UFTI DSRC and Other Communication Options for Transportation Connectivity Workshop

Overview of DSRC Messages and Performance Requirements

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Agenda

- IEEE 802.11 & 1609 Overview
- SAE J2735 Overview
- SAE J2945 Overview
- Messages used in Deployments
- USDOT CV Services
- Challenges

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IEEE 802.11 and 1609

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IEEE 802.11 and 1609

- **IEEE P802.11p-2010- Standard for Information Technology -Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications Amendment 6: Wireless Access in Vehicular Environments (WAVE).***
  - 802.11p Specifies the extensions to IEEE 802.11 that are necessary to provide wireless communications in a vehicular (CV) environment.
  - Specifies the PHY and MAC Layers in the OSI Model
  - 802.11p-2010 was incorporated into 802.11-2012

- **1609.0 - Architecture**
  - Provides an overview of the IEEE 802.11p and 1609 DSRC/WAVE system, its components, operation, as well as how the 802.11p and 1609 standards fit together to form the overall system.

- **1609.2 - Security Services for Applications and Management Messages***
  - Defines secure message formats and processing as well as the circumstances for using secure message exchanges and how those messages should be processed based upon the purpose of the exchange.

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*part of the communication stack

IEEE 802.11 and 1609

- **1609.3 - Networking Services***
  - Defines network and transport layer services, including addressing and routing, in support of secure WAVE data exchange.
  - Defines the Wave Short Message Protocol (WSMP); a WAVE-specific alternative to IPv6 (Internet Protocol version 6) for exchanging data.
    - Mostly utilized for Broadcast messages.
  - Only supports WSMP and IPv6.
  - Defines the WAVE Service Advertisement (WSA)
    - Contains a list of supported services
  - Describes PSIDs
    - A Provider Service Identifier (PSID) is message/application classification
    - Organization can request a PSID from IEEE and define and describe how that PSID is to be used

- **1609.4 - Multi-Channel Operations***
  - Provides enhancements to the IEEE 802.11 MAC to support Multi-Channel operations.

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IEEE 802.11 and 1609

- **1609.12- Identifier Allocations**
    - Contains the list of Recognized PSIDs
    - The organization reasonable for defining how the PSID is used

- 802.11p and 1609 were sited in the NHTS Notice of Proposed Rule Making (NPRM) released in early 2016

https://www.standards.its.dot.gov/Factsheets/Factsheet/80

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SAE J2735

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SAE J2735

- J2735 defines the format and structure of message, data frames, and data elements for exchanging data between vehicles (V2V) and between vehicles and infrastructure (V2I); Data Dictionary.
- Data Elements are primitive objects
  - e.g. speed, heading, latitude, longitude, elevation, etc.
- Data Frames are a collection of Data Elements
  - e.g. The *Position3D* Data Frame is comprised of latitude, longitude, and elevation Data Elements
- A Message is a collection of Data Frames and Data Elements
  - e.g. Signal Phase and Timing message contains MinuteOfTheYear and DescriptiveName data elements and IntersectionStateList data frame

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SAE J2735

- J2735 contains:
    - 17 Messages
    - 156 Data Frames
    - 230 Data Elements
    - 58 external data element definition references

- Objects are defined in terms of Abstract Syntax Notation One (ASN.1)
    - Description language for defining data structures

- 1 Message ≠ 1 Application; 1 Message = Multiple Applications

- Some objects in a message are Mandatory and some are Optional

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J2735 Messages

MessageFrame
BasicSafetyMessage
CommonSafetyRequest
EmergencyVehicleAlert
IntersectionCollisionAvoidance
MapData
NMEAcorrections
PersonalSafetyMessage
ProbeDataManagement
ProbeVehicleData

RoadSideAlert
RTCMcorrections
SignalPhaseAndTiming
SignalRequestMessage
SignalStatusMessage
TravelerInformationMessage
TestMessage

