Connected Vehicle and Intelligent Transportation Systems

US DOT Connected Vehicle Pilot Program and EU Cooperative ITS (C-ITS)

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AT&T
Greenwood Village, CO
6 Dec 2017

Objectives of this Presentation

ITS Security for Vehicular Networks

-- A Writer's Life

-- Applications for Connected Vehicles

-- ITS Models (US DOT Connected Vehicle, Use Cases)

-- Connected Car Pilot (NYC, THEA, WYO)

-- EU Cooperative ITS Projects (SCOOP@F)

Car-to-X Networking

-- The Networking Models

-- Fully Connected Vehicle (US DOT CV Pilot)

-- Standards - Basic Safety Message, WAVE, DSRC

-- Case Study – EU PRESERVE project (C-ITS)

Topics in Security and Privacy

-- Case Study – EU PRESERVE project (C-ITS)

A Writer's Life –

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Editor - IEEE IT Professional magazine
Cloud Security, RBAC, Identity Management, Vehicular Networks
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Citation indices	All	Since 2012
Citations	1148	1086
h-index	7	6
i10-index	7	4

Co-authors View all...
Georgios Karagiannis, D. Richard (Rick) Kuhn

Title 1–20	Cited by	Year
Vehicular networking: A survey and tutorial on requirements, architectures, challenges, standards and solutions G Karagiannis, O Altintas, E Ekici, G Heijenk, B Jarupan, K Lin, T Weil IEEE communications surveys & tutorials 13 (4), 584-616	705	2011
Adding attributes to role-based access control DR Kuhn, EJ Coyne, TR Weil Computer 43 (6), 79-81	306	2010
ABAC and RBAC: scalable, flexible, and auditable access management E Coyne, TR Weil IT Professional 15 (3), 0014-16	53	2013
Final report: Vehicle infrastructure integration (VII) proof of concept (POC) test–Executive summary R Kandarpa, M Chenzaie, M Dorfman, J Anderson, J Marousek, ... US Department of Transportation, IntelliDrive (SM), Tech. Rep	25	2009
Service management for ITS using WAVE (1609.3) networking T Weil GLOBECOM Workshops, 2009 IEEE, 1-6	14	2009
Final Report: Vehicle Infrastructure Integration Proof-of-Concept Results and Findings-Infrastructure R Kandarpa, M Chenzaie, J Anderson, J Marousek, T Weil, F Perry, ... US Department of Transportation, Washington, DC, USA	11	2009

IEEE National Capital Area **scanner**

IEEE SCANNER - Above the Fold (Mostly)

Stories in Engineering and Science (2005-2009)

In my tenure as Washington DC Editor of the IEEE SCANNER(2005-2007) and AdCom officer (2007-2009) I had the wonderful chance to tour the science, engineering and technology world of IEEE as a roving reporter and editor of this newspaper. My travels took me to Deep Space (NASA), Satellite Communication(InterlSat), the flagship conference of the Telecom industry (GLOBECOM) and beyond. As the son of an AP journalist and itinerant newspaper reporter the SCANNER gave me a front row seat to the journeys of science and engineering.

The stories and photographs below are the journalistic opportunities presented to me by the SCANNER newsletter.

- Nov-Dec 2009 - Celebrating the 125th IEEE Anniversary Year (UDC)
- Sept-Oct 2009 - Preserving History at the History of Technical Societies Conference
- July-Aug 2009 - Washington Section Participates in Congressional Visit Day
- May-June 2009 - Passing The Gavel
- Nov-Dec 2008 - A Tour of NASA Goddard Test and Integration Facility (pg. 6)
- Sept-Oct 2008 - Globecom Committee Closes the Books at ICC 2008 in Beijing
- Sept-Oct 2007 - Globecom Volunteers Prepare for the November Conference
- July-Aug 2007 - DC COMSOC Hosts WiMax Lecture at JDSU
- Jan-Feb 2007 - Globecom Volunteers Visit the San Francisco Conference
- Nov-Dec 2006 - Sensors Conference Panel Reviews DoD Technologies
- July-Aug 2006 - Globecom 2007 Committee Builds a Program
- Sept-Oct 2005 - COMSOC Members Tour the IntelSat Satellite Center
- May-June 2005 - DCCEAS Recognizes Jerry Gibbon as Engineer of the Year

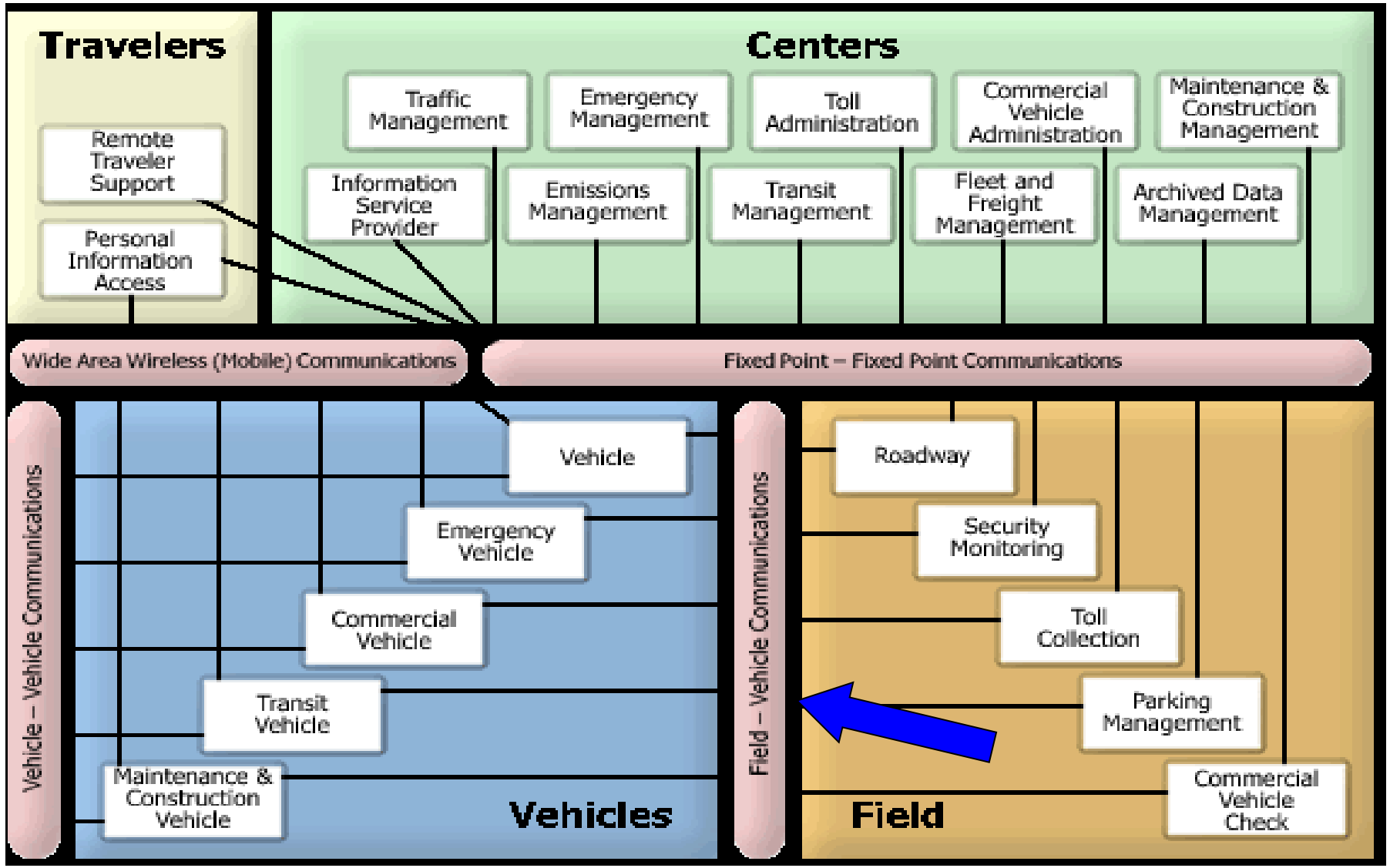
SECURING IT

VPKI Hits the Highway
Secure Communication for the Connected Vehicle Program

Tim Weil, SCRAM Systems

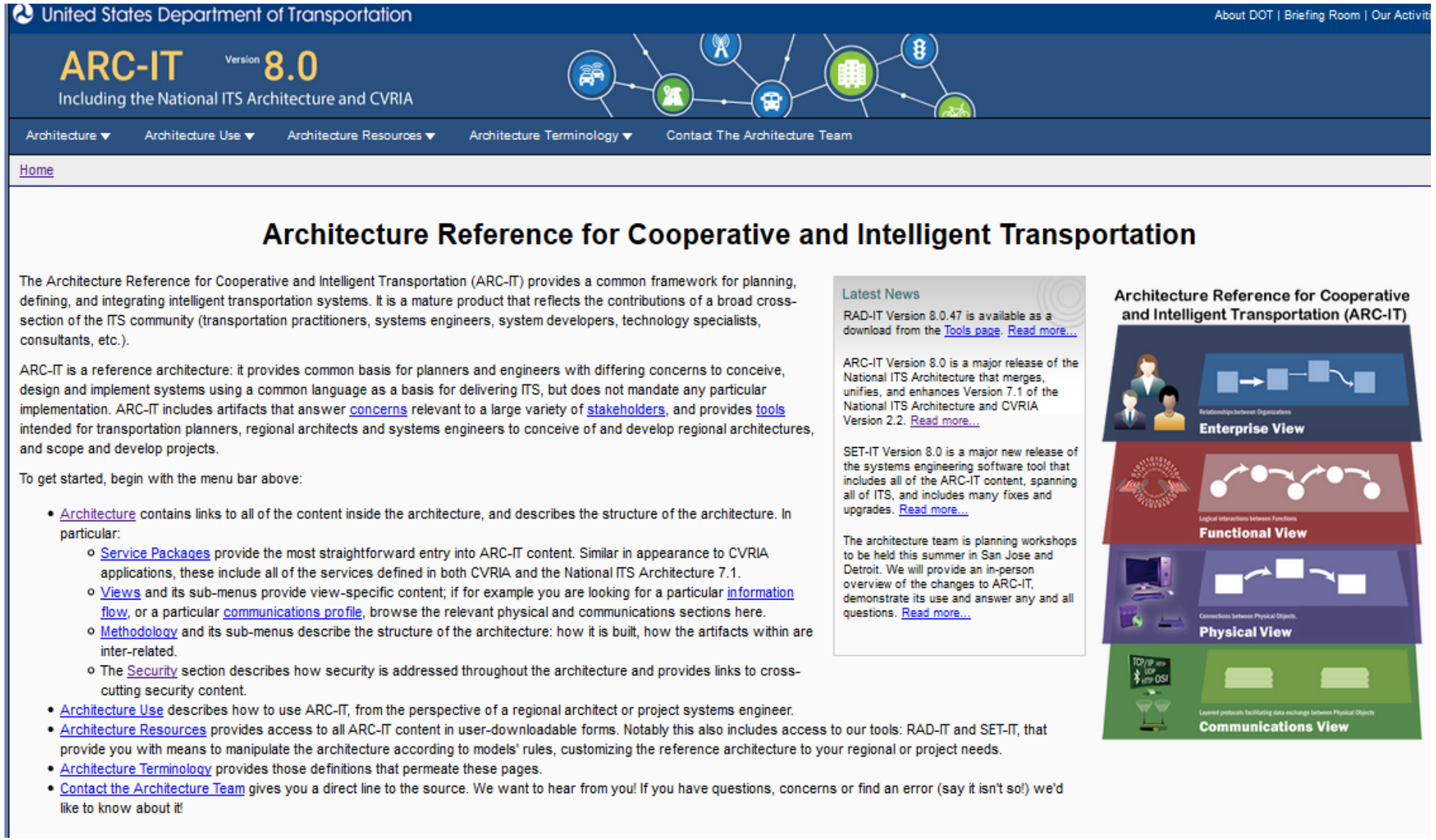
Introduction − USDOT ITS National Architecture (legacy)

