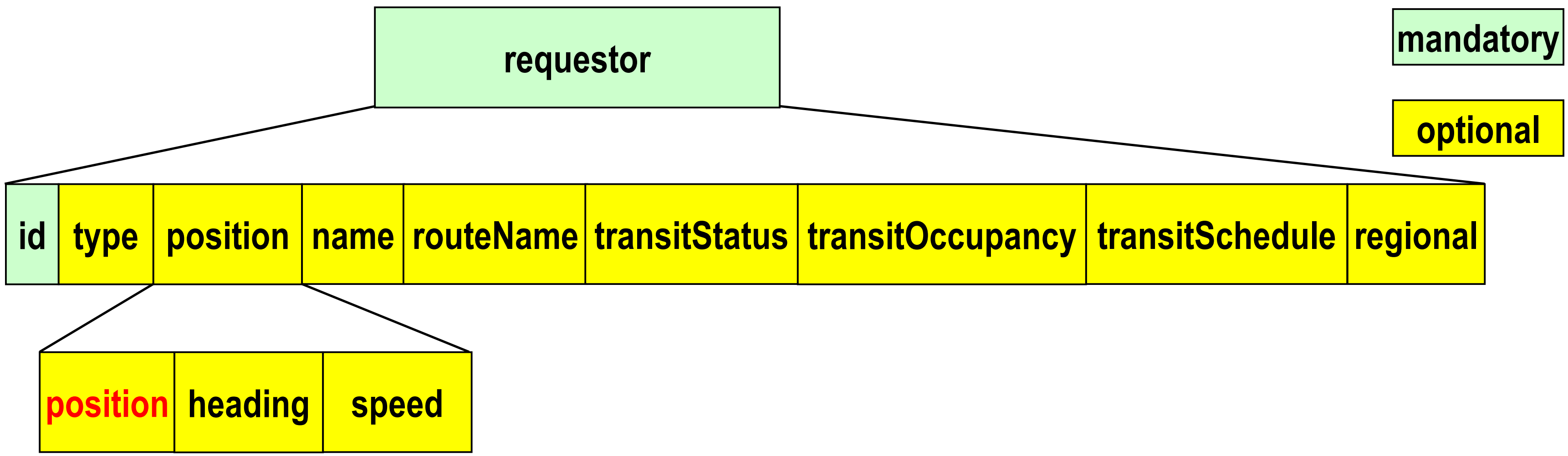
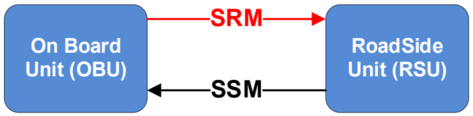
Signal Request Message (SRM)

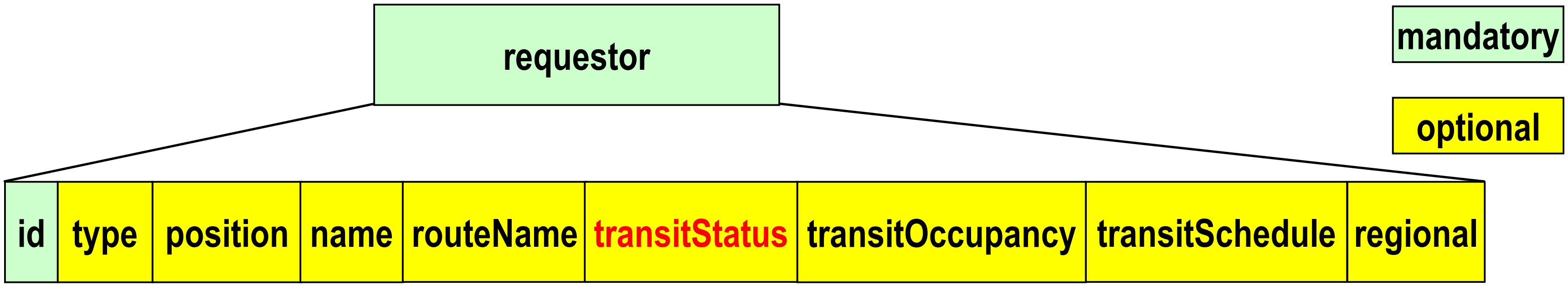




- **position.** Latitude, longitude, elevation (optional)
- **heading.** Direction of travel of the requestor
- **speed.** Transmission state and vehicle speed
- **name.** A descriptive name for debugging
- **routeName.** A route name for transit use

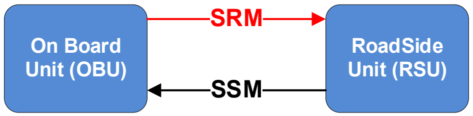
Signal Request Message (SRM)





- **transitStatus.** Status of the transit vehicle. E.g., parked, ADA access in progress, loading bicycle, vehicle door open, at stop line.
- **transitOccupancy.** Relative level of ridership (7 levels from Empty to Full).
- **transitSchedule.** Schedule adherence delta of the requesting vehicle in 10 second steps.

Signal Request Message (SRM)



Mandatory Elements

- **second.** Time message was generated
- **id.** Identifier of the requestor. Generally a fixed id.

Request for Service

- **id.** Identifies the target intersection for the priority request
- **requestID.** An identifier for the priority request
- **requestType.** Request type (new, update, cancel)
- **inboundlane.** Identifier of the lane the requestor expects to enter the intersection

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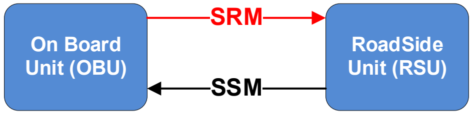
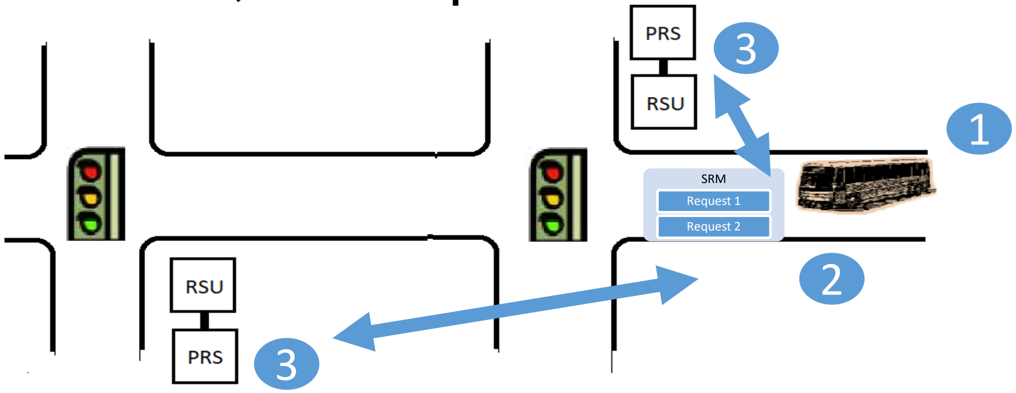
Signal Request Message (SRM)



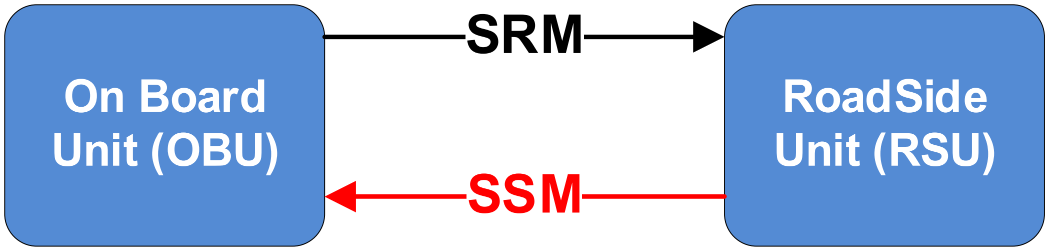
Example

1. A transit vehicle enters DSRC range and approaches two signalized intersections
2. The transit vehicle wirelessly broadcasts a SRM, with its ETA and the identifier of the lanes to enter and egress at both intersections
3. The RSU for at both intersections receives the SRM and relays the request to the PRS, which processes the request.