<BasicInformationMessage>

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BasicSafetyMessage

- Core V2V Safety Message
- Broadcast by vehicles to provide situational data (location, heading, speed, etc.) to surrounding vehicles, used to assess threat potentials
- Common in-vehicle Applications
  - Forwarded Collision Warning (FCW)
  - Emergency Electronic Brake Lights (EEBL)
  - Do Not Pass Warning (DNPW)
  - Left Turn Assist (LTA)
  - etc.
- Part I; all data elements are mandatory
- Part II; can contain any number of vehicle-related Optional objects

- BSMs can also be "collected" by TCMs to assess roadway conditions; travel times, congestion, etc.

- Sited in the NHTS NPRM

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SPaT/Map

- Signal Phase and Timing (SPaT)
  - Broadcast by Roadside Units (RSU) to provide current signal status (color) by lane and when the status is expected to change
    - Requires a connection to the Signal Controller and for the Signal Controllers to provide required data
- Map
  - Broadcast by RSUs to provide geometric layout of an intersection
  - Used in conjunction with SPaT
  - Ties SPaT Status and lane geometry
- Common in-vehicle Applications
  - Red Light Warning
  - Speed Optimization through a corridor
  - Eco-Approach and Departure at Signalized Intersections (Vehicle Powertrain Management)

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PersonalSafetyMessage (PSM)

- Broadcast by Vulnerable Road User (VRU) devices to announce their presence to approaching vehicles
  - VRUs can include
    - Pedestrians
    - Bicycles
    - Road Construction Crew
  - Devices can include
    - Cell Phones
    - Bike mounted H/W
    - Construction equipment (Cones, Barrels, badges, etc.)

- Still Under Development

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ProbeVehicleData

- Unicast from a vehicle to a TMC or other infrastructure-based system
- Similar to BSM, but contains additional vehicle status and traveling behavior data
- Core data frames are time & location based "Snapshots"
  - Snapshots contain sensor value/state at an moment in time
  - A single PVD Message can contain up to 32 Snapshots
  - Snapshots are generated based on
    - Periodic-time/distance traveled
    - "Events"-when the state or status of certain Vehicle elements/systems change (on/off) (e.g. traction control system engaged) or when a pre-defined threshold is exceeded (e.g. hard braking)
    - Start/Stop
- Vehicles generate and store Snapshots throughout their "trip" (ignition on –to ignition off)
- Transmitted while in communication range of a RSU
- Once the vehicle leaves communication range, and remaining messages/snapshots are deleted

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ProbeDataManagment

- Broadcast by RSUs to instruct vehicles to adjust data (snapshot) collection thresholds and/or transmission strategy
  - Change "Hard Braking" Threshold
  - Collect snapshots ever x seconds/m traveled
  - Transmit a Probe Data Message every minute while within communication range
- Direction based
- Terminate adjustments based on time or distance

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SSM and SRM

- SignalStatusMessage (SSM)
  - Broadcast by RSUs to announce pending Priority/Pre-emption requests

- SignalRequestMessage (SRM)
  - Broadcast by vehicles to request Priority/Pre-emption

- Common Applications
  - First Responder Signal Priority
  - Transit Signal Priority
  - Fright Signal Priority

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TIM/BIM

- TravelerInformationMessage (TIM)
  - Broadcast by RSUs to convey roadway conditions/attributes
  - Common Applications
    - **Curve Speed Warning**: provides roadway geometry and advised speed through a curve
    - **Work Zone**: provides roadway geometry (lane closures/shifts, etc.) and advised speed through the Zone. May also contain active dates and time of day
    - **Next Exit Services**: provides food, lodging, gas, etc. information
- BasicInformation Message(BIM)
  - Under Development
  - May replace the TIM

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SAE J2945

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J2945 Family

The J2945 family of SAE standards describe Use Cases and Performance Requirements for J2735 messages