http://local.iteris.com/cvria/html/about/connectedvehicle.html



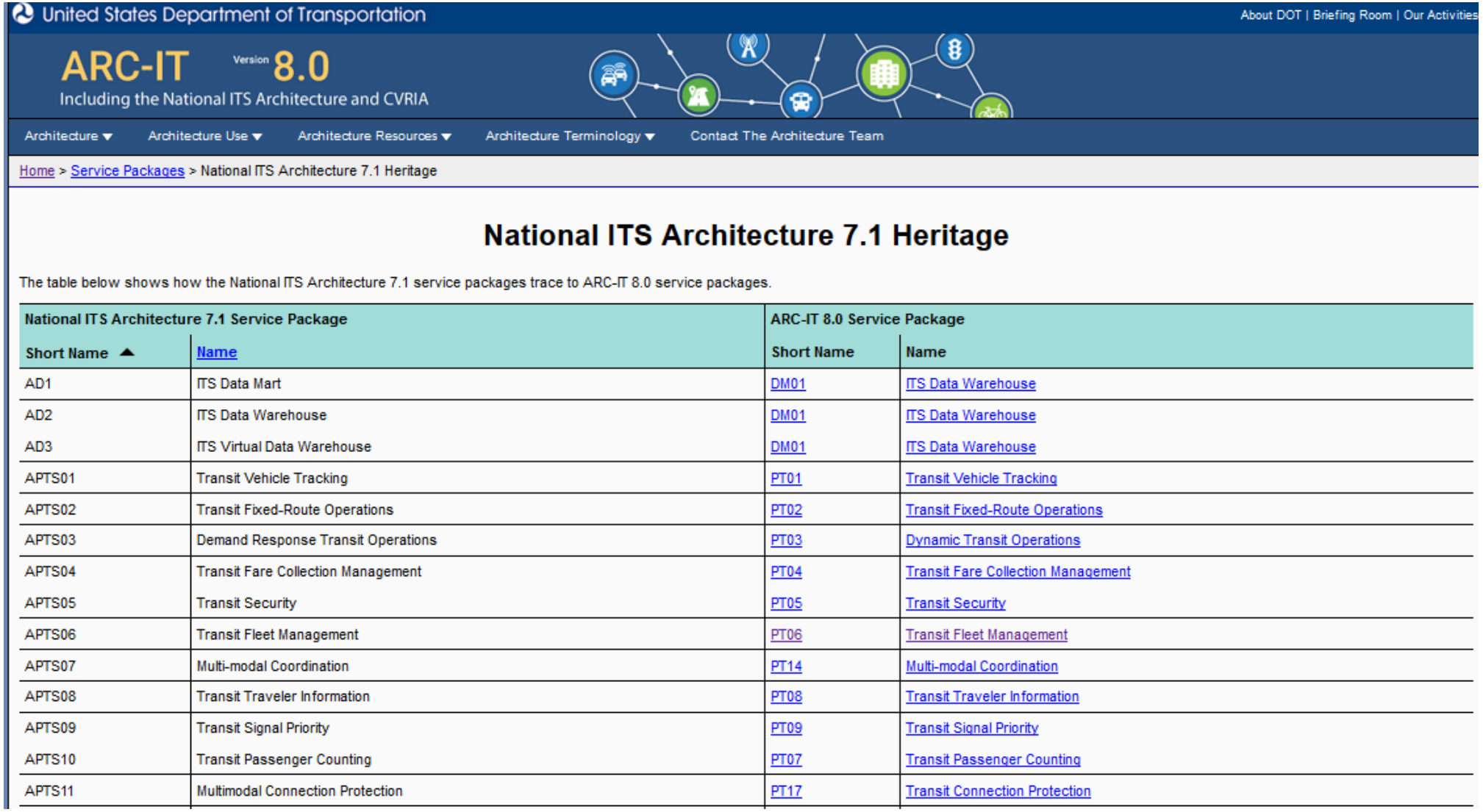
Introduction – USDOT ITS National Architecture (ARC-IT)

http://local.iteris.com/arc-it/index.html



Catalog of Services (CVRIA)

http://local.iteris.com/arc-it/html/servicepackages/servicepackages-areaspsort.html



United States Department of Transportation

About DOT | Briefing Room | Our Activities

ARC-IT Version 8.0

Including the National ITS Architecture and CVRIA

Architecture ▾ | Architecture Use ▾ | Architecture Resources ▾ | Architecture Terminology ▾ | Contact The Architecture Team

Home > Service Packages > National ITS Architecture 7.1 Heritage

National ITS Architecture 7.1 Heritage

The table below shows how the National ITS Architecture 7.1 service packages trace to ARC-IT 8.0 service packages.

National ITS Architecture 7.1 Service Package		ARC-IT 8.0 Service Package	
Short Name ▲	Name	Short Name	Name
AD1	ITS Data Mart	DM01	ITS Data Warehouse
AD2	ITS Data Warehouse	DM01	ITS Data Warehouse
AD3	ITS Virtual Data Warehouse	DM01	ITS Data Warehouse
APTS01	Transit Vehicle Tracking	PT01	Transit Vehicle Tracking
APTS02	Transit Fixed-Route Operations	PT02	Transit Fixed-Route Operations
APTS03	Demand Response Transit Operations	PT03	Dynamic Transit Operations
APTS04	Transit Fare Collection Management	PT04	Transit Fare Collection Management
APTS05	Transit Security	PT05	Transit Security
APTS06	Transit Fleet Management	PT06	Transit Fleet Management
APTS07	Multi-modal Coordination	PT14	Multi-modal Coordination
APTS08	Transit Traveler Information	PT08	Transit Traveler Information
APTS09	Transit Signal Priority	PT09	Transit Signal Priority
APTS10	Transit Passenger Counting	PT07	Transit Passenger Counting
APTS11	Multimodal Connection Protection	PT17	Transit Connection Protection

Introduction − ITS Use Cases Services and Applications

CONNECTED VEHICLE APPLICATIONS

V2I Safety

- Red Light Violation Warning
- Curve Speed Warning
- Stop Sign Gap Assist
- Spot Weather Impact Warning
- Reduced Speed/Work Zone Warning
- Pedestrian in Signalized Crosswalk Warning (Transit)

V2V Safety

- Emergency Electronic Brake Lights (EEBL)
- Forward Collision Warning (FCW)
- Intersection Movement Assist (IMA)
- Left Turn Assist (LTA)
- Blind Spot/Lane Change Warning (BSW/LCW)
- Do Not Pass Warning (DNPW)
- Vehicle Turning Right in Front of Bus Warning (Transit)

Agency Data

- Probe-based Pavement Maintenance
- Probe-enabled Traffic Monitoring
- Vehicle Classification-based Traffic Studies
- CV-enabled Turning Movement & Intersection Analysis
- CV-enabled Origin-Destination Studies
- Work Zone Traveler Information

Environment

- Eco-Approach and Departure at Signalized Intersections
- Eco-Traffic Signal Timing
- Eco-Traffic Signal Priority
- Connected Eco-Driving
- Wireless Inductive/Resonance Charging
- Eco-Lanes Management
- Eco-Speed Harmonization
- Eco-Cooperative Adaptive Cruise Control
- Eco-Traveler Information
- Eco-Ramp Metering
- Low Emissions Zone Management
- AFV Charging / Fueling Information
- Eco-Smart Parking
- Dynamic Eco-Routing (light vehicle, transit, freight)
- Eco-ICM Decision Support System

Road Weather

- Motorist Advisories and Warnings (MAW)
- Enhanced MDSS
- Vehicle Data Translator (VDT)
- Weather Response Traffic Information (WxTINFO)

Mobility

- Advanced Traveler Information System
- Intelligent Traffic Signal System (I-SIG)
- Signal Priority (transit, freight)
- Mobile Accessible Pedestrian Signal System (PED-SIG)
- Emergency Vehicle Preemption (PREEMPT)
- Dynamic Speed Harmonization (SPD-HARM)
- Queue Warning (Q-WARN)
- Cooperative Adaptive Cruise Control (CACC)
- Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
- Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)
- Emergency Communications and Evacuation (EVAC)
- Connection Protection (T-CONNECT)
- Dynamic Transit Operations (T-DISP)
- Dynamic Ridesharing (D-RIDE)
- Freight-Specific Dynamic Travel Planning and Performance
- Drayage Optimization

Smart Roadside

- Wireless Inspection
- Smart Truck Parking

Connected Vehicle Pilot Deployment Program, V. Fessmann, US DOT ITS JPO
https://www.its.dot.gov/pilots/pdf/CV_PilotWebinar5_Devices_QPL.pdf

US DOT ITS JPO – Connected Vehicle Pilot Deployment Program

https://www.its.dot.gov/pilots/

Tampa-Hillsborough Expressway Authority (THEA) Pilot

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

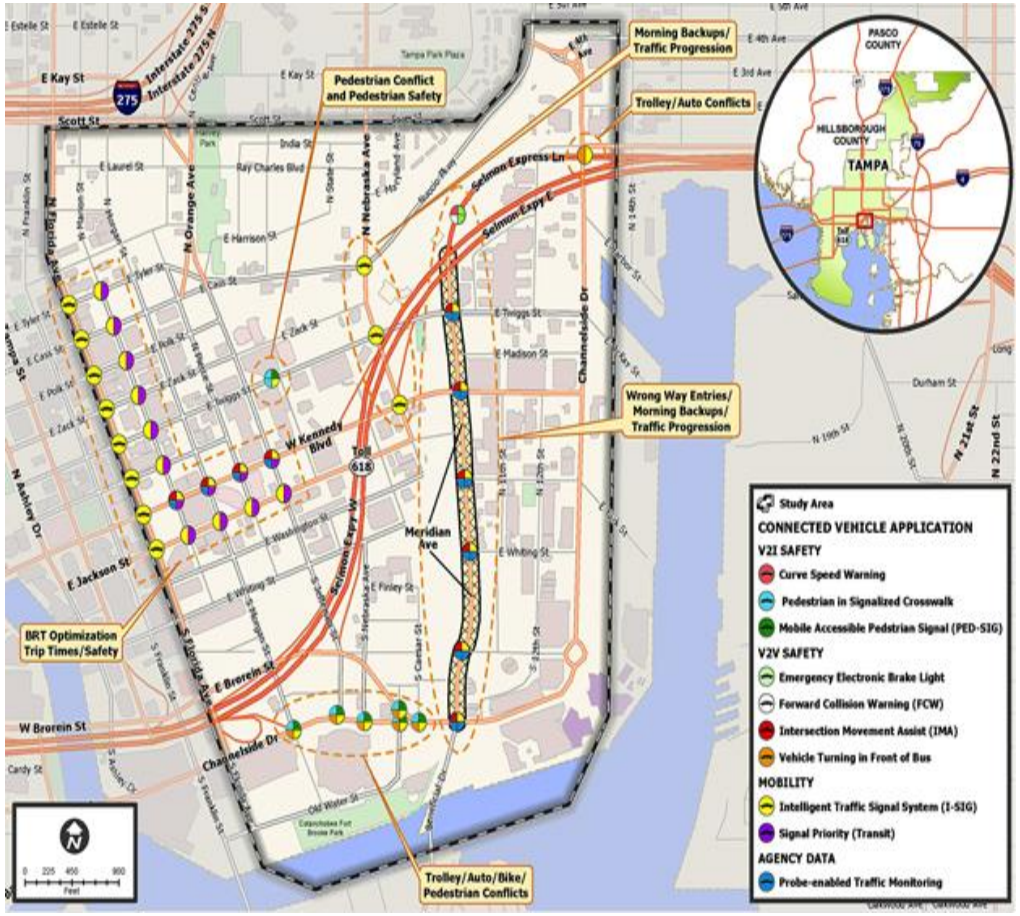


Table 1. Tampa (THEA) Pilot Site Proposed CV Applications

ID	Category	Tampa (THEA) – CV Application
1	V2I Safety	End of Ramp Deceleration Warning (ERDW)
2		Pedestrian in Signalized Crosswalk Warning (PED-X)
3		Wrong Way Entry (WWE)
4	V2V Safety	Emergency Electronic Brake Lights (EEBL)
5		Forward Collision Warning (FCW)
6		Intersection Movement Assist (IMA)
7		Vehicle Turning Right in Front of a Transit Vehicle (VTRFTV)
8	Mobility	Mobile Accessible Pedestrian Signal System (PED-SIG)
9		Intelligent Traffic Signal System (I-SIG)
10		Transit Signal Priority (TSP)
11	Agency Data	Probe-enabled Data Monitoring (PeDM)

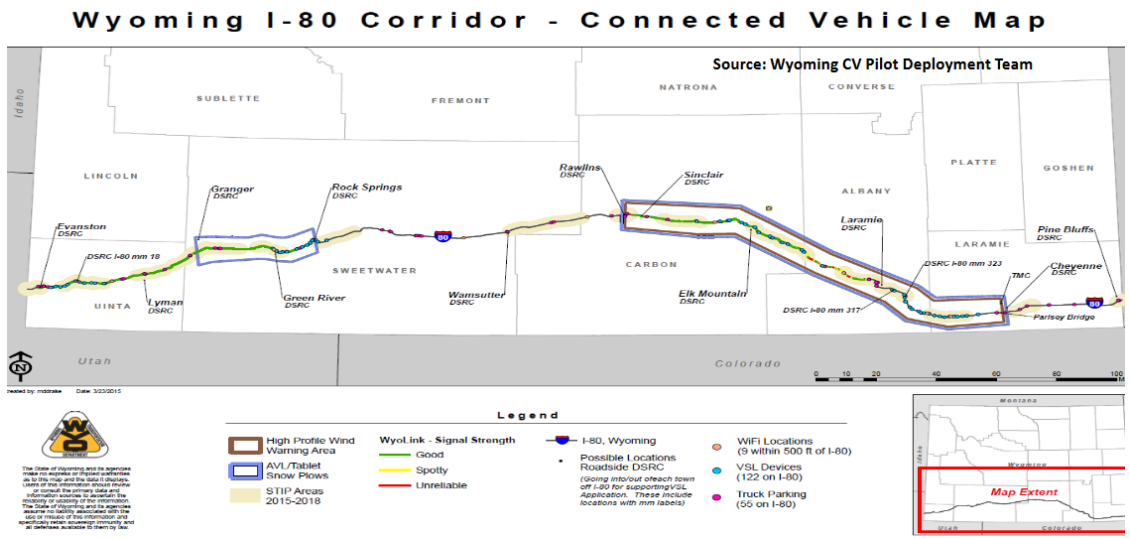
Table 2. Tampa (THEA) Pilot Site Proposed CV Devices

Tampa (THEA) – Devices	Estimated Number
Roadside Unit (RSU) at Intersection	40
Vehicle Equipped with On-Board Unit (OBU)	1,600
Pedestrian Equipped with App in Smartphone	500
HART Transit Bus Equipped with OBU	10
TECO Line Street Car Equipped with OBU	10
Total Equipped Vehicles	1,620

Tampa-Hillsborough Expressway Authority (THEA) owns and operates the Selmon Reversible Express Lanes (REL), which is a first-of-its-kind facility to address urban congestion. The REL morning commute endpoint intersection is on major routes into and out of the downtown Tampa commercial business district. Drivers experience significant delay during the morning peak hour resulting in, and often caused by, a correspondingly large number of rear-end crashes and red light running collisions. Because the lanes are reversible, wrong way entry is possible.The THEA CV Pilot will employ Dedicated Short Range Communication (DSRC) to enable transmissions among approximately 1,600 cars, 10 buses, 10 trolleys, 500 pedestrians with smartphone applications, and approximately 40 roadside units.