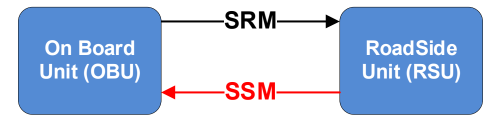


Signal Status Message (SSM)

- Broadcast by the infrastructure (**Roadside Unit**) and can be received by a vehicle (**On-Board Unit**)
- Provides the status of each priority request received by one or more signalized intersections



Signal Status Message (SSM)



MSG_SignalStatusMessage					
messageId	timeStamp	second	sequenceNumber	status	regional

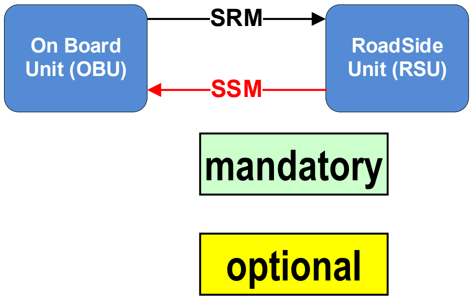
mandatory

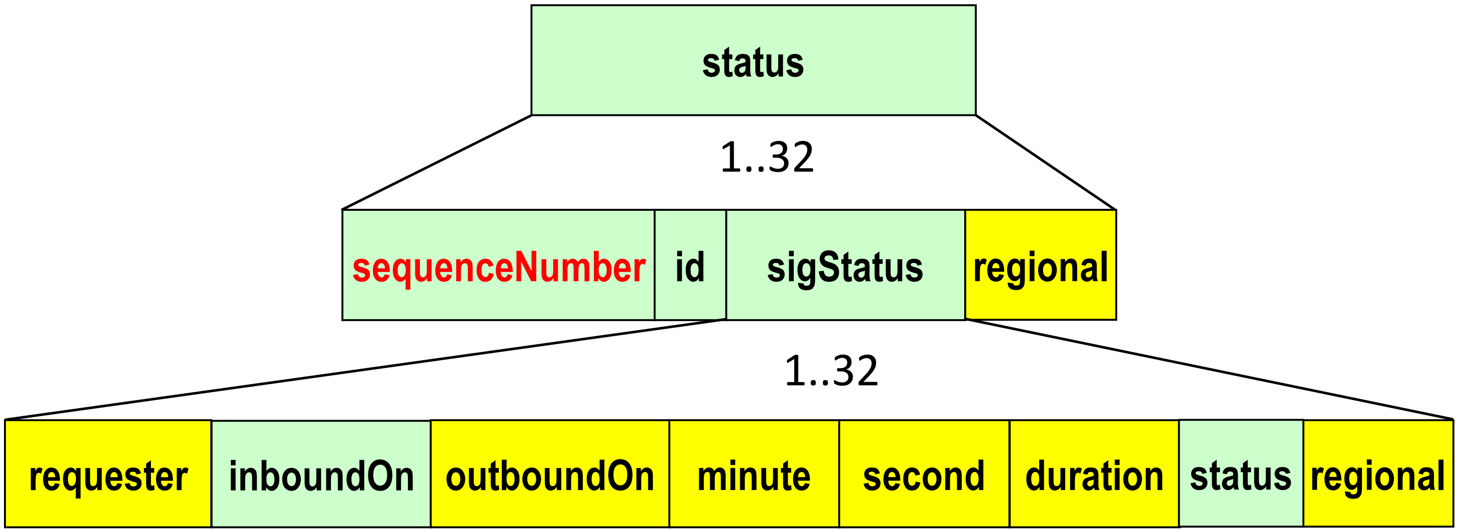
optional

1..32

- **messageId.** DE_DSRCmsgID = 15
- **timestamp.** Number of elapsed minutes in the year
- **second.** Number of milliseconds within the minute
- **sequenceNumber.** Message counter.
- **status.** Data about an intersection and received requests
- **regional.** Regional extensions

Signal Status Message (SSM)





- **sequenceNumber.** Message counter for the intersection. Increments when the status changes.
- **id.** Regionally unique intersection identifier.
- **inBoundOn.** The identifier of the lane for entering the intersection.

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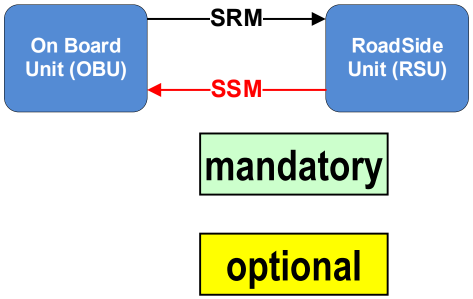
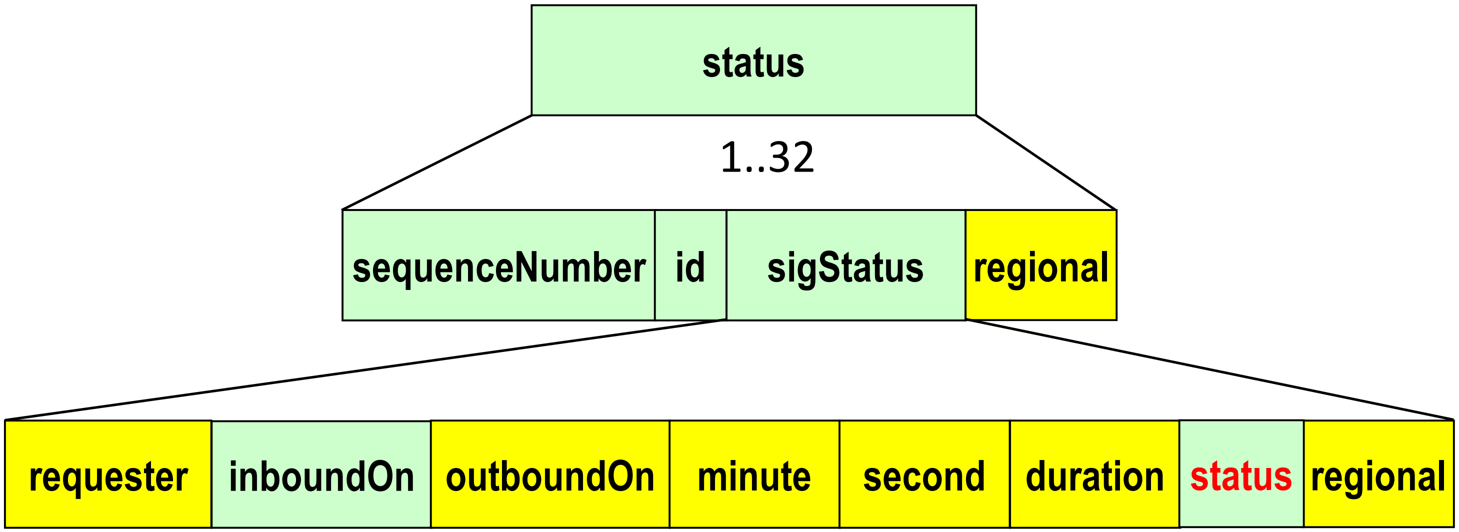
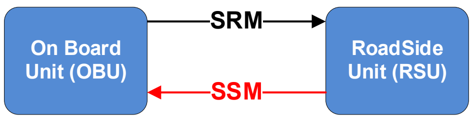
Signal Status Message (SSM)