- /0 Common Requirements
- /1 On-Board SysReq for V2V Safety Communications
- /2 V2V Safety Awareness
- /3 Weather and Road Reporting
- /4 TIM
- /5 Mayday Systems
- /6 Coordinated Maneuvers (Platooning and CACC)
- /7 Transit Systems
- /8 Freight Systems
- /9 VRU
- /10 SPaT and Map

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J2945/0

- DSRC Systems Engineering Process Guidance for J2945/x Documents and Common Design Concepts

- Provides Systems Engineering and DSRC Interface requirements for the J2945 family of standards

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J2945/1

- Specifies system requirements for on-board vehicle-to-vehicle (V2V) safety communication systems for light-duty vehicles.

- Includes profiles, functional requirements, and performance requirements for transmitting and receiving the BSM over an IEEE 802.11/1609 DSRC link.

- Sited in the NHTS NPRM

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J2945/2

- Extends the V2V Communications capabilities defined in J2945/1 to support additional applications and the National ITS Architecture.

- Includes needs and requirements for the following Applications:
  - Emergency Vehicle Alert
  - Roadside Alert
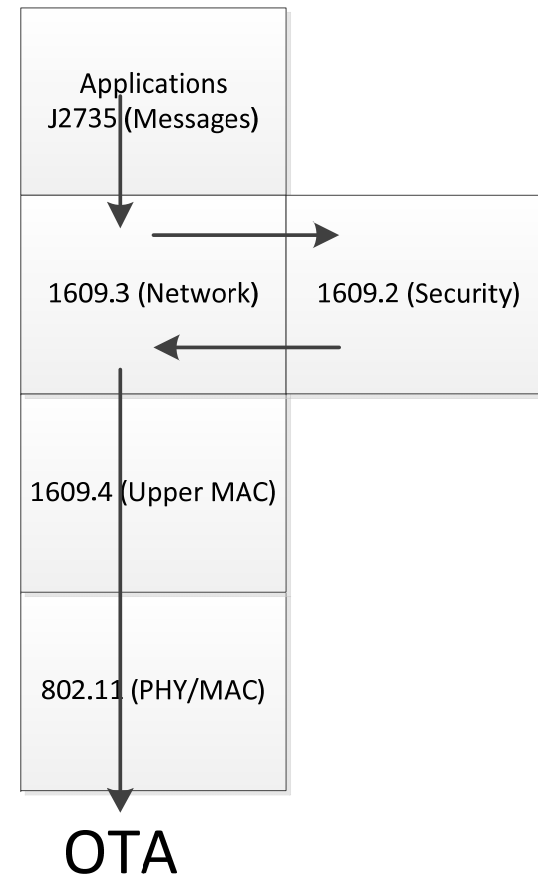 - Safety Awareness Alert

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J2945/9

- Provides recommendations for safety communications between a Vulnerable Road User (VRU) and a vehicle.
- Addresses vehicle on-board system reception of messages from road user devices carried by pedestrians, bicycle riders and public safety personnel, to provide driver/vehicle system awareness and potentially offer safety alerts to VRUs.
- Includes profiles, functional requirements, and performance requirements for transmitting and receiving the PersonalSafetyMessage over an IEEE 802.11/1609 DSRC link.

- In Ballot

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J2945/10

- Provides System Requirements and Guidance for using the SPaT and Map messages

- In development

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Communication Stack

Applications
J2735 (Messages)

1609.3 (Network) · 1609.2 (Security)

1609.4 (Upper MAC)

802.11 (PHY/MAC)

OTA

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Messages by Test Bed

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Messages by Test Bed

- Smart Columbus
  - SPaT/Map
  - BSM
  - SRM
  - SSM
  - TIM

- USDOT MI Test Bed
  - SPaT/Map
  - BSM
  - TIM: CSW

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Messages by Test Bed

- MDOT Test Bed
  - SPaT/Map
  - BSM
  - TIM: CSW

- City of Detroit Test Bed
  - SPaT/Map
  - TIM: CSW, WZW

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Messages by Test Bed

- City of Ann Arbor
  - SPaT/Map
  - BSM
  - TIM: CSW

- CV Pilots (THEA, WY, NY)
  - SPaT/Map
  - BSM
  - TIM
  - ProbeVehicleData?
  - ProbeDataManagement?