Wyoming (WY) DOT Connected Car Pilot

https://wydotcvp.wyoroad.info/



Wyoming is an important freight corridor that plays a critical role in the movement of goods across the country and between the United States, Canada, and Mexico. As shown in the figure below, Interstate 80 (I-80) in southern Wyoming which is above 6000 feet is a major corridor for east/west freight movement and moves more than 32 million tons of freight per year. During winter seasons when wind speeds and wind gusts exceed 30 mph and 65 mph respectively, crash rates on I-80 have been found to be 3 to 5 times as high as summer crash rates. This resulted in 200 truck blowovers within 4 years and often led to road closures.

Table 1. WYDOT Pilot Site Proposed CV Applications

ID	Category	ICF/WYDOT – CV Application
1	V2V Safety	Forward Collision Warning (FCW)
2	V2I/I2V Safety	I2V Situational Awareness*
3		Work Zone Warnings (WZW)*
4		Spot Weather Impact Warning (SWIW)*
5	V2I and V2V Safety	Distress Notification (DN)

Table 2. WYDOT Pilot Site Proposed CV Devices

ICF/WYDOT – Devices	Estimated Number
Roadside Unit (RSU)	75
WYDOT Fleet Subsystem On-Board Unit (OBU)	100
Integrated Commercial Truck Subsystem OBU	150
Retrofit Vehicle Subsystem OBU	25
Basic Vehicle Subsystem OBU	125
Total Equipped Vehicles	400

WYDOT will develop systems that support the use of CV Technology along the 402 miles of I-80 in Wyoming. As listed in Table 2, approximately 75 roadside units (RSUs) that can receive and broadcast message using Dedicated Short Range Communication (DSRC) will be deployed along various sections of I-80. WYDOT will equip around 400 vehicles, a combination of fleet vehicles and commercial trucks with on-board units (OBUs). Of the 400 vehicles, at least 150 would be heavy trucks that are expected to be regular users of I-80. In addition, of the 400 equipped-vehicles, 100 WYDOT fleet vehicles, snowplows and highway patrol vehicles, will be equipped with OBUs and mobile weather sensors. units along city streets

New York City (NYC) Connected Car Pilot - http://www.cvp.nyc/

The NYCDOT leads the New York City Pilot, which aims to improve the safety of travelers and pedestrians in the city through the deployment of V2V and V2I connected vehicle technologies. This objective directly aligns with the city's Vision Zero initiative. In 2014, NYC began its *Vision Zero* program to reduce the number of fatalities and injuries resulting from traffic crashes.

ID	Category	NYCDOT – CV Application
1	V2I/I2V Safety	Speed Compliance
2		Curve Speed Compliance
3		Speed Compliance/Work Zone
4		Red Light Violation Warning
5		Oversize Vehicle Compliance
6		Emergency Communications and Evacuation Information
7	V2V Safety	Forward Crash Warning (FCW)
8		Emergency Electronics Brake Lights (EEBL)
9		Blind Spot Warning (BSW)
10		Lane Change Warning/Assist (LCA)
11		Intersection Movement Assist (IMA)
12		Vehicle Turning Right in Front of Bus Warning
13	V2I/I2V Pedestrian	Pedestrian in Signalized Crosswalk
14		Mobile Accessible Pedestrian Signal System (PED-SIG)
15	Mobility	Intelligent Traffic Signal System (I-SIGCVDATA)

NYCDOT – Devices	Estimated Number
Roadside Unit (RSU) at Manhattan and Brooklyn Intersections and FDR Drive	353
Taxi Equipped with Aftermarket Safety Device (ASD)*	5,850
MTA Fleet Equipped with ASD*	1,250
UPS Truck Equipped with ASD*	400
NYCDOT Fleet Equipped with ASD*	250
DSNY Fleet Equipped with ASD*	250
Vulnerable Road User (Pedestrians/Bicyclists) Device	100
PED Detection System	10 + 1 spare
Total Equipped Vehicles	8,000

The NYCDOT CV Pilot Deployment project area encompasses three distinct areas in the boroughs of Manhattan and Brooklyn (see the figure below). The first area includes a 4-mile segment of Franklin D. Roosevelt (FDR) Drive in the Upper East Side and East Harlem neighborhoods of Manhattan. The second area includes four one-way corridors in Manhattan. The third area covers a 1.6-mile segment of Flatbush Avenue in Brooklyn. As shown in Table 2, approximately 5,800 cabs, 1,250 MTA buses, 400 commercial fleet delivery trucks, and 500 City vehicles will be fit with CV technology. The deployment will include approximately 310 signalized intersections for vehicle-to-infrastructure (V2I) technology using DSRC technology.

New York City (NYC) Connected Car Pilot - http://www.cvp.nyc/

Applications by Connected Vehicle Test Bed

ICF/Wyoming
Work Zone Warnings
Spot Weather Impact Warning
Situational Awareness
Freight-Specific Dynamic Travel Planning
Automatic Alerts for Emergency Responders
CV-enabled Weather-Responsive Variable Speed Limits
Road Weather Advisories for Trucks and Vehicles
Truck Parking Availability for Freight Carriers

Tampa (THEA)
Curve Speed Warning
Pedestrian in Signalized Crosswalk Warning (Transit)
Emergency Electronic Brake Lights (EEBL)
Forward Collision Warning (FCW)
Intersection Movement Assist (IMA)
Vehicle Turning Right in Front of Bus Warning (Transit)
Intelligent Traffic Signal System (I-SIG)
Mobile Accessible Pedestrian Signal System (PED-SIG)
Transit Signal Priority (TSP)
Probe-enabled Traffic Monitoring

New York City (NYC)
Curve Speed Warning
Pedestrian in Signalized Crosswalk Warning (Transit)
Red Light Violation Warning
Reduced Speed/Work Zone Warning
Blind Spot Warning (BSW) *
Emergency Electronic Brake Lights (EEBL) *
Forward Crash Warning *
Intersection Movement Assist (IMA) *
Lane Change Assist (LCA) *
Stationary Vehicle Ahead (SVA) *
Vehicle Turning Right in Front of Bus Warning (Transit)
Advanced Traveler Information System
Emergency Communications and Evacuation (EVAC)
Freight-Specific Dynamic Travel Planning and Performance Measurement (F-ATIS)
Intelligent Traffic Signal System (I-SIG)
Mobile Accessible Pedestrian Signal System (PED-SIG)
Eco-Speed Harmonization

- **Deployment of applications is dependent upon Final ConOps and funding*

Federal Highway Administration Awards Nearly $54 Million in AdvancedTransportation and Congestion Management Technologies Grants – Oct 2017 (1 of 2)

State	Project Name	Recipient/Project Description
AZ	Loop 101 Mobility Project	**Arizona DOT.** The funding will be used to improve safety and existing arterial capacity in the Loop 101 corridor by deploying technology and systems to support ICM, public transportation, SMARTDriveSM and other connected traffic management and other real-time information technologies.
CA	Global Opportunities at the Port of Oakland Freight Intelligent Transportation System	**Alameda County Transportation Commission.** The GoPort Freight ITS project will deploy the nation's first integration of Freight Community System and advanced ITS technology that will include a new port-specific TMC, traffic sensors, advanced traveler information, traffic messaging, trucking information for mobile apps, rail grade warning and terminal queue information.
FL	Connecting the East Orlando Communities	**Florida DOT.** The FDOT, MetroPlan Orlando and the University of Central Florida (UCF) will utilize the grant to advance numerous ITS technologies as part of PedSafe, GreenWay, SmartCommunity and SunStore.
ID	SMART Arterial Management	**Ada County Highway District.** The funding will be used to replace traffic signal controllers and detection systems at 82 intersections to implement new traffic signal performance measures.
MI	Improving Safety and Connectivity in Four Detroit Neighborhoods	**City of Detroit.** The funds will be used to increase mobility for residents in four target neighborhoods with high-traffic corridors.
OH	Connecting Cleveland Project	**Greater Cleveland Regional Transit Authority.** The CCP will improve communications infrastructure, enhance rider and passenger safety and reduce rider travel time. It will also enhance the overall efficiency of the transportation system while contributing to community revitalization.

Federal Highway Administration Awards Nearly $54 Million in AdvancedTransportation and Congestion Management Technologies Grants – Oct 2017 (2 of 2)

State	Project Name	Recipient/Project Description
SC	Greenville Automated (A-Taxi) Shuttles	**County of Greenville.** The deployment of an integrated system of Automated Taxi-Shuttles (A-Taxis) on public roads will be the first in the nation– improving access to transportation for disadvantaged and mobility impaired residents.
TX	The Texas Connected Freight Corridors Project	**Texas DOT.** The Texas Connected Freight Corridors project will deploy connected vehicle technologies in over 1,000 trucks and agency fleet vehicles that will be able to transmit data and receive warnings from 12 CV applications.
VA	Truck Reservation System and Automated Work Flow Data Model	**Virginia Port Authority.** The project involves the design, implementation and deployment of a second-generation truck reservation system that builds on the successes of the Port of NY/NJ reservation system for access to container terminals.
WA	Multimodal Integrated Corridor Mobility for All	**City of Seattle DOT.** The MICMA project will leverage and enhance Intelligent Transportation System (ITS) and Mobility-as-a-Service (MaaS) platforms to create a multimodal operations environment that responds to all users.

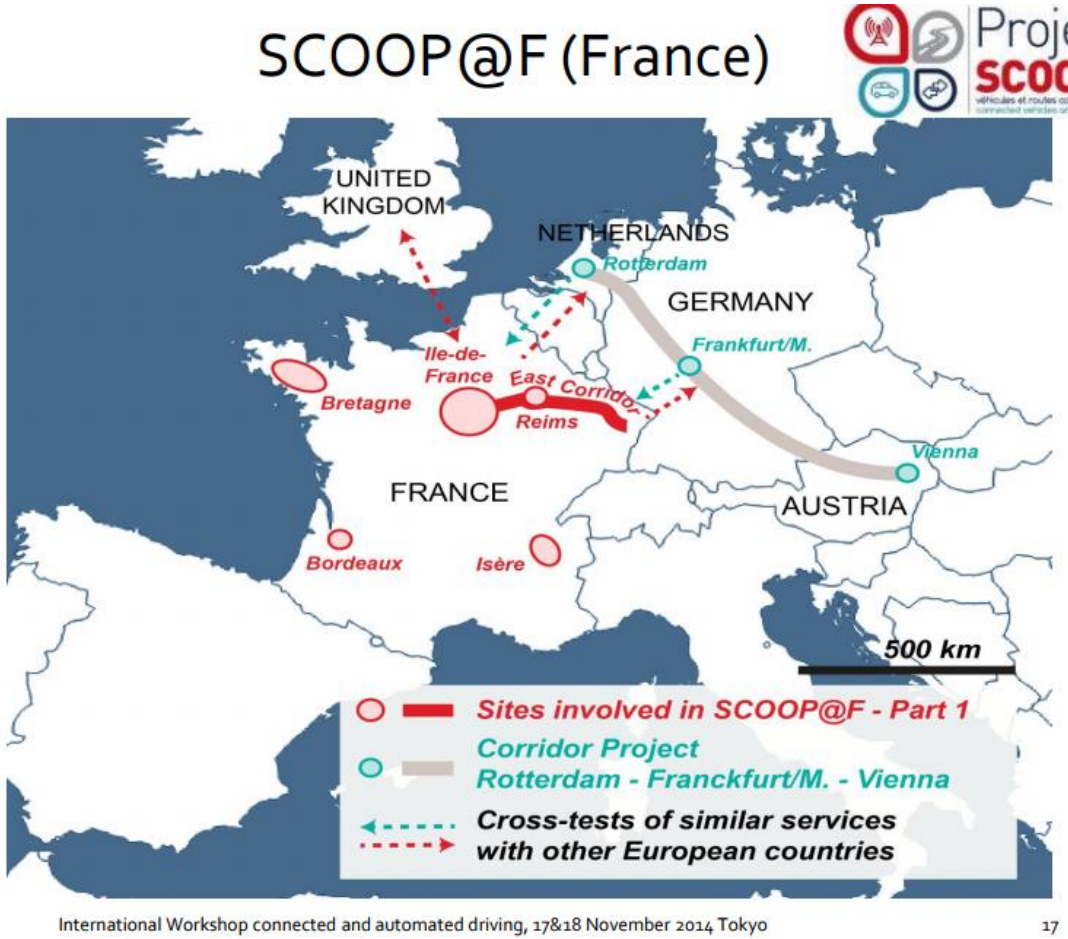
EU C-ITS Resources

EU Consortium Active ITS Road Projects (EU)