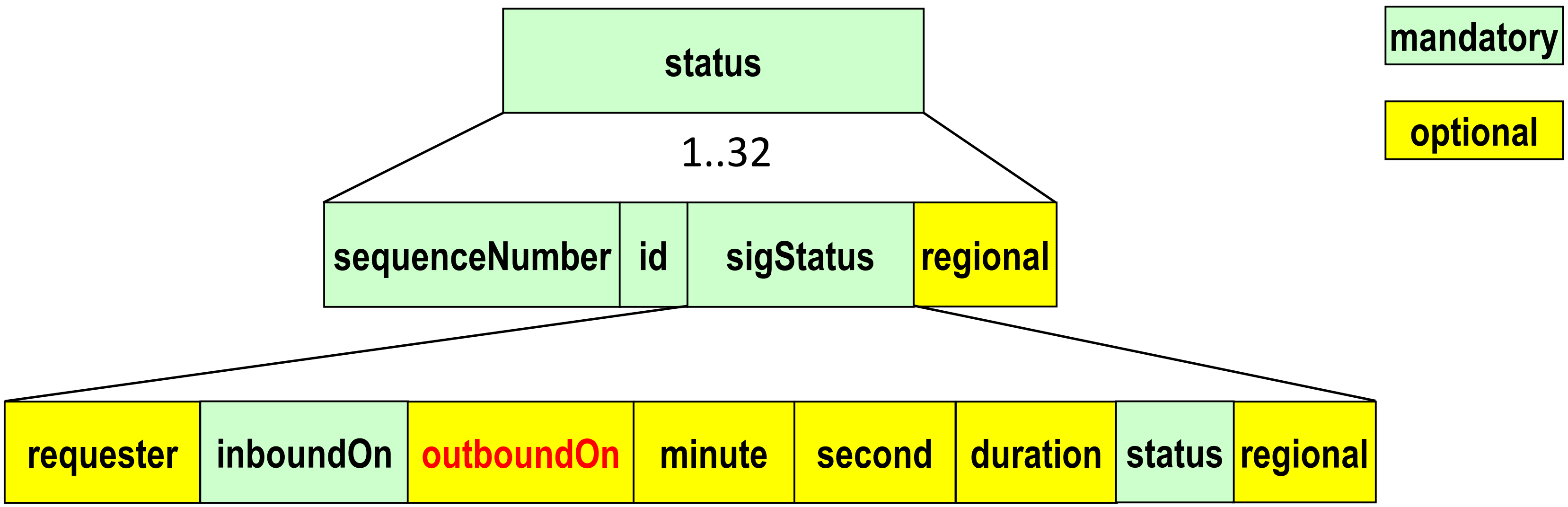




- **status.** Status of the priority request. Values include processing, granted, rejected, maxPresence, reserviceLocked
- **requester.** Data about the priority request – vehicle identifier, requestID, and message counter.

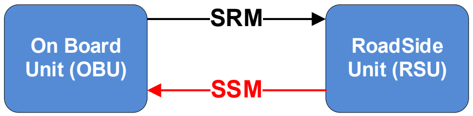
Signal Status Message (SSM)





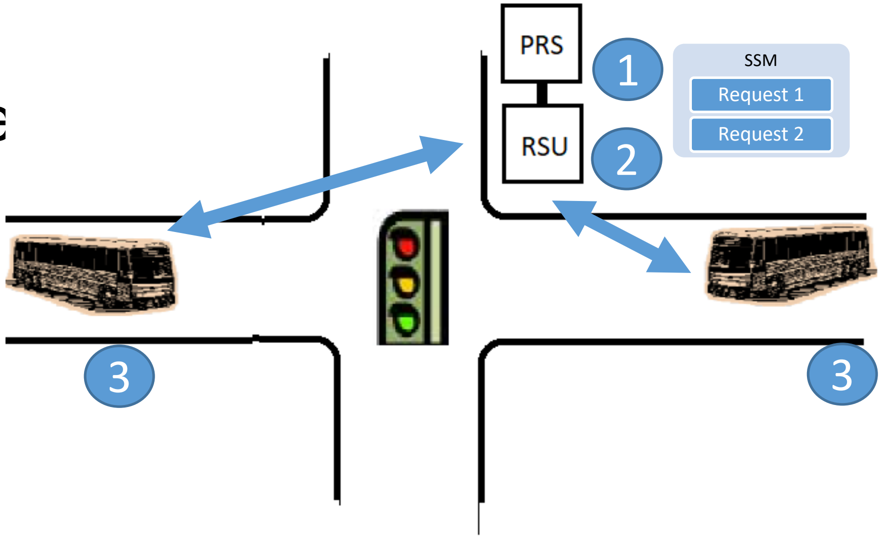
- **outboundOn.** The identifier of the lane for exiting the intersection.
- **minute.** Estimated time of arrival (ETA) in number of elapsed minutes in the year
- **second.** Estimated time of arrival (ETA) in number of elapsed seconds into the minute

Signal Status Message (SSM)



Example

1. A RSU receives two SRM requests and the PRS processes the request
2. The signal controller provides the PRS with the status of the requests, then the PRS generates a SSM that is broadcasted by the RSU with the status of all SRM requests received.
3. Transit vehicles receive the SSM and travel through the signalized intersection when service is provided.



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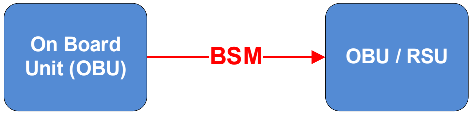
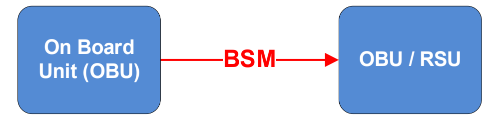
Basic Safety Message (BSM)



- Broadcasted by an **OBU**
  - Provides the **location**, kinematics, and sensor information about the vehicle
  - Optionally, provides the **type** of vehicle
  - If certified, indicates what (security) permissions it has
- BSMs may be used to determine if priority should be granted based on the **location**, **vehicle type** and (security) **permissions** of the vehicle
- Must be configured to work reliably and with security protections

SAE J2735

Basic Safety Message (BSM)



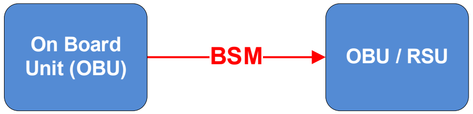
MSG_BasicSafetyMessage		
coreData	Part II	regional

mandatory

optional

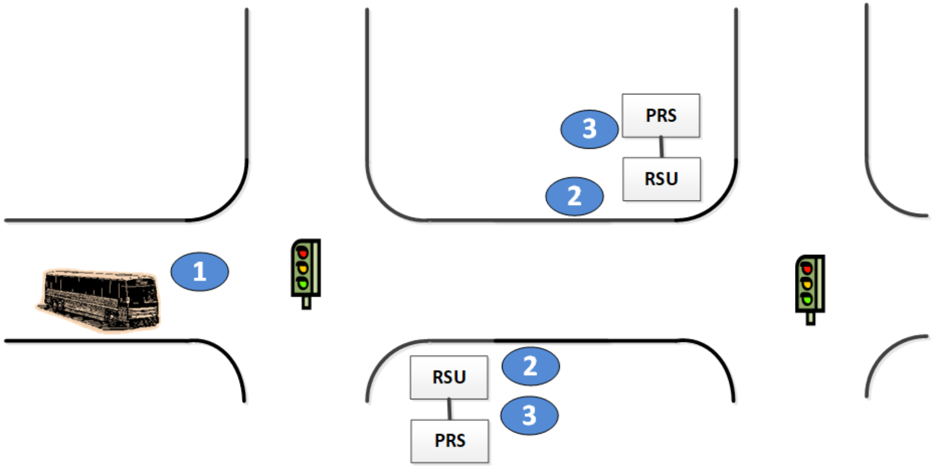
- **messageId.** DE_DSRCmsgID = 20
- **coreData.** Critical data elements included with every basic safety message including location, positional accuracy, transmission, speed, heading, acceleration, brake status and vehicle size
- **Part II.** Optional extensions including event states, exterior light status, path history, and vehicle classification (type)
- **regional.** Regional extensions

Basic Safety Message (BSM)



Example

1. A transit vehicle enters DSRC range and approaches two signalized intersections, while wirelessly broadcasting BSMs
2. The RSU receives and processes the BSM information to determine its location, vehicle type and service permissions
3. If the transit vehicle satisfies the established criteria for signal priority, the RSU sends a priority request to the priority request server (PRS)