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USDOT CV Services
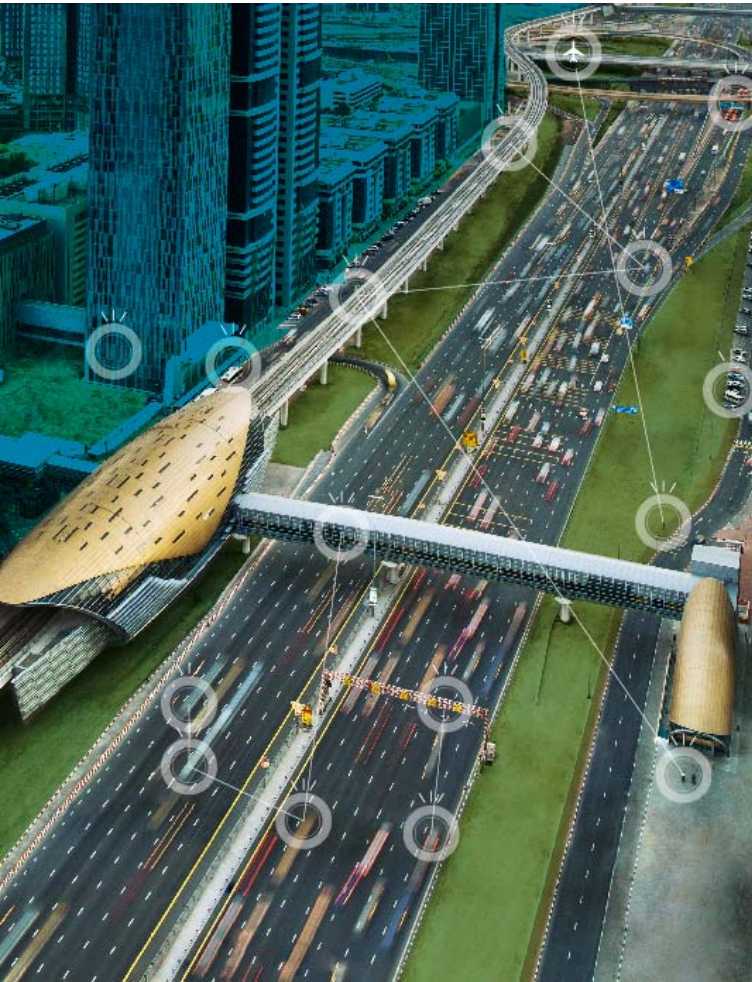
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USDOT Services

- Operational Data Environment (ODE)
  - Local or Regional data collection and distribution system
- Situational Data Clearinghouse (SDC)
  - National data collection and distribution system
  - Collects and distributes data in real time
- Situational Data Warehouse (SDW)
  - National data archive and distribution system
  - Stores and provides access to data for up to 12 months
- Security Credential Management System (SCMS)
  - Generates and distributes IEEE 1609.2 Security Material used to sign and encrypt messages
- J2735 Map Tool
  - Open web tool for creating J2735 compliant Map Messages