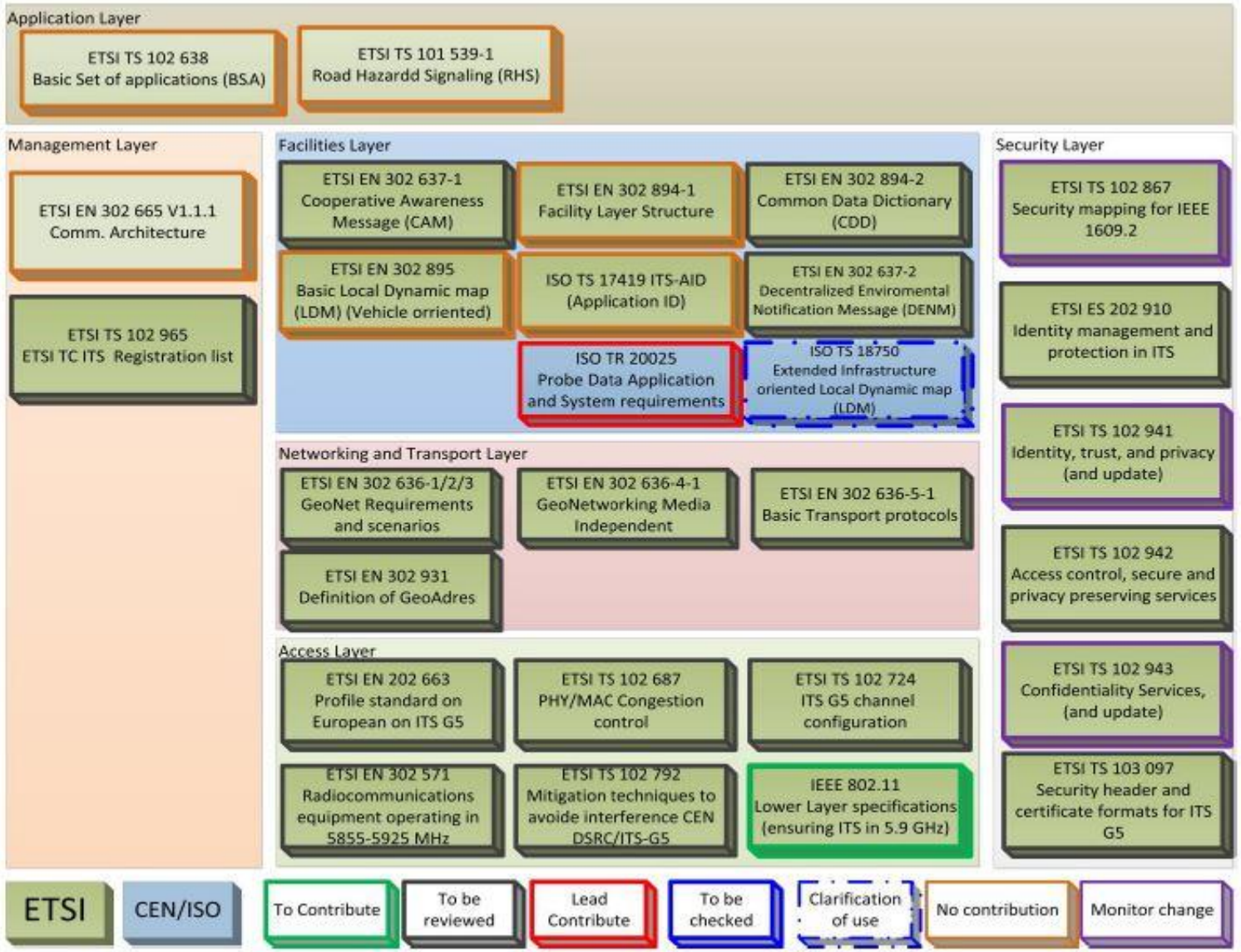
- C-ITS Cooperative, Connected and Automated Mobility
- EU Open In-Vehicle Platform
- EU ITS Road Corridor Initiatives - Amsterdam Group
- Connected Vehicles and Roads - Project Scoop@F
- Cooperative ITS Deployment Coordination Support
- Project Scoop@F- EU ITS Corridors
- C-ITS Applications – SCOOP@F

EU Consortium Foundation Projects (EU)

- Secure Vehicle Communication (SeVeCom)
- Car-To-Car Consortium (Car2Car)
- ITS-Europe(Ertico)
- EU C2C Pilot Program
- CVIS - Cooperative Vehicles Infrastructure Systems



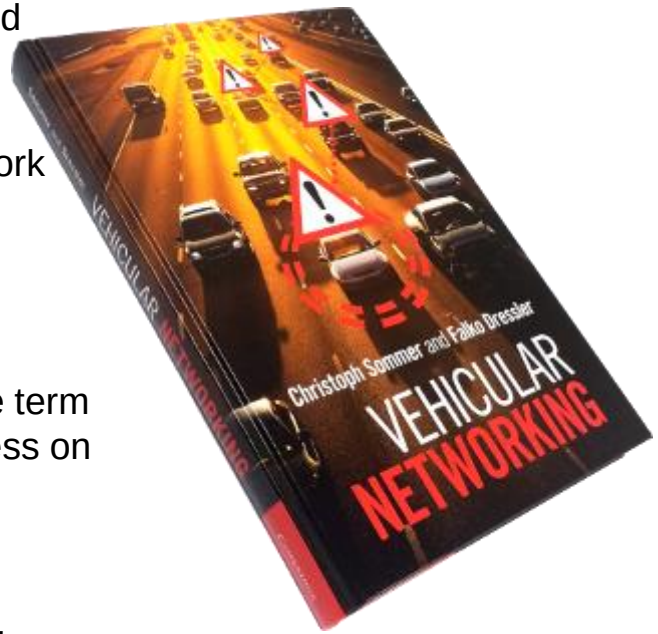
EU Cooperative Intelligent Transporation Systems – Standards 2014



[1] Standards for C-ITS (2014) – http://its-standards.info/Standards_for_C-ITS.pdf

Car-to-X (C2X) communication patterns

Vehicular networking is what we adopted as the most general classifier, referring to the field of computer communications and networking as applied to vehicles. Vehicular networking thus encompasses both in-car and inter-vehicle communication aspects as well as their fusion.



Inter-vehicle communication (IVC) restricts this to exclude wired communication as well as any network (wired or wireless) within vehicles. It thus refers to a system where vehicles are participants in a wireless network. Other participants such as roadside units (RSUs) can explicitly be part of this network.

Vehicular ad-hoc network (VANET) has its origins in the discipline of mobile ad-hoc networks (MANETs), casting VANETs as a novel application domain. Being the basis for what we call IVC today, the term is still somewhat synonymous with IVC, but focuses on spontaneously created ad-hoc networks, much less on pre-deployed infrastructure like using RSUs or cellular networks.

Intelligent transportation system (ITS) describes the overall goal of being able make better use of transportation networks, for which road networks are one of many such networks and IVC is one means among many. Lately, other modes of transportation have faded into the background and ITS has become synonymous with intelligent road networks.

Vehicle to vehicle (V2V) as well as vehicle to infrastructure (V2I) andvehicle to X (V2X) all refer to the end points of communication, indicating whether information is being exchanged with other vehicles, with infrastructure (also called vehicle-to-roadside), or with arbitrary nodes – independently of the technology being used. car for vehicle (forming C2C, C2I, and C2X) to refer to the same concepts.

Car-to-X (C2X) communication patterns and Use Cases

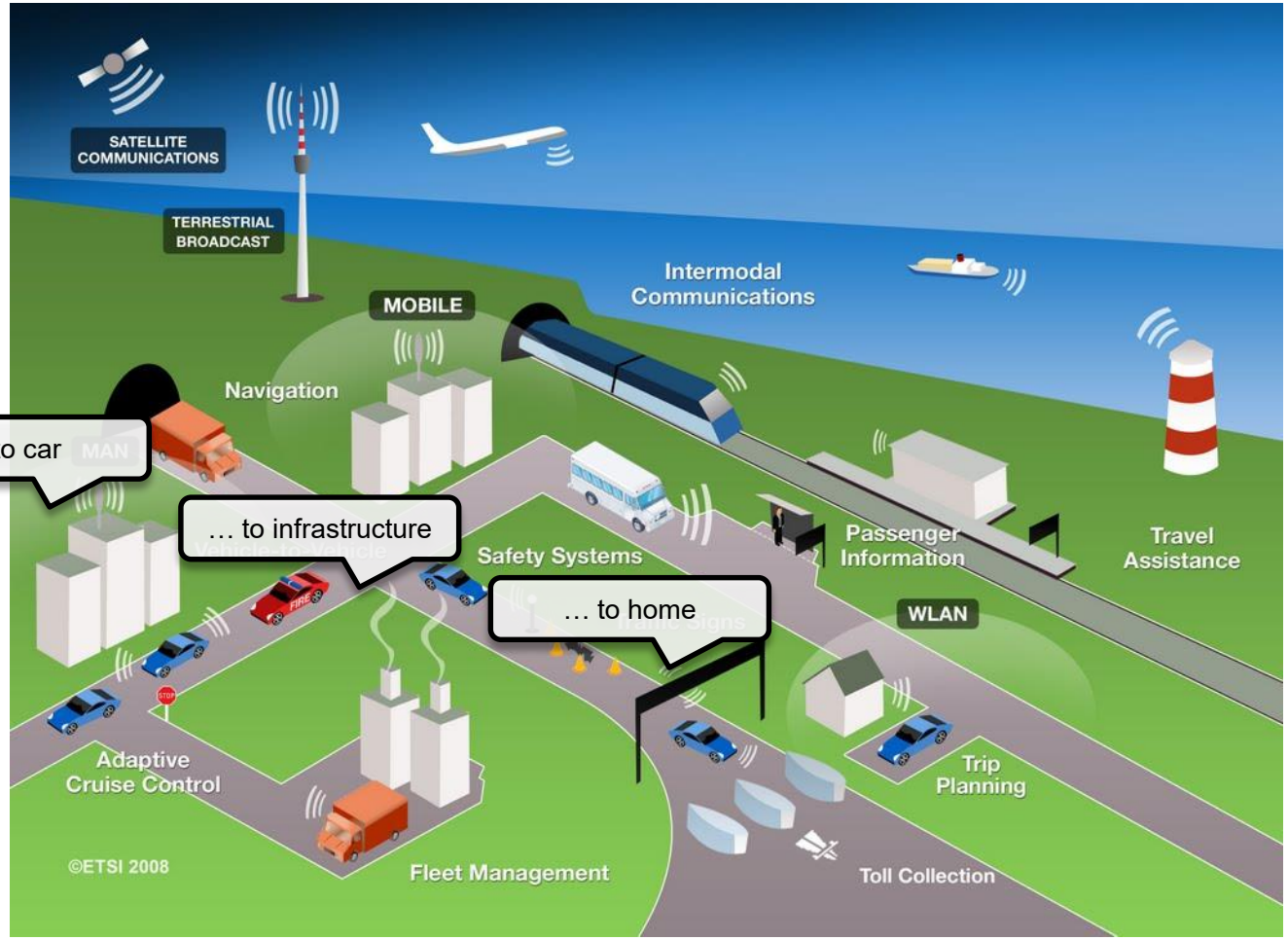
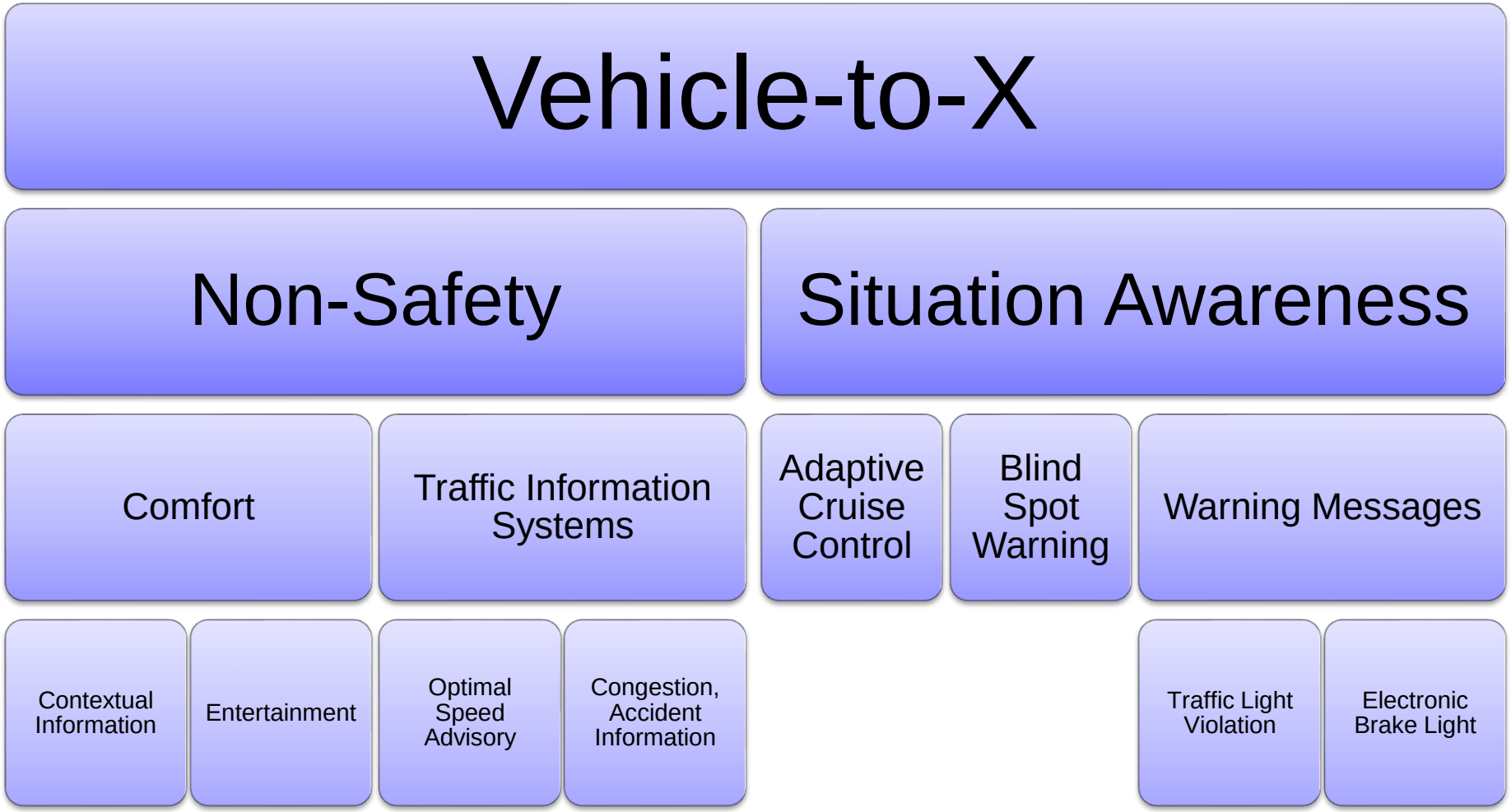