IEEE 1609.2

- **IEEE Standard for Wireless Access in Vehicular Environments (WAVE) – Security Services for Applications and Management Messages**
- **IEEE 1609.2 Certificates**
- Part of the CV security system
  - Participants in the CV environment trusting the validity of information received from other system participants
- Indicates that the sender is **trusted** and has been granted the privileges to transmit the messages

Service Specific Permissions (SSP)

- Included as part of the IEEE 1609.2 certificates to indicate additional privileges
    - Such as the ability to request preferential treatment.
- Equipping authorized transit and emergency vehicles with these certificates authorizing the TSP requests, requests from non-eligible vehicles can be excluded from the priority services.
- See **CV265, Introduction to IEEE 1609 Family of Standards for Wireless Access in Vehicular Environments (WAVE)**
- See **CSE201, Introduction to Security Credential Management System (SCMS)**

Early Adoption of the Standards

- Few actual TSP in CV implementations at this time
  - Most are single agencies
- Several implementations are planned
- Need **regional interoperability**
- TSP applications are **communications technology neutral**
- **Same** standards/messages used for emergency vehicles/freight vehicles

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Question

What is a mandatory element of the SRM?

Answer Choices

a) Request Identifier

b) Requestor Identifier

c) SequenceNumber (message counter)

d) Estimated time of arrival

Review of Answers

a) Request Identifier

Incorrect. A request identifier is not mandatory unless a specific request is made

b) Requestor Identifier

Correct! The identifier of the requestor must be included in all Signal Request Messages

c) SequenceNumber (message counter)

Incorrect. The message counter is optional.

d) Estimated Time of Arrival

Incorrect. The estimated time of arrival of the requestor is optional.

Learning Objective 3

Describe What Agencies Need to Do to Prepare for CV TSP Implementation

What Agencies Need to do to Prepare for CV TSP Implementation

- Define the **roles** and **responsibilities** of the traffic and transit agencies
- Define the **physical architecture**
- Present additional **deployment guidance** (security, authorization, vehicle priority, check-in/check-out, nearside vs farside)

Roles and Responsibilities of the Traffic and Transit Agencies

Transit Agencies

- Responsible for identifying the **business rules** when Priority Requests are generated
  - Schedule adherence
  - Transit vehicle load
  - Transit vehicle in service/not in service
- Identify the goals and objectives (**performance measures**) for the TSP system
- **Outreach** to other local agencies that may need preferential treatment to fit within the priority structure
  - Emergency vehicle operators
  - Freight operators
  - May include cost-sharing

Roles and Responsibilities of the Traffic and Transit Agencies

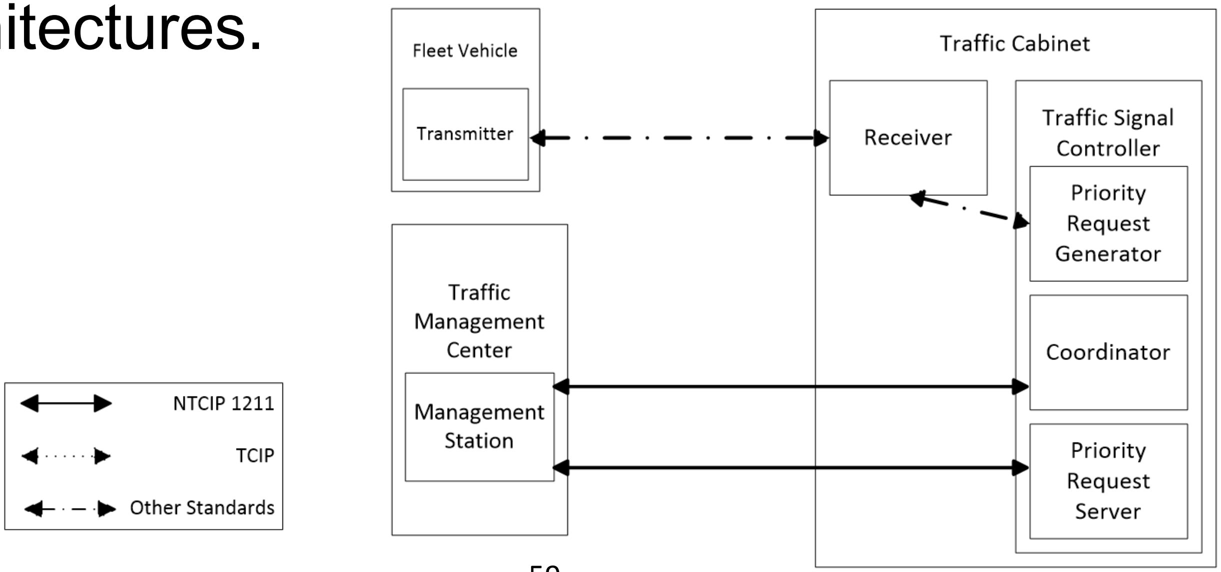
Traffic Agencies

- Responsible for granting priority requests based on the business rules provided by the transit agency
- Identify constraints on the business rules based on the traffic signal system infrastructure

Physical Architecture

NTCIP 1211

- Describes six common but different system architectures for SCP, including the physical components, the logical components (PRG, PRS, CO) and the interfaces between them.
  - Implementations are allowed to use a different architecture, and may support multiple architectures.



Physical Architecture

Connected Vehicle Environment

- What communications technology to use?
  - DSRC vs. 3GPP PC5 Mode 4
- How is security provided?