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https://cvcs.samanage.com

Challenges

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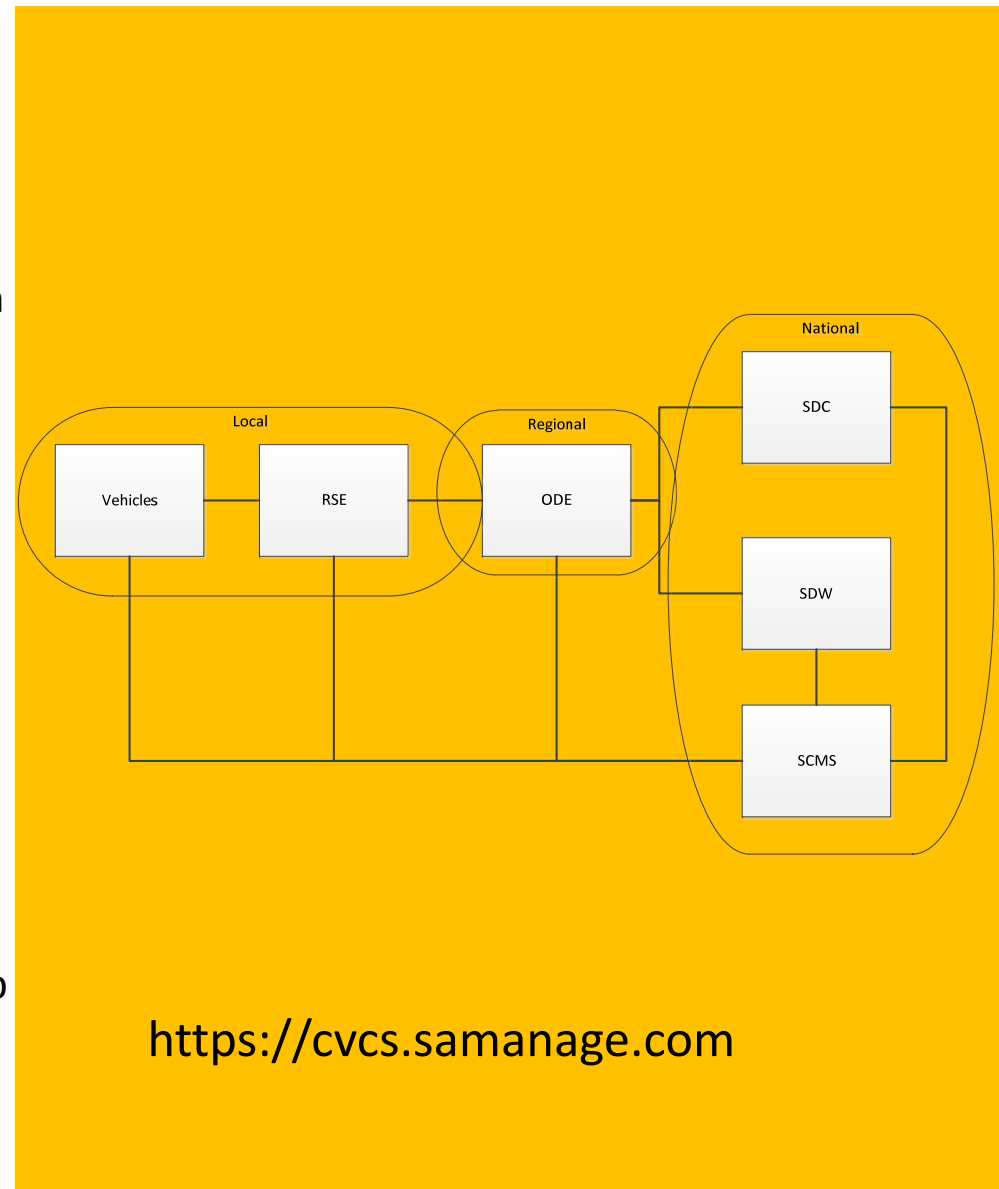
INTEROPERABILITY

- To truly make an impact all vehicle and applications need to operated Nation wide, not just a particular city or state or region

- New deployments seem to be coming on line everyday

- **Interoperability between systems\deployments\applications can be big challenge.**

  - The Standards do a good job of defining data objects, however, some definitions and use of those data objects can be open to interpretation

  - Applications can require different "Optional" objects

- USDOT CV services and sponsored deployments provide a good foundation for interoperability

- Recommended following the USDOT deployment efforts

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Overview of SAE DSRC Messages and Performance Requirements

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