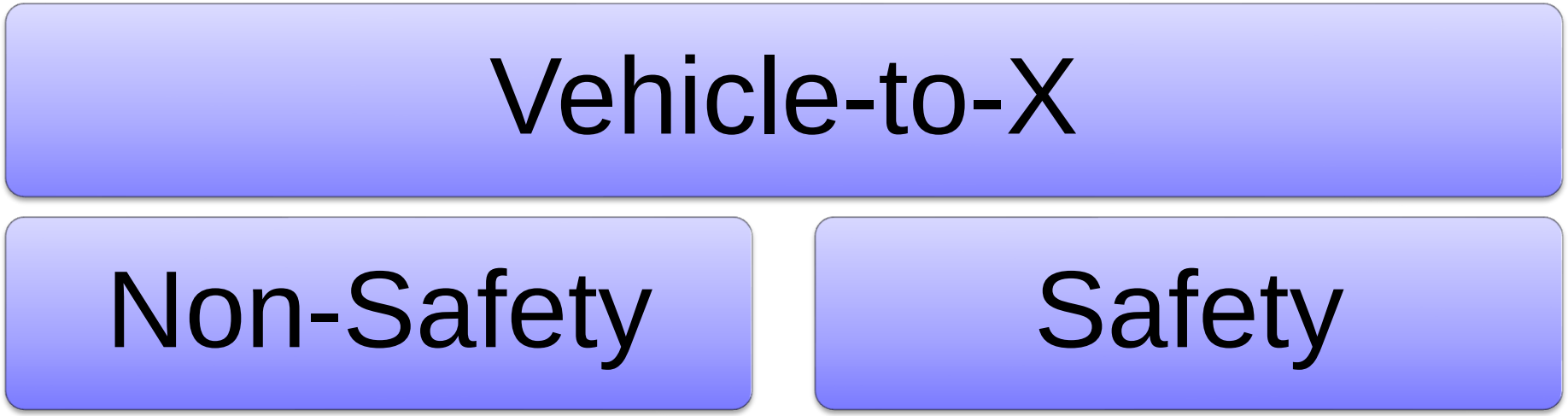
Illustration: ETSI

Taxonomy of Use Cases



1). F. Dressler, C. Sommer, Vehicular Networking

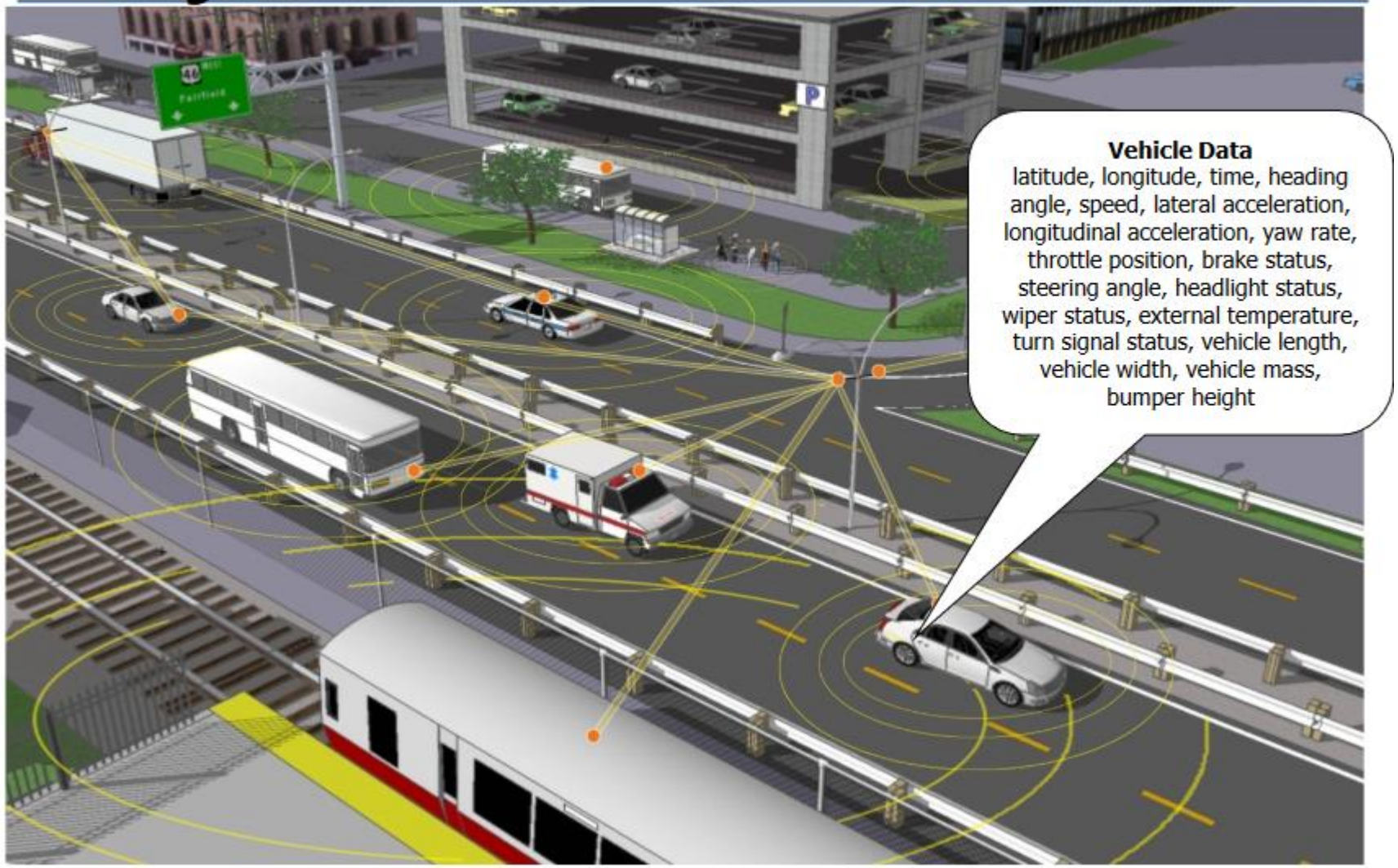
Taxonomy of Use Cases



1). F. Dressler, C. Sommer, Vehicular Networking

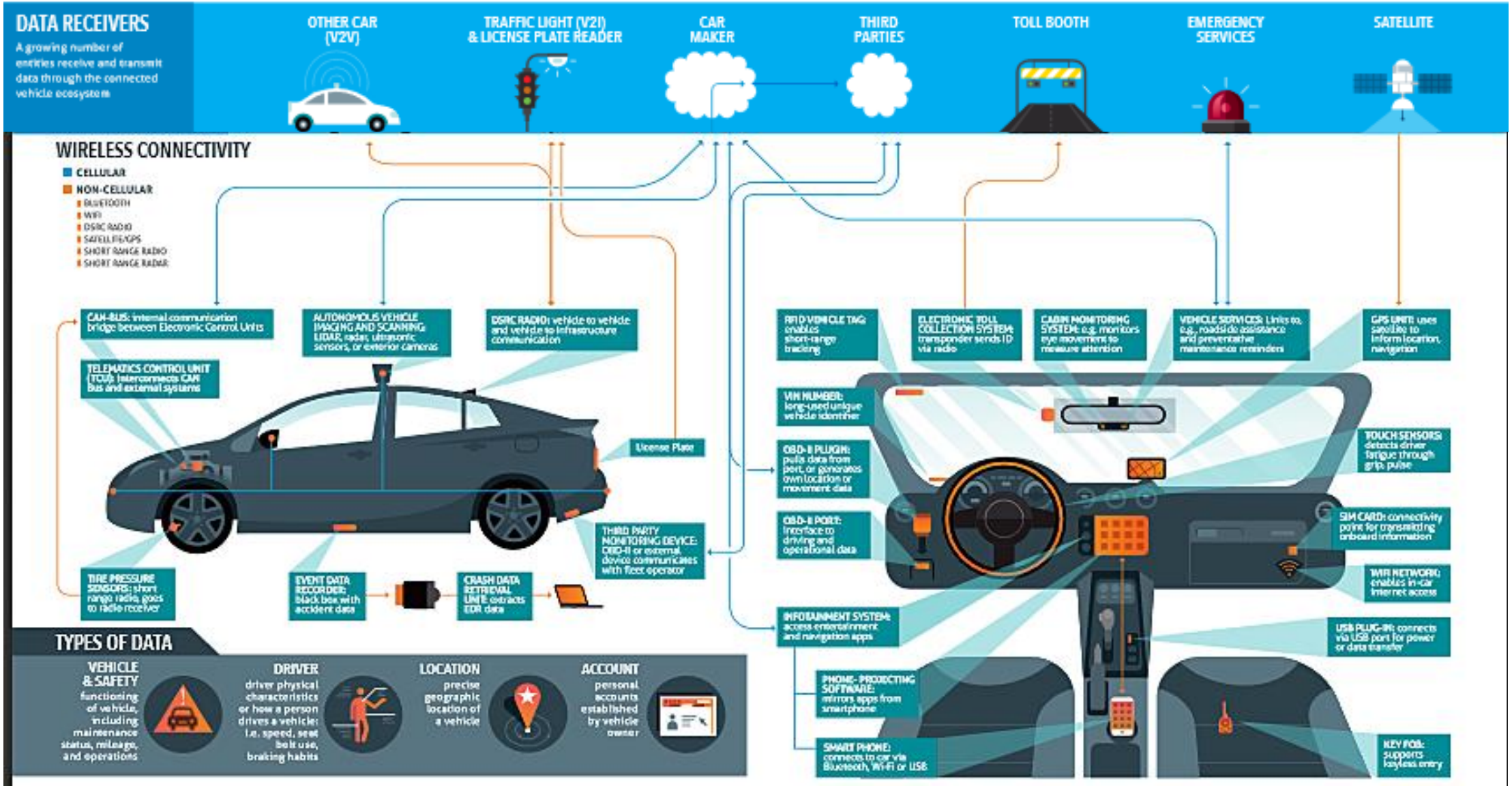
US DOT Model – Future of Transportation

Fully Connected Vehicle



Vehicle Based Data and Availability, B. Cronin, US DOT ITS JPO, 2012
https://www.its.dot.gov/itspac/october2012/PDF/data_availability.pdf

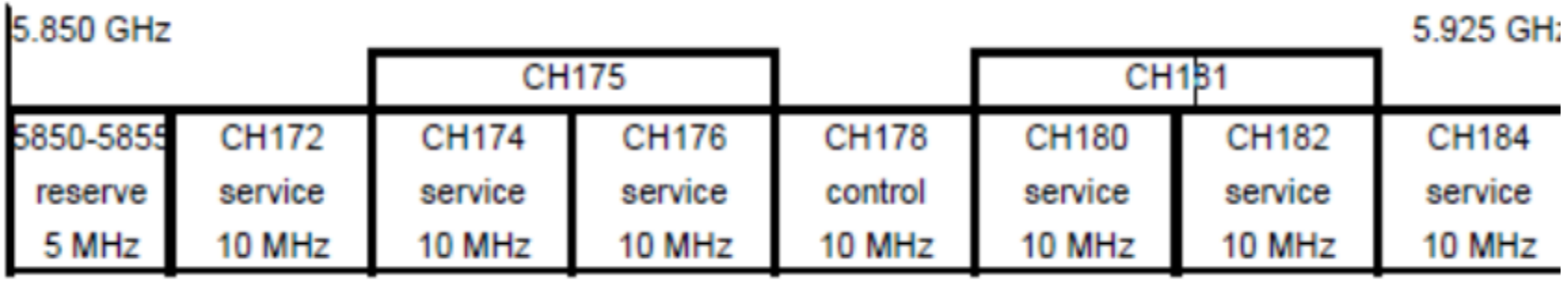
Future of Privacy Forum Infographics - Data and the Connected Car https://fpf.org



Today's connected technologies are making transportation safer and more convnient. Many new features are enabled by the collection and processing of data. Cars are becoming part of a trusted mobile ecosystem that ensures data flows between a network of carmakers, vendors and others to support individuals' safety, logistics, infotainment, and security needs. This visual represents devices that may be employed in today's connected cars; no single vehicle will have all of these features, but most new vehicles have some. Much connected car data is protected by technical controls, laws, self-regulatory commitments, privacy policies, and other emerging mechanisms or controls.