Physical Architecture

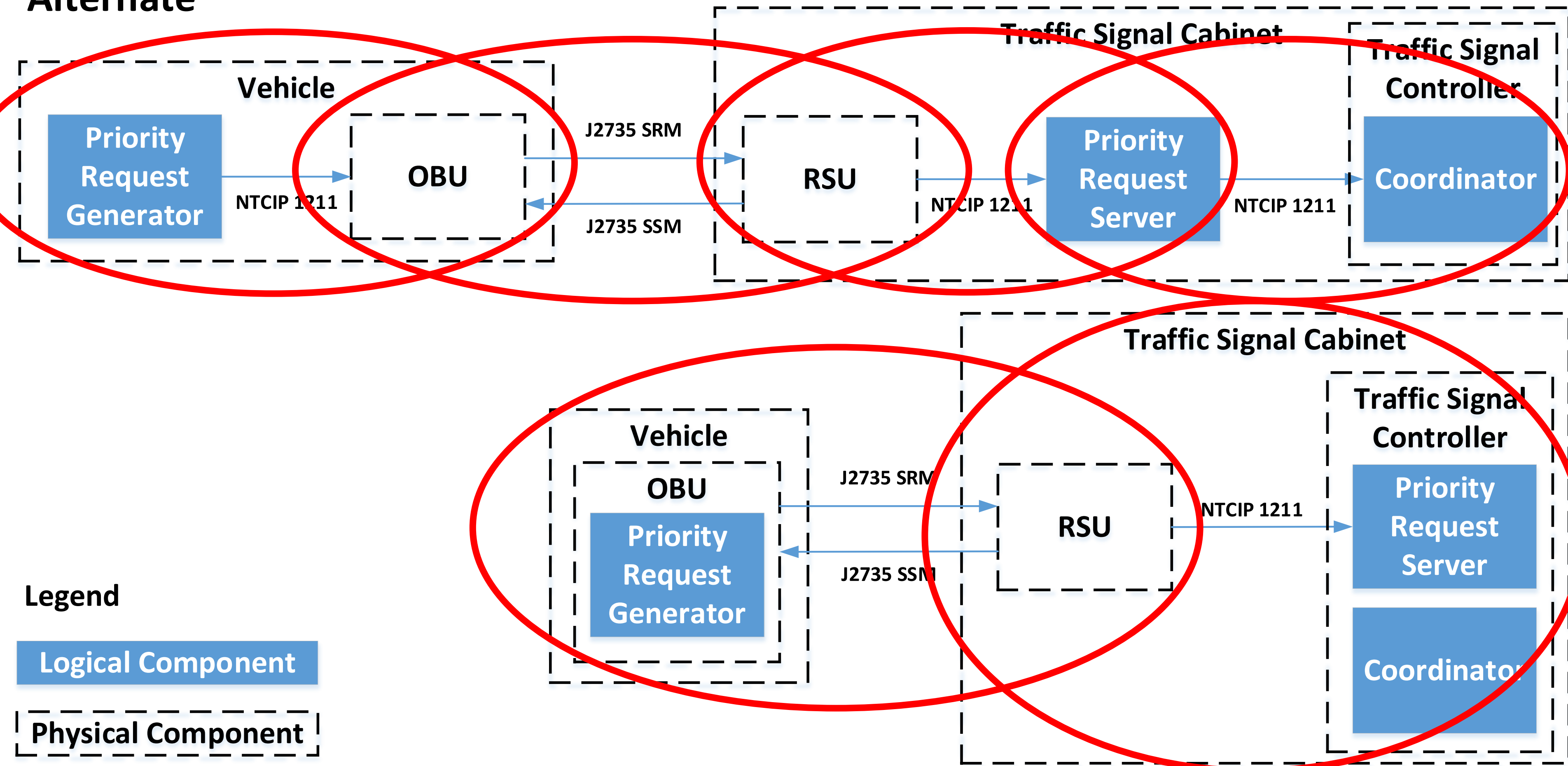
SRM / SSM

- The SAE J2735 SRM and SSM are exchanged between the OBU and the RSU
- PRG generates the priority request
  - May be part of the vehicle on-board systems, the OBU, or a separate physical device
- PRS receives the priority requests and generates a service request to the CO
  - May be part of the Coordinator (controller), the RSU, a separate device in the cabinet or a central location

Physical Architecture

SRM / SSM

Alternate



Legend

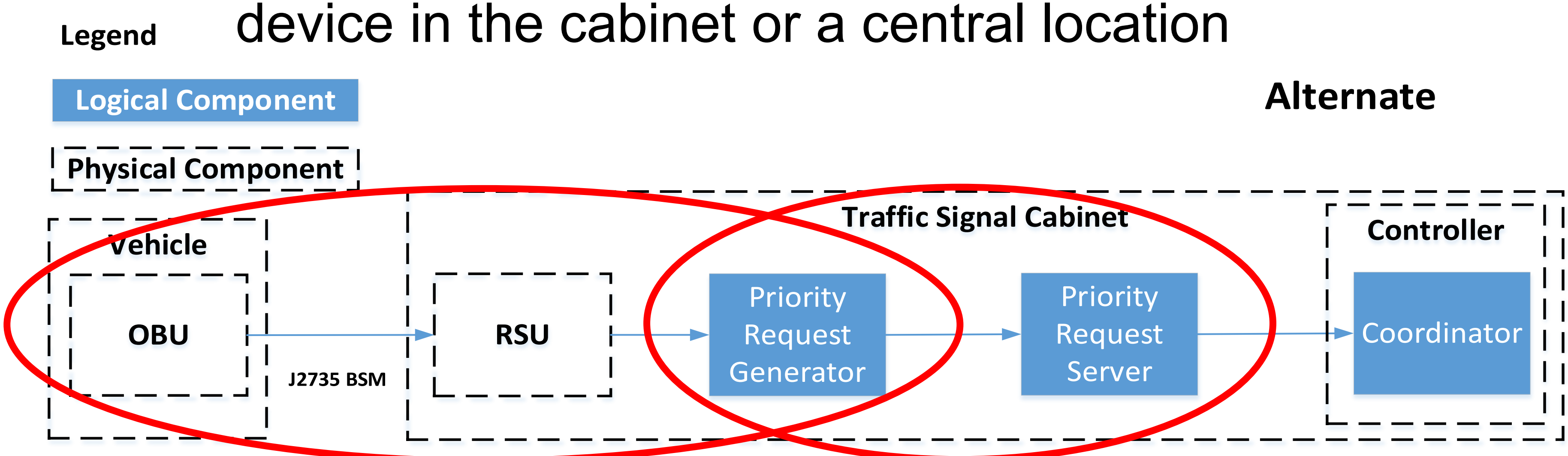
Logical Component

Physical Component

Physical Architecture

BSM

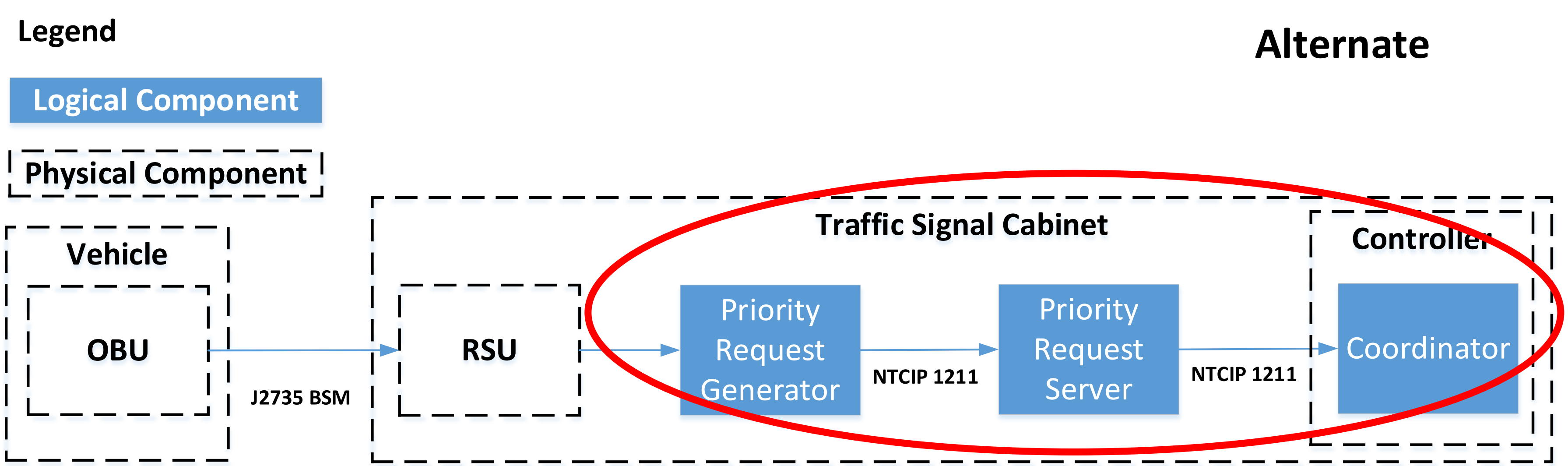
- The SAE J2735 BSM is broadcasted by the OBU and received by the RSU
- PRG generates the priority request based on the vehicle's current location, current kinematics (speed, heading), (vehicle) type, and / or permissions
  - May be part of the RSU or a separate physical device in the cabinet or a central location



Physical Architecture

BSM

- PRS receives the priority requests and generates a service request to the CO
  - May be part of the Coordinator (controller) or a separate device in the cabinet or a central location



Vehicle Type/Class

- Used to determine priority
- Different type of vehicles (e.g., railroad, emergency vehicles, transit vehicles, freight)
- Can also distinguish between different classes of the same vehicle type (e.g., for transit vehicles: LRT, BRT, express bus, or local bus)
  - Called **subRole** in SAE J2735
  - Called vehicle class in NTCIP 1211

Additional Deployment Guidance

Check In / Check Out

Check In

- **When** should the PRG begin generating priority requests?
  - Consider the transmission signal strength of the OBU and the receiving strength (sensitivity) of the RSU
  - Consider the transmission rate and latency of the communications technology (and the AVL system)

Check Out

- **When** will the traffic signal controller know that the requestor has checked out?