Basics of Dedicated Short Range Radio (DSRC)

https://www.its.dot.gov/presentations/world_congress2016/Leonard_DSRC_Spectrum2016.pdf



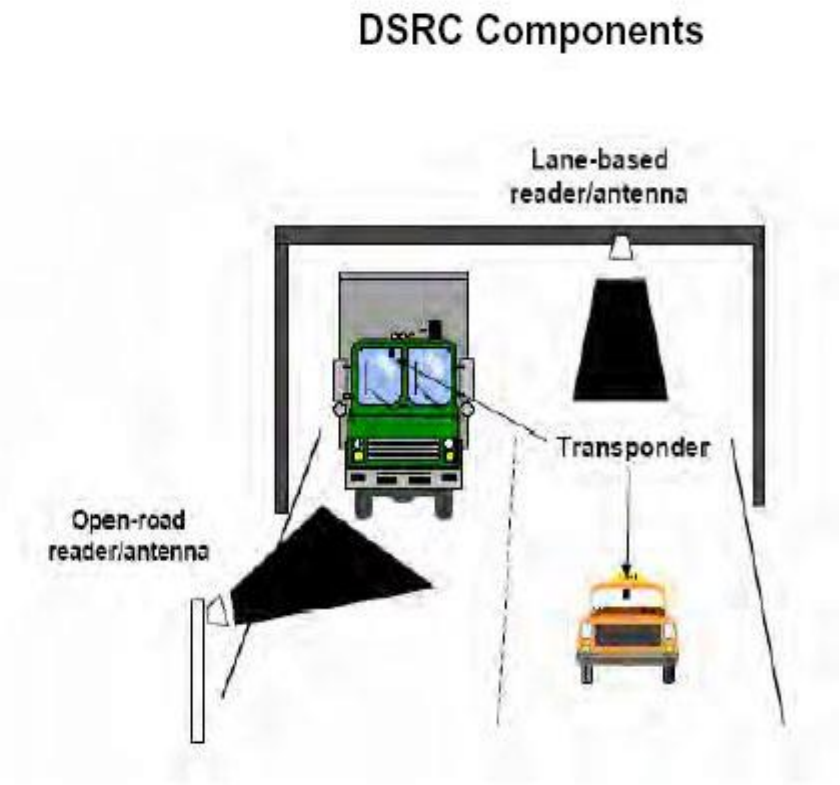
Source: FCC Report and Order FCC 03-324

- **Packet-based** medium based on **IEEE 802.11** specifications for lower-layer definition
- Additional **network** layer definitions and a **cryptographic** process for establishing trust and protecting confidentiality given in **IEEE 1609 family**
- **Payload** definitions and performance requirements for common data units established in **SAE standards**
- General **IP transport** available with certain **priority** requirements and packet **size** limitations

DSRC Use Case – Truck Platooning
https://www.youtube.com/watch?v=YBTL0GNwqKs

DSRC Operations Model

- Dedicated Short Range Communications (DSRC) technology has been chosen to support both Public Safety and Private operations
- DSRC fact sheet:
  - Based on IEEE 802.11p
  - Range up to 1000m
  - Data rates from 6-27 Mbps
  - 7 licensed channels in 5.9GHz
  - Low latency ~50ms
  - Security using public key infrastructure (PKI)
  - Long term stability (technology evolution is controlled by FCC and standards)
  - Postured for IPv6 at roll-out



IEEE Standards Association Publications (WAVE) –

https://standards.ieee.org/develop/wg/1609_WG.html

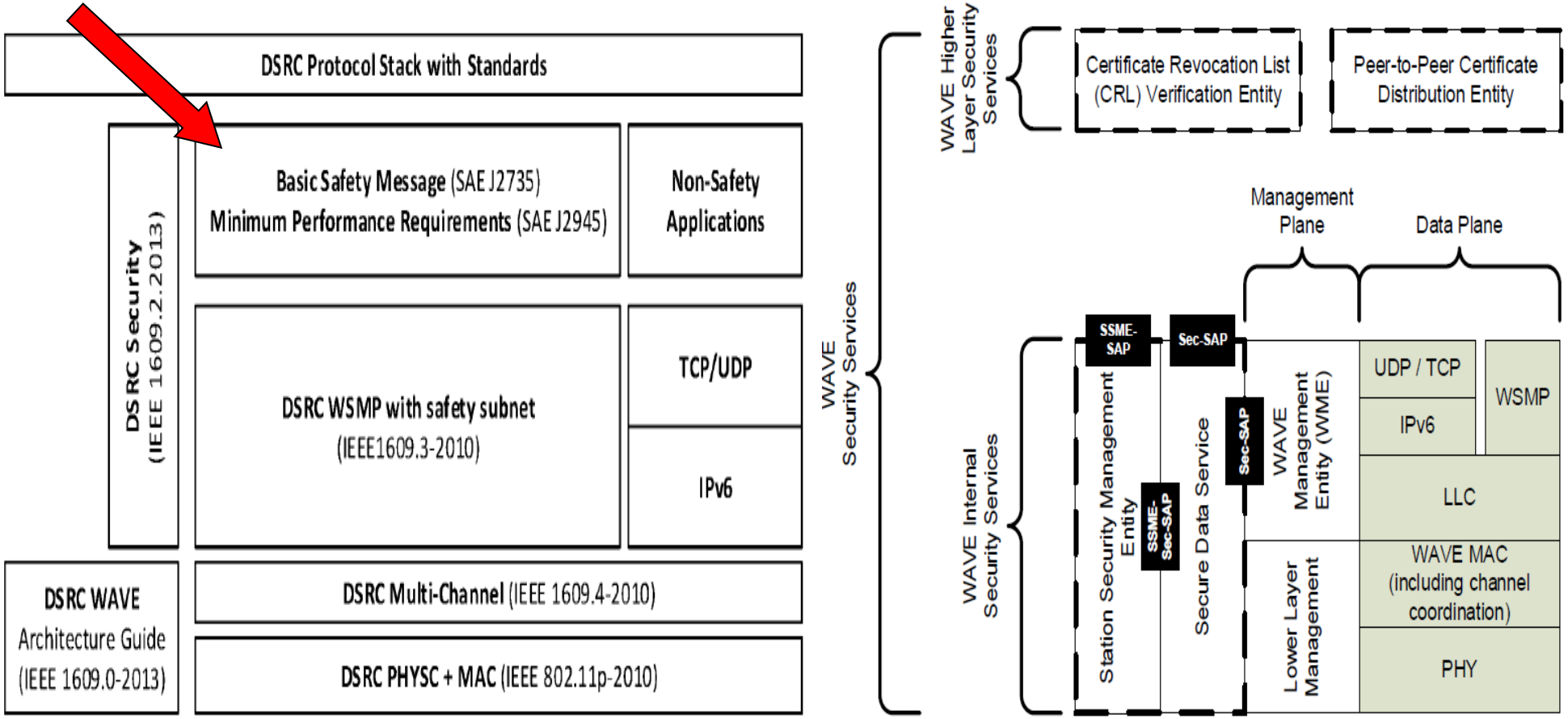
- IEEE P802.11p, Amendment to STANDARD FOR Information technology—Telecommunications and information exchange between systems—LAN/MAN Specific Requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Wireless Access in Vehicular Environments (WAVE).
- IEEE Std 1609.0-2013 – IEEE Trial-Use Standard for Wireless Access in Vehicular Environments (WAVE) - Architecture
- IEEE Std 1609.2-2016™, IEEE Standard for Wireless Access in Vehicular Environments (WAVE)—Security Services for Applications and Management Messages.
- IEEE Std 1609.3-2010™, IEEE Trial-Use Standard for Wireless Access in Vehicular Environments (WAVE)—Networking Services.
- IEEE Std 1609.4-2011™,, IEEE Trial-Use Standard for Wireless Access in Vehicular Environments (WAVE)—Multi-Channel Operation.
- IEEE Std 1609.11-2011™, IEEE Draft Standard for Wireless Access in Vehicular Environments (WAVE)—Over-the-Air Data Exchange Protocol for Intelligent Transportation Systems (ITS) - Electronic Payment Service
- IEEE Std 1609.12-2016™, IEEE Draft Standard for Wireless Access in Vehicular Environments (WAVE)—Identifier Allocation

Wireless Access in Vehicular Environments (WAVE) Services

WAVE system is a radio communications system intended to provide seamless, interoperable services to transportation. These services include those recognized by the U.S. National Intelligent Transportation Systems (ITS) Architecture a and many others contemplated by the automotive and transportation infrastructure industries. These services include vehicle-to-roadside communication, vehicle-to-vehicle communications, and potentially communication among other devices. Networking Services provides services to WAVE devices and systems. Layers 3 and 4 of the open system interconnect (OSI) model and the Internet Protocol (IP), User Datagram Protocol (UDP), and Transmission Control Protocol (TCP)elements of the Internet model are represented. Management and data services within WAVE devices are provided.

The term dedicated short range communications (DSRC) is sometimes used in the U. S. to refer to radio spectrum or technologies associated with WAVE. For example, U. S. Federal Communications Commission (FCC) documents allocate spectrum to “mobile service for use by DSRC systems operating in the Intelligent Transportation System (ITS) radio service,” and the Society of Automotive Engineers (SAE) has specified messages in SAE J2735 “for use by applications intended to utilize the 5.9 GHz dedicated short range communications for wireless access in vehicular environments.”

WAVE Protocol stack showing DSRC layers and details of WAVE Security Services



[1] IEEE Vehicular Technology Society, "**IEEE1609.0 (WAVE Architecture)**," IEEE Std

Basic Safety Messages (BSM)

Fundamentals

- Connected V2V safety applications are built around the SAE J2735 BSM, which has two parts
  - BSM Part 1:
    - Contains the core data elements (vehicle size, position, speed, heading acceleration, brake system status)
    - Transmitted approximately 10x per second
  - BSM Part 2:
    - Added to part 1 depending upon events (e.g., ABS activated)
    - Contains a variable set of data elements drawn from many optional data elements (availability by vehicle model varies)
    - Transmitted less frequently
  - No on-vehicle BSM storage of BSM data

Test Bed Data Systems

- Example: Safety Pilot (26 RSEs and <3000 vehicles):
  - SPaT Data (6 sites): 28,821,437 messages per day
  - MAP Data (6 sites): 2,510,384 messages per day
  - TIM (3 sites): 227,766 messages per day
  - BSM (26 sites): 16,740,785 messages per day
  - Total data per month: 18.4 TB

BSMs are one of the primary building blocks for V2V communications. They provide situational awareness information to individual vehicles regarding traffic and safety. BSMs are broadcast ten times per second by a vehicle to all neighboring vehicles and are designed to warn the drivers of those vehicles of crash imminent situations.