Additional Deployment Guidance

Nearside / Farside

Nearside

- Estimated Time of Arrival for nearside bus stops varies widely, impacting signal coordination
  - How long will the vehicle be stopped?
  - **Door open** / **left turn signal** indication is helpful
  - Right turning vehicles are another issue

Additional Deployment Guidance

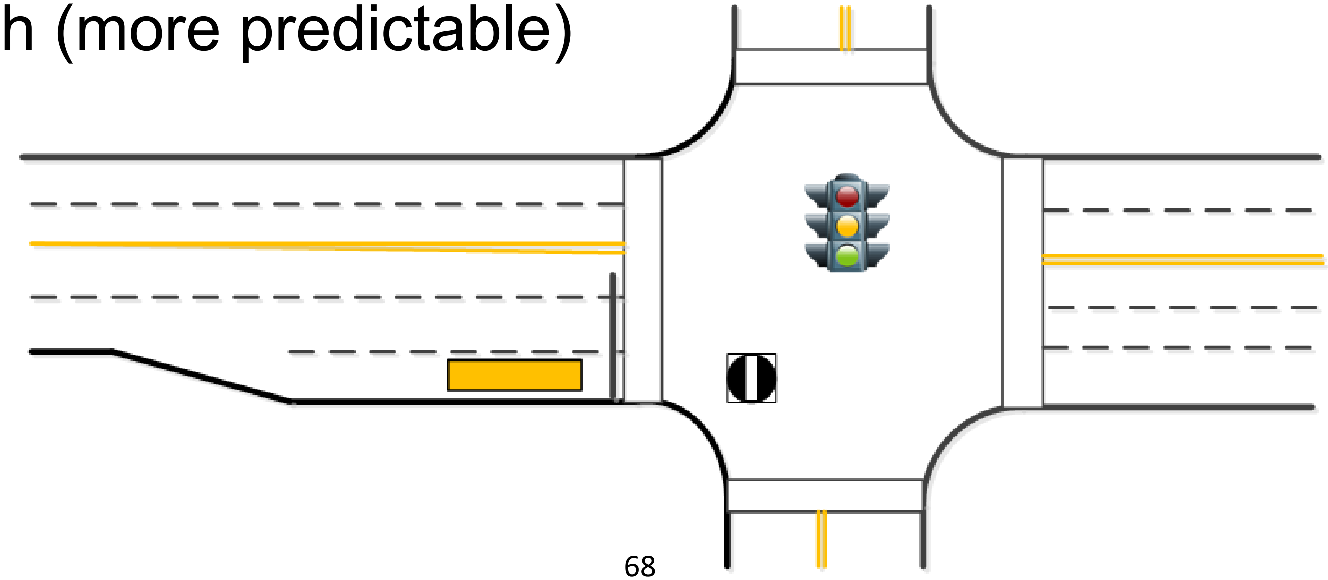
Nearside / Farside

Nearside

- Queue jumps may be effective
    - The check-in point may be the stopbar

Farside

- Approach speeds toward the intersection will not vary much (more predictable)



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Question

Where would a PRS NOT likely to be located?

Answer Choices

a) A transit vehicle
b) A traffic management center
c) A traffic signal controller cabinet
d) A traffic signal controller

Review of Answers

a) A transit vehicle

Correct! A PRS is not likely to be found aboard a transit vehicle

b) A traffic management center

Incorrect. The functions of the PRS may be performed at a centralized server at a traffic management center.

c) A traffic signal controller cabinet

Incorrect. A PRS could be a physical device in the cabinet.

d) A traffic signal controller

Incorrect. The functions of the PRS may be performed by the traffic signal controller

Learning Objective 4

Implementation Considerations

CASE STUDY

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U.S. Department of Transportation
ITS Joint Program Office
Image Source: Thinkstock USDOT

Implementation Considerations

Case Studies

- Multi-Modal Intelligent Traffic Signal Systems (MMITSS)
- Tampa Hillsborough Expressway Authority (THEA) Connected Vehicle Pilot
- Redwood Road, Salt Lake City, Utah
- SANDAG Bus-on-Shoulders

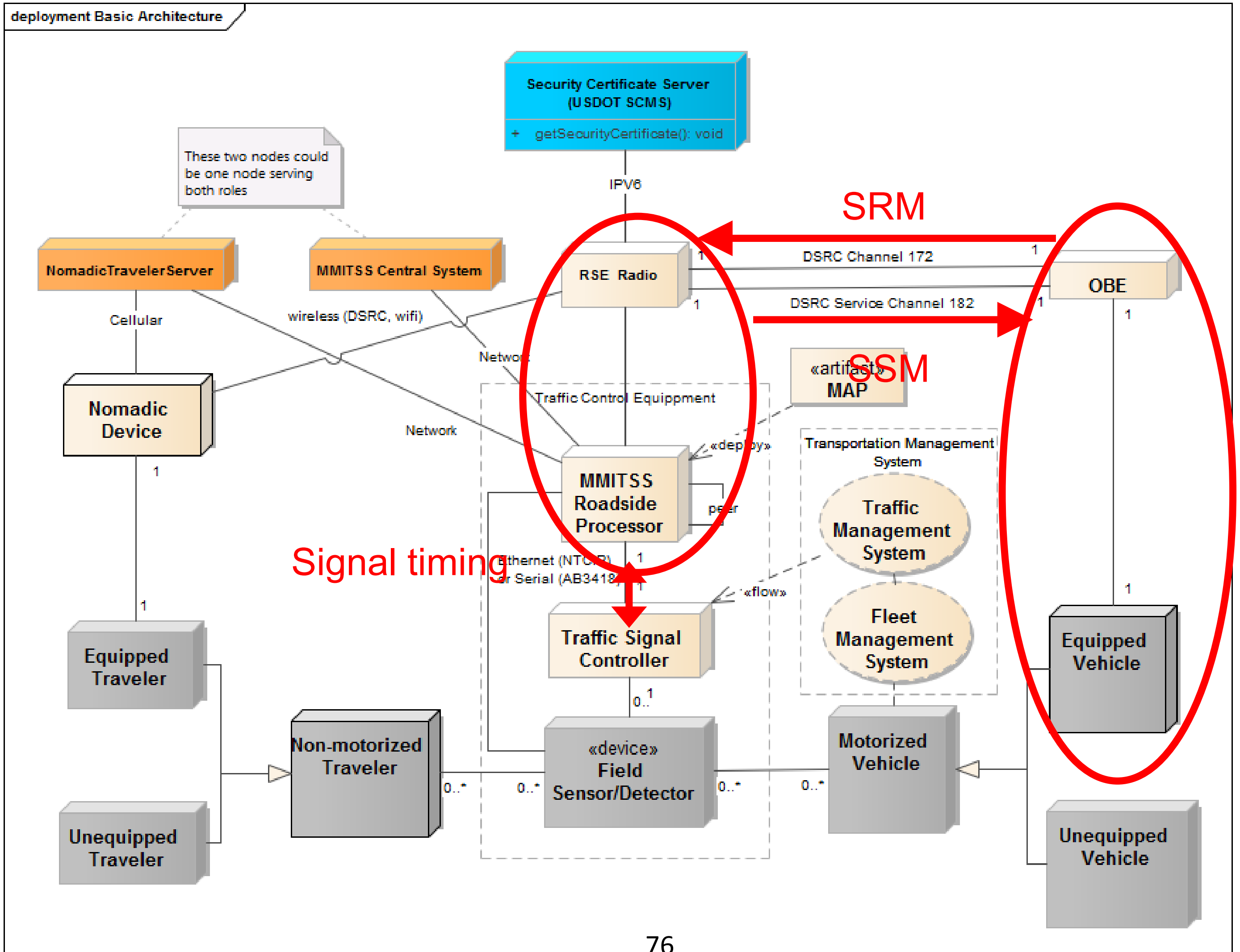
Multi-Modal Intelligent Traffic Signal Systems (MMITSS)

Introduction

- First implementations of signal priority in a CV Environment
  - Anthem, AZ
  - Palo Alto, CA
- Funded under the Connected Vehicle Pooled Fund Study.
- Used SAE **J2735_200911**
  - SRM, SSM, MAP, SPaT messages
  - Some minor differences with the SAE J2735_201603 version
- Used **NTCIP 1202** to exchange data between the RSU and the signal controller