Basic Vehicle State

(Veh. ID, Seq. #, time, position, motion, control, veh. size)

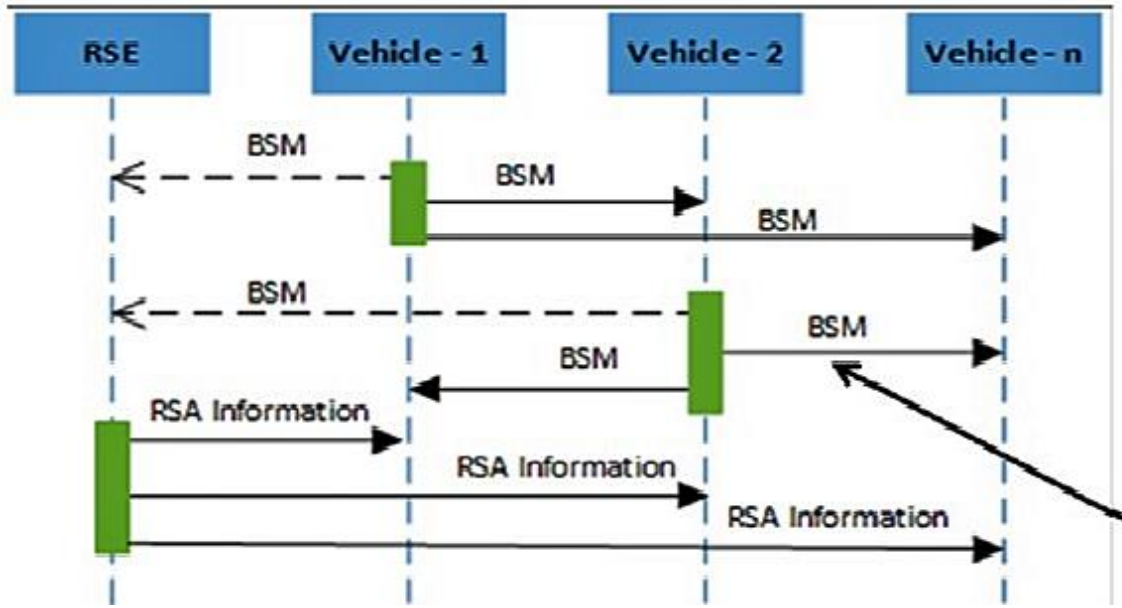
Part I is mandatory in the Basic Safety message

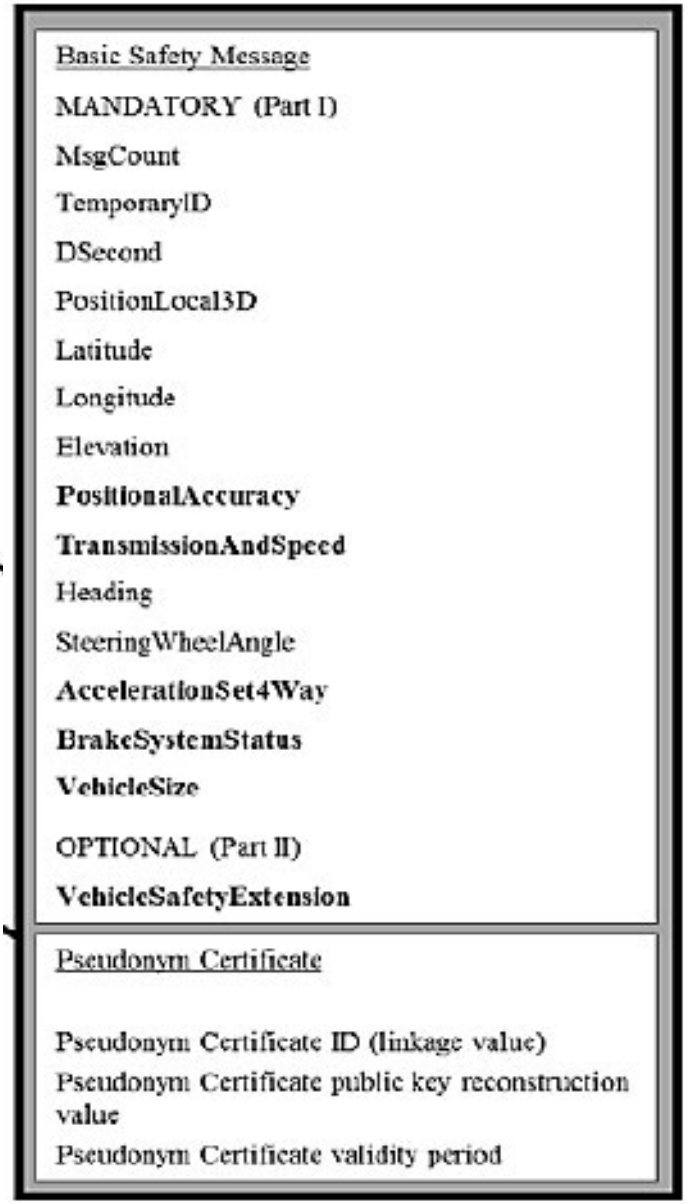
Vehicle Safety Extension

- **Event Flags**
- **Path History**
- **Path Prediction**
- **RTCM Corrections**

Required for V-V safety applications, but not in every message

Vehicle Broadcast of a Basic Safety Message





Basic connectivity options between vehicles and RSUs. BSMs are one of the primary building blocks for V2V communications. They provide situational awareness information to individual vehicles regarding traffic and safety items including imminent crash avoidance applications. These messages are broadcast to all OBE within range but may also be received by RSUs. BSMs originate only from vehicles. Messages that will be broadcast from an RSU to vehicle OBE in support of safety are not classified as BSM by SAE J2735 but include RSA, TIM, SPAT, MAP, EVA, or other message types; "RSA" is used on the figure to represent all safety messages originating from RSUs.

Using V2V communications for imminent crash avoidance applications requires frequent transmission of BSMs—nominally, 10 times per second. These messages contain unencrypted information regarding the device's position, speed, and further values as defined in SAE J2735. These messages are broadcast and can be received by all OBE and RSUs within range. Although the body of the messages is unencrypted, the sender signs each message and the receiver verifies whether the signature is valid, In order to verify the authenticity and integrity of the message. This requires an SCMS, which, in this case, is realized by a public key infrastructure to provide necessary signing credentials.

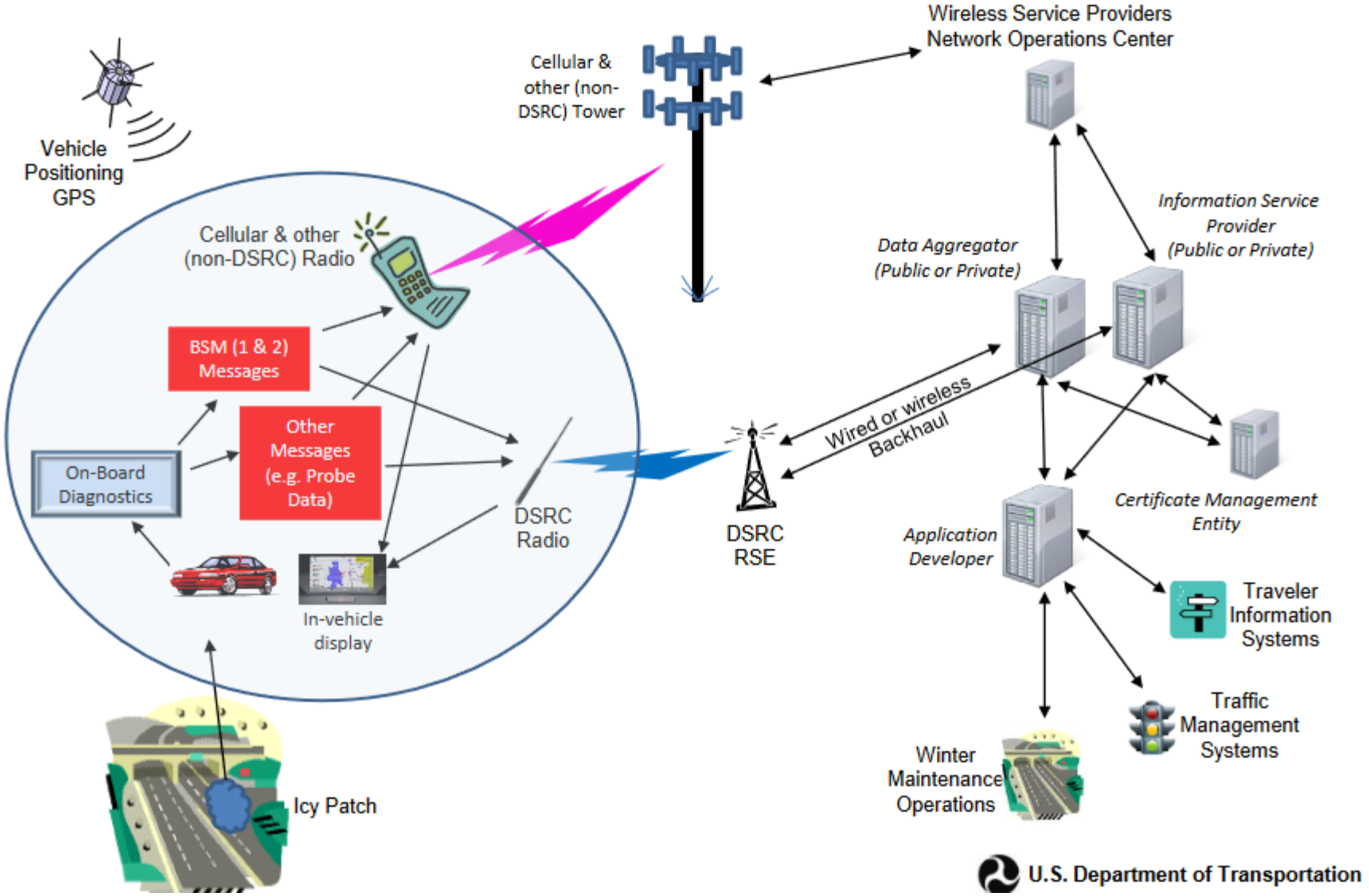
"Privacy Issues for Consideration by USDOT Based on Review of Preliminary Technical Framework," FHWA-JPO-15-236
https://www.regulations.gov/document?D=NHTSA-2016-0126-0003

SAE J2945/1 – On-board Minimum Performance Requirements for V2V Safety Systems - BSM Part 1 Data

- Time (UTC time)
- Message Count (random starting time)
- Temporary ID (randomized every 5 min)
- Position Data Elements (Latitude, Longitude, Elevation)
- Positional Accuracy (Semi Major Axis, Semi Minor Axis, Semi Major Axis Orientation)
- Transmission State
- Speed
- Heading
- Steering Wheel Angle
- Acceleration (Longitudinal, Lateral, Vertical, Yaw Rate)
- Brake System Status (for each wheel [traction, abs, scs, brakeBoost, and auxBrakes])
- Vehicle Size (Width, Length)

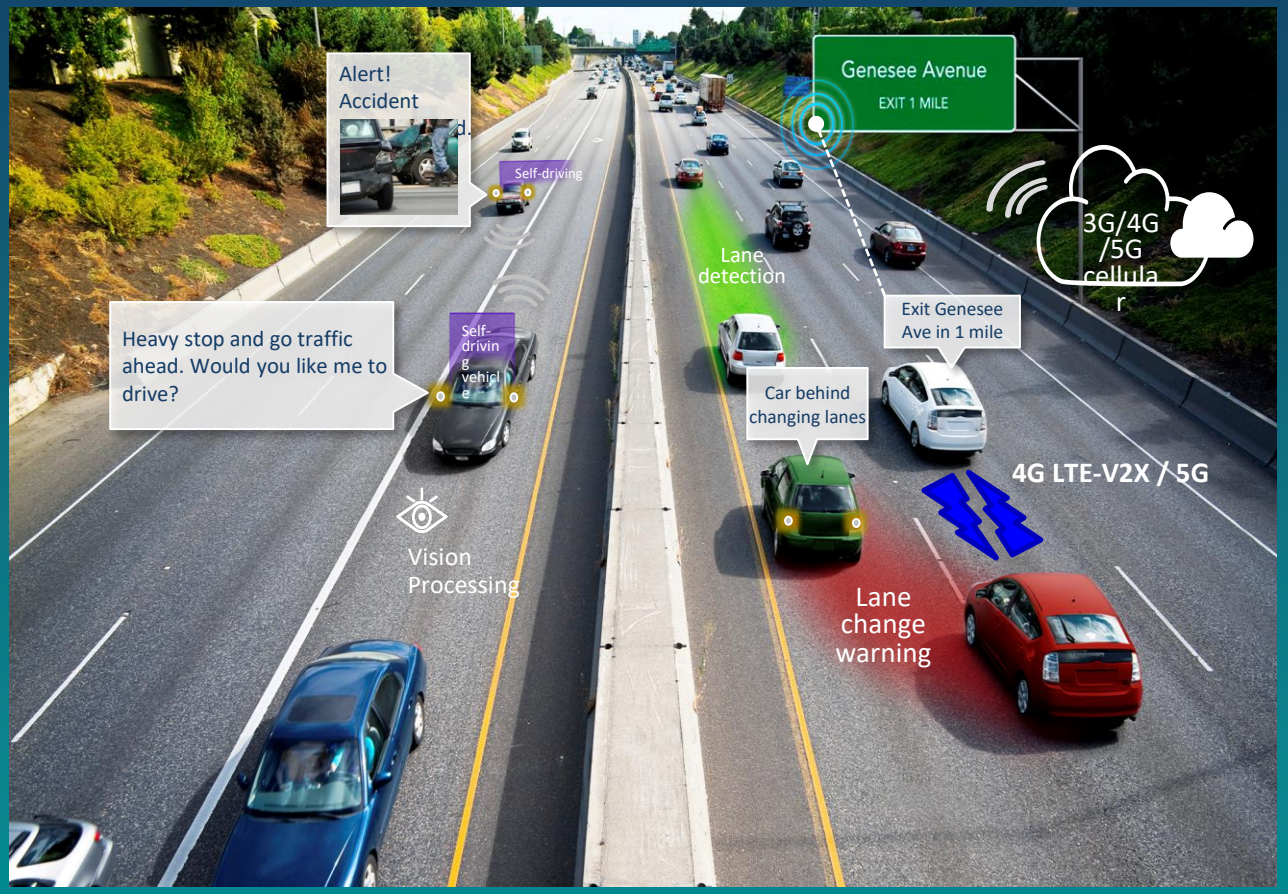
[1] J. Misener, SAE Connected Vehicle Standards, CES 2016, Jan 2016

Private Vehicles Receiving BSMs from DSRC and non-DSRC Sources



Vehicle Based Data and Availability, B. Cronin, US DOT ITS JPO, 2012
https://www.its.dot.gov/itspac/october2012/PDF/data_availability.pdf

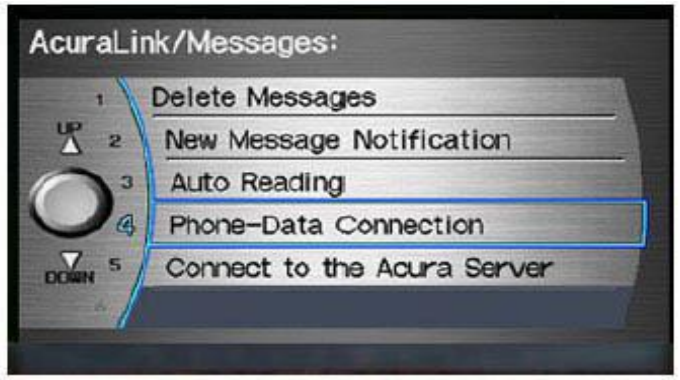
A New Era of Connected Car Capabilities



The variety of connected vehicle applications can be handled by a variety of over the air technologies, depending on application requirements

ITS Security and Privacy – Data You Can Trust

Privacy



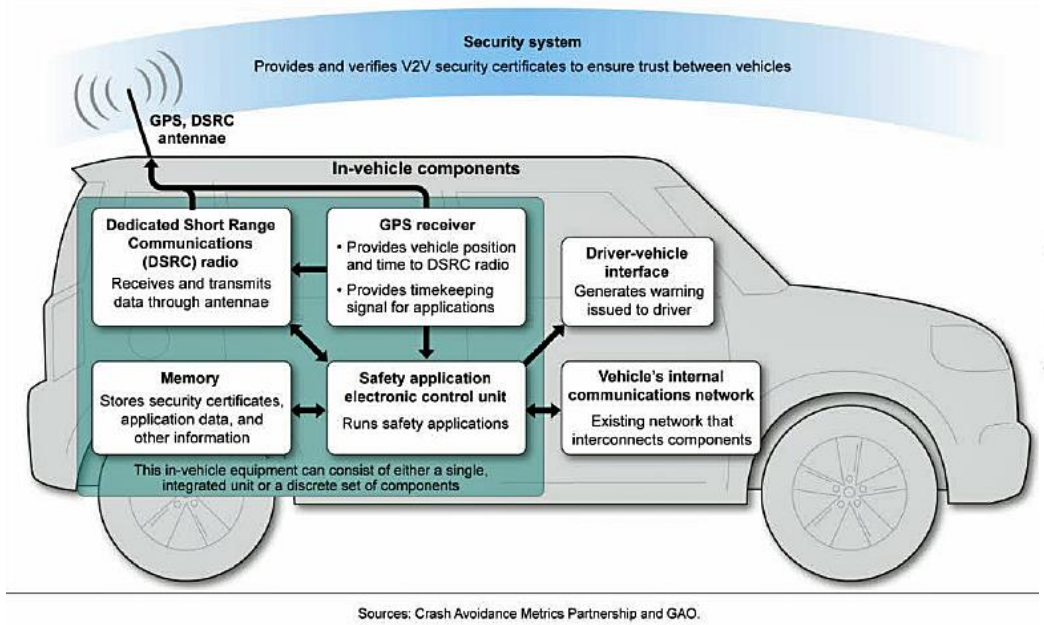
Confidentiality

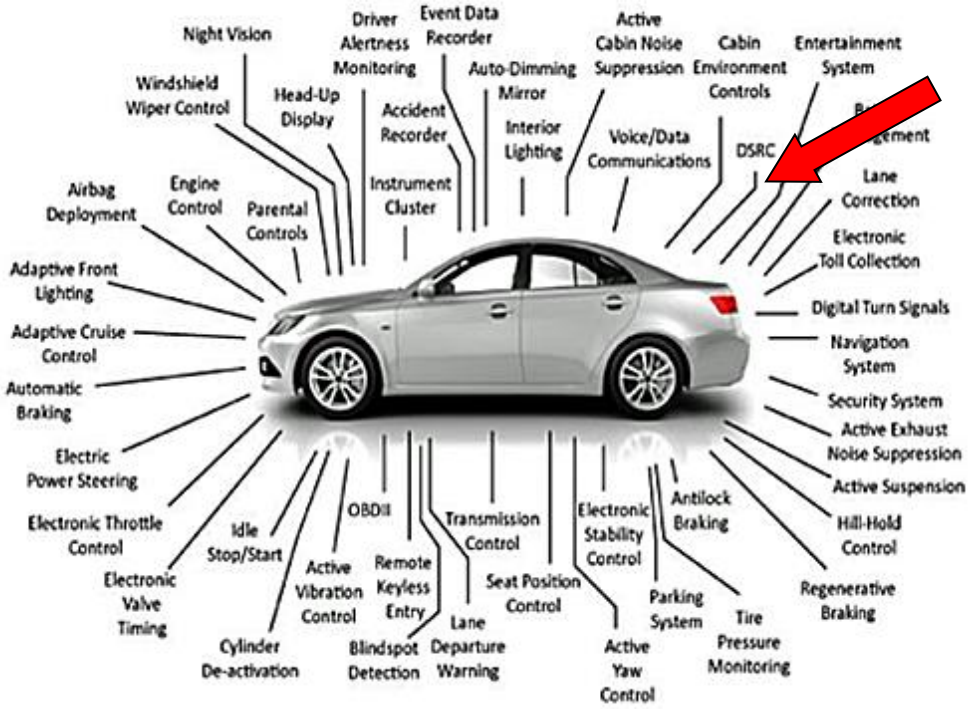
Availability

Integrity

Note – SCSM Design emphasizes ‘Authenticity’ (trust the sender) and ‘availability’ is not highlighted in the VPKI specification

Smart vehicle are *unsecure robots*





- Modern cars include:
  - more than 80 ECUs
  - many logically interacting subsystems

- …sensors, actuators, and their intelligent interconnection

**** A. Bicchi, L. Pallottino, et al, "Misbehavior Detection in Large Networks of Heterogeneous Vehicles", CAMP Workshop on Misbehavior Detection - https://stash.campllc.org/projects/SCMS/repos/mbd-workshop/browse/Day%202%20-%203%20-%20V2X%20Talk%20Fagiolini.pptx**

Representative VC projects, consortia, and working groups related to V-PKI

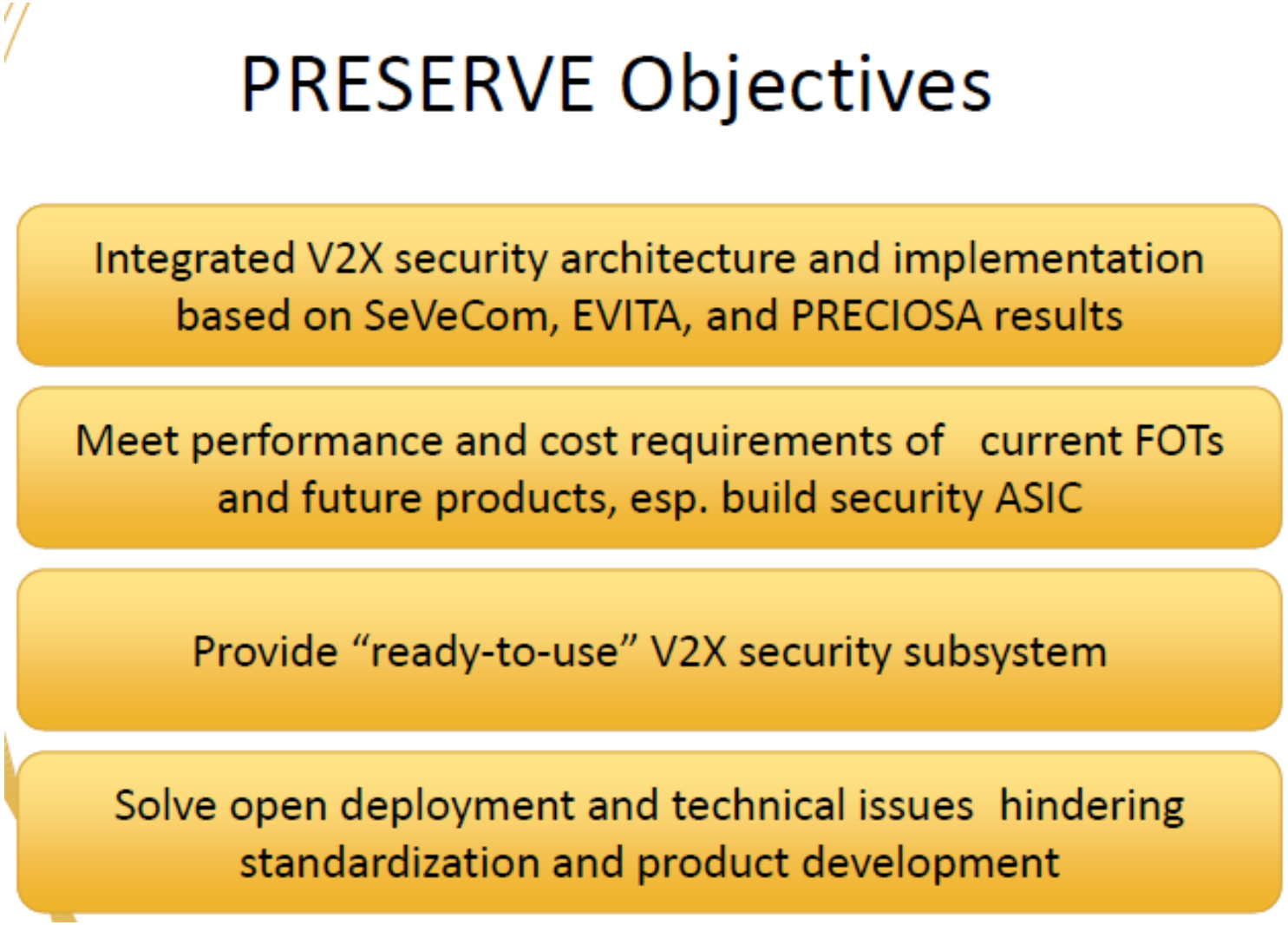
Project information			
Project name		**External funding**	
	Period		**Brief description of objectives**
Car to Car Communication Consortium (C2C-CC)	Ongoing	N/A	Development of a European industry standard for VC communication systems, active safety applications prototyping and demonstrations, harmonization of VC standards worldwide, realistic deployment strategies and business models; http://www.car-2-car.org/
ETSI TC ITS	Ongoing	N/A	Standardization activities to support the development and implementation of intelligent transportation systems; http://portal.etsi.org/Portal_Common/home.asp
EVITA	2008–2010	European Union	Secure and trustworthy intravehicular communication; architec-ture for automotive onboard networks to thwart tampering and protect sensitive data inside a vehicle; http://evita-project.org/
IEEE P1609	Ongoing	N/A	Standard for wireless access in vehicular environments (WAVE) — Resource manager, physical and medium access control, security services, networking services, multichannel operations for V2V and V2I communication; http://www.standards.its.dot.gov/fact_sheet.asp?f=80
SEVECOM	2006–2009	European Union	Security architecture for vehicular communication systems; identity management, security and privacy-enhancing mechanisms and protocols; in-car protection; data consistency; system per- formance evaluation; demonstration; http://www.sevecom.com
IntelliDrive (Previously VII consortium - VIIC)	2005–2008	Department of Transportation USA	Initiative of the ITS Joint Programs Office (JPO) at the DoT's Research and Innovative Technology Administration (RITA) VC technologies and applications, V2V, V2I, mobility, and policy research; http://www.intellidriveusa.org/
CAMP/VSC-2	2005–2009	Department of Transportation USA	Cooperative Intersection Collision Avoidance System — Violations (CICAS-V); Emergency Electronic Brake Lights (EEBL); Vehicle Safety Communications — Applications (VSC-A)
Preciosa	2008-2010	European Union	Privacy Enabled Capability In CO-operative systems and Safety Applications (PRECIOSA) is to demonstrated that co-operative systems can comply with future privacy regulations by demonstrating that an example application can be endowed with technologies for suitable privacy protection of location related data - http://www.transport-research.info/project/privacy-enabled capability-co-operative-systems-and-safety-applications
Oversee	2010-2012	European Union	Open Vehicular Secure Platform - e overall goal of OVERSEE is to contribute to the efficiency and safety of road transport by developing the OVERSEE platform, which will provide a secure, standardized and generic communication and application platform for vehicles - https://www.oversee-project.com/
Drive-C2X	2011-2014	European Union	The objective of the DRIVE C2X Integrated Project is to carry out comprehensive assessment of cooperative systems through Field Operational Tests in various places in Europe in order to verify their benefits and to pave the way for market implementation.
Preserve	2011-2015	European Union	The goal of PRESERVE (Preparing Secure Vehicle-to-X Communication Systems) is to bring secure and privacy protected V2X communication closer to reality by providing and field testing a security and privacy subsystem for V2X system - https://www.preserve-project.eu/
Connected Car Safety Pilot	2011-2014	Department of Transportation USA	The objective of the SPMD was to support the evaluation of dedicated short-r ange communication technology for V2V safety applications, which operate at 5.9 GHz in a real- world, concentrated environment. The main focus was to collect data to support (1) the functional evaluation of V2V safety applications, (2) the assessment of the operational aspects of messages that support vehicle to -infrastructure (V2I) safety applications and (3) comprehension of the operational and implementation characteristics of a prototype security operating concept

1). P Papadimitratos, et al , "Vehicular communication systems: Enabling Technologies, Applications, IEEE Communications Magazine, Nov 2009

Recent EU ITS Security and Privacy Related Projects