Multi-Modal Intelligent Traffic Signal Systems (MMITSS)

System Architecture



Multi-Modal Intelligent Traffic Signal Systems (MMITSS)

Lessons Learned

- Supports emergency vehicles and transit vehicles.
- This implementation considered priority based on **performance measures** such as overall delay
  - Prior signal priority implementations were generally on a first come, first serve basis, particularly based on vehicle class (e.g., emergency vehicles).
- **Improved** vehicle travel time and travel time reliability
- **Reduced delay** for equipped transit vehicles by 8.2%

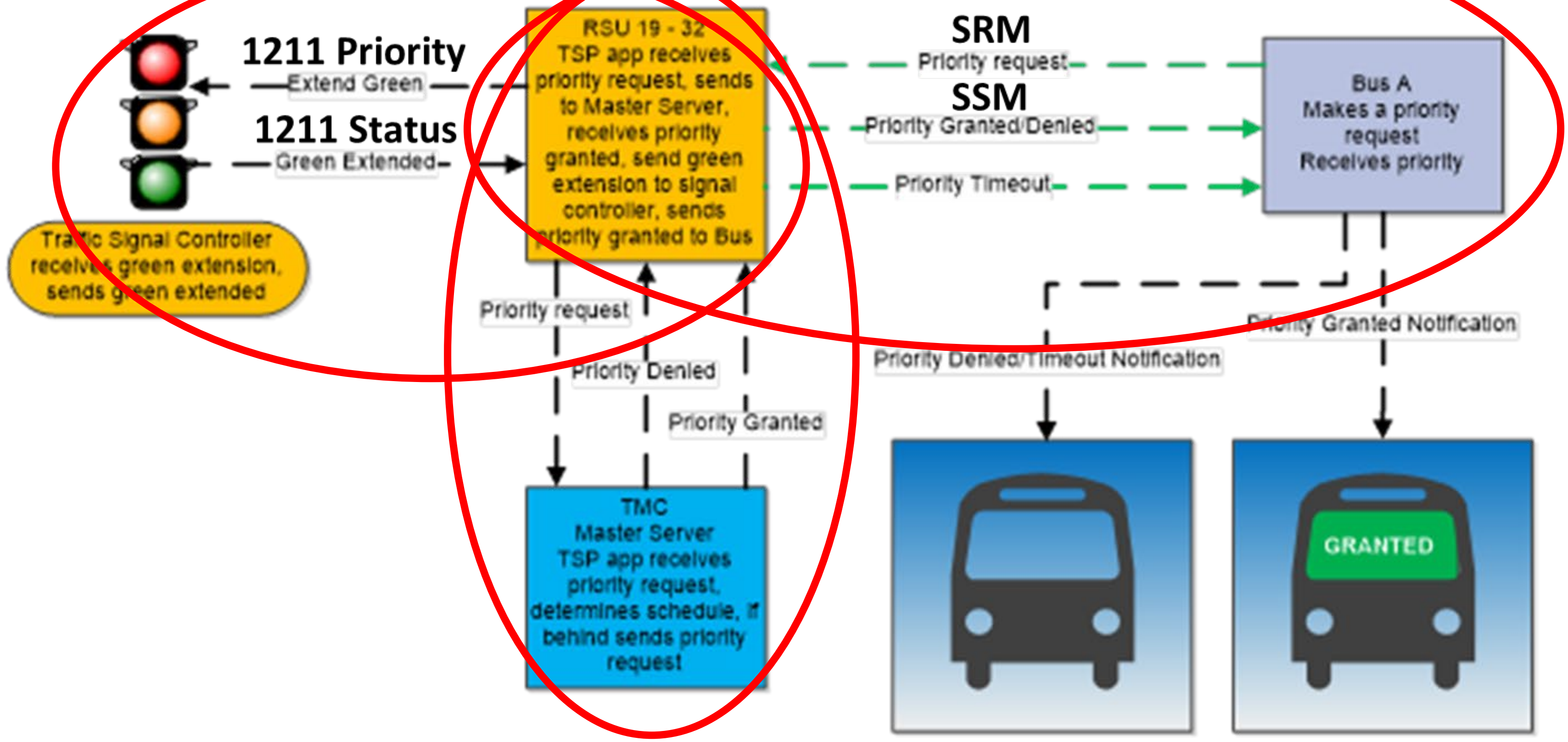
Tampa Hillsborough Expressway Authority (THEA) Connected Vehicle Pilot

Introduction

- One of the sites for USDOT's **CV Pilot Deployment Program**
- Multimodal deployment in downtown Tampa, Florida
- Includes a **transit signal priority** application
  - 10 Hillsborough Area Regional Transit (HART) buses
- Based on the MMITSS implementation, but with some modifications
  - Adds support for **coordination**
  - Converts SRM to **NTCIP 1211** priority requests to the controller and NTCIP 1211 priority status objects from the controller to SSM

System Architecture

Priority by Controller



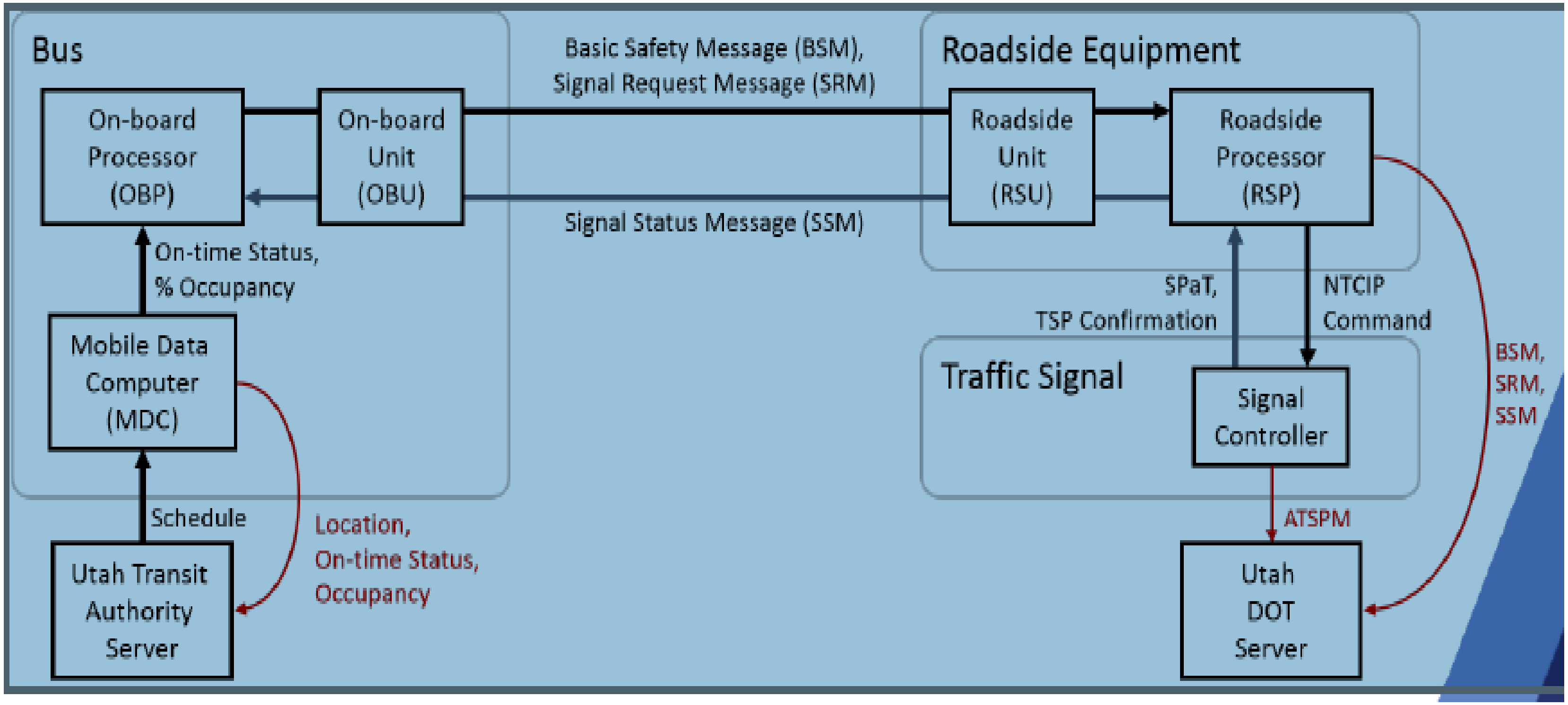
Source: https://www.its.dot.gov/pilots/pilots_thea.htm

Salt Lake City, Utah

Introduction

- Utah DOT (UDOT) – deployed **DSRC**
  - Redwood Road - 27 signalized intersections
  - Utah Valley Express (UVX) Bus Rapid Transit in Provo, Utah – 47 signalized intersections
- Opportunity to gain **experience** with connected vehicles
- Goal of the TSP project is to improve schedule reliability and meet the **SPaT Challenge**
- Modified Arizona MMITSS to integrate the buses' current on-time performance and passenger loading in the priority decision

System Architecture



Source: Utah DOT

Lessons Learned

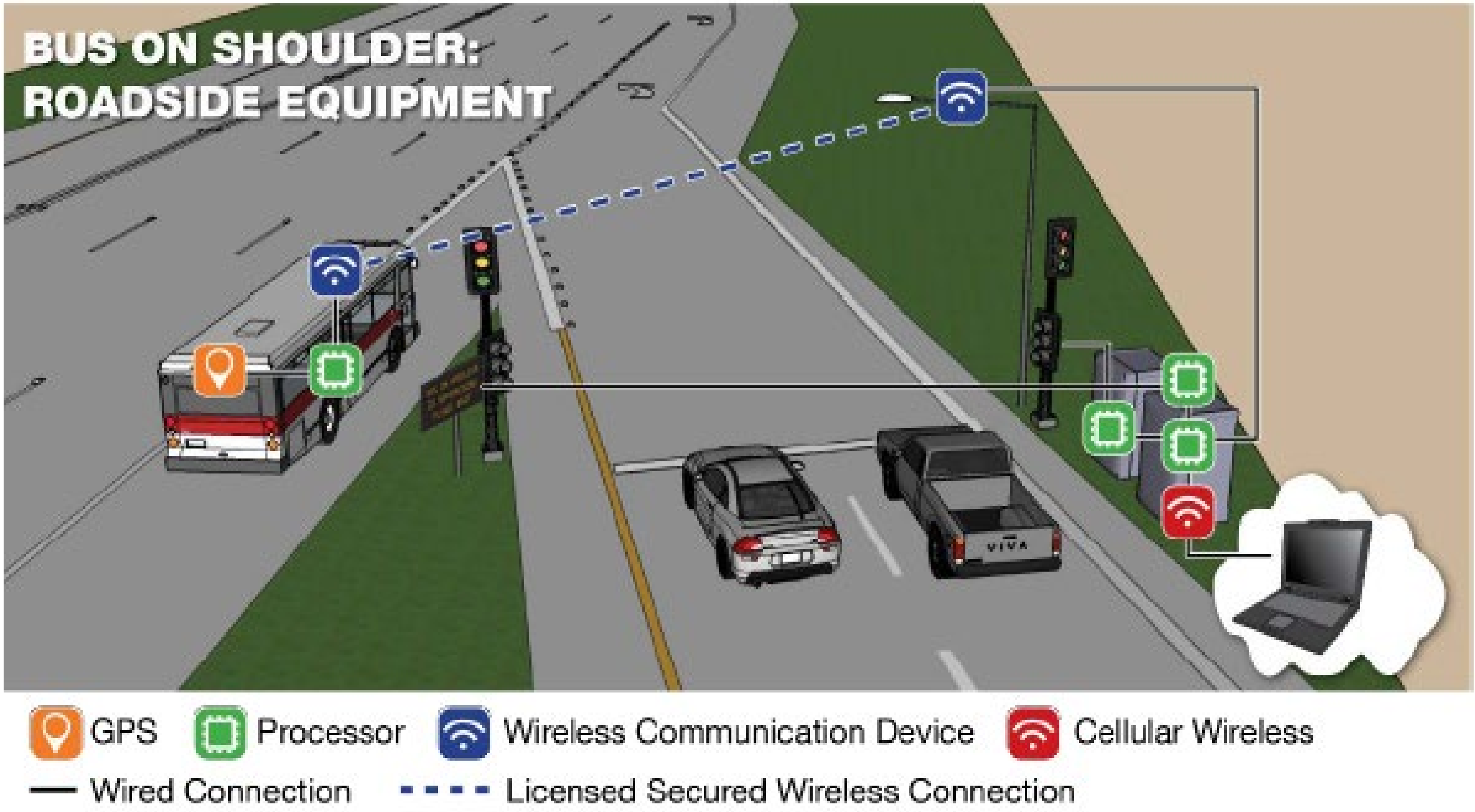
- Same equipped intersections provide signal preemption to UDOT snowplow vehicles in addition to other signalized intersections
    - 46 snow plows
- Evaluation study underway for the UVX BRT Project and the Snow Plow Pre-emption Project
- More TSP and Snow Plow Pre-emption Corridors being added.

Introduction

- Pilot project to **explore technologies** to support buses traveling in transit-only lanes of a freeway
    - SANDAG, in partnership with San Diego Metropolitan Transit System (MTS), the California Department of Transportation (Caltrans), and the US Department of Transportation (USDOT)
- The transit-only lanes are in the shoulder lanes so where the shoulder lanes and the on-ramp lanes merge is a conflict area.
- Using CV technology with **ramp meters** to hold vehicles on the on-ramps as transit vehicles approach the conflict (merge) area

SANDAG Bus On Shoulders

Concept



Source: SANDAG

System Architecture

- OBUs are installed on the transit vehicles and RSUs are installed at the ramp meters
  - Using V2I communications and WSMs
- Transit vehicles broadcast **BSMs**
- Ramp meters broadcast **SSMs**

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Question

Which of the following is an important consideration when deploying TSP in a CV environment?

Answer Choices

a) Security
b) Physical architecture
c) Criteria for granting priority requests
d) All of the above

Review of Answers

a) Security

Incorrect. Security is an important consideration for CV.

b) Physical architecture

Incorrect. The physical architecture is an important consideration for TSP system.

c) Criteria for granting priority requests

Incorrect. The criteria for granting priority requests is an important consideration for a TSP system.

d) All of the above

Correct! All of the above are important considerations for a TSP system in a CV environment.

Module Summary

Describe how transit signal priority may be provided in a connected vehicle environment

Describe TSP Standards in a Connected Vehicle Environment

Describe what agencies need to do to prepare for CV TSP implementation

Implementation Considerations

We Have Now Completed the TSP Curriculum

- **Module 8**: Arterial Management and Transit Signal Priority: Understanding User Needs for **Signal Control Priority** (SCP) Based on NTCIP 1211 Standard - Part 1 of 2.
- **Module 9**: Arterial Management and Transit Signal Priority: Understanding User Needs for **Signal Control Priority** (SCP) Based on NTCIP 1211 Standard - Part 2 of 2
- **Module 20**: Application of Arterial Management/**Transit Signal Priority** Standards

Modules of Interest

- **Module 11**: Transit and the Connected Vehicle Environment/Emerging Technologies, Applications and Future Platforms
- **Module 23**: Leveraging Communications Technologies for Transit On-Board Integration
- **CV273**: Introduction of SPaT / MAP Messages
- **CSE201:** Introduction to Security Credential Management System
- **CV265**: Introduction to IEEE 1609 Family of Standards for Wireless Access in Vehicular Environments (WAVE)

Thank you for completing this module.

Feedback

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

Thank you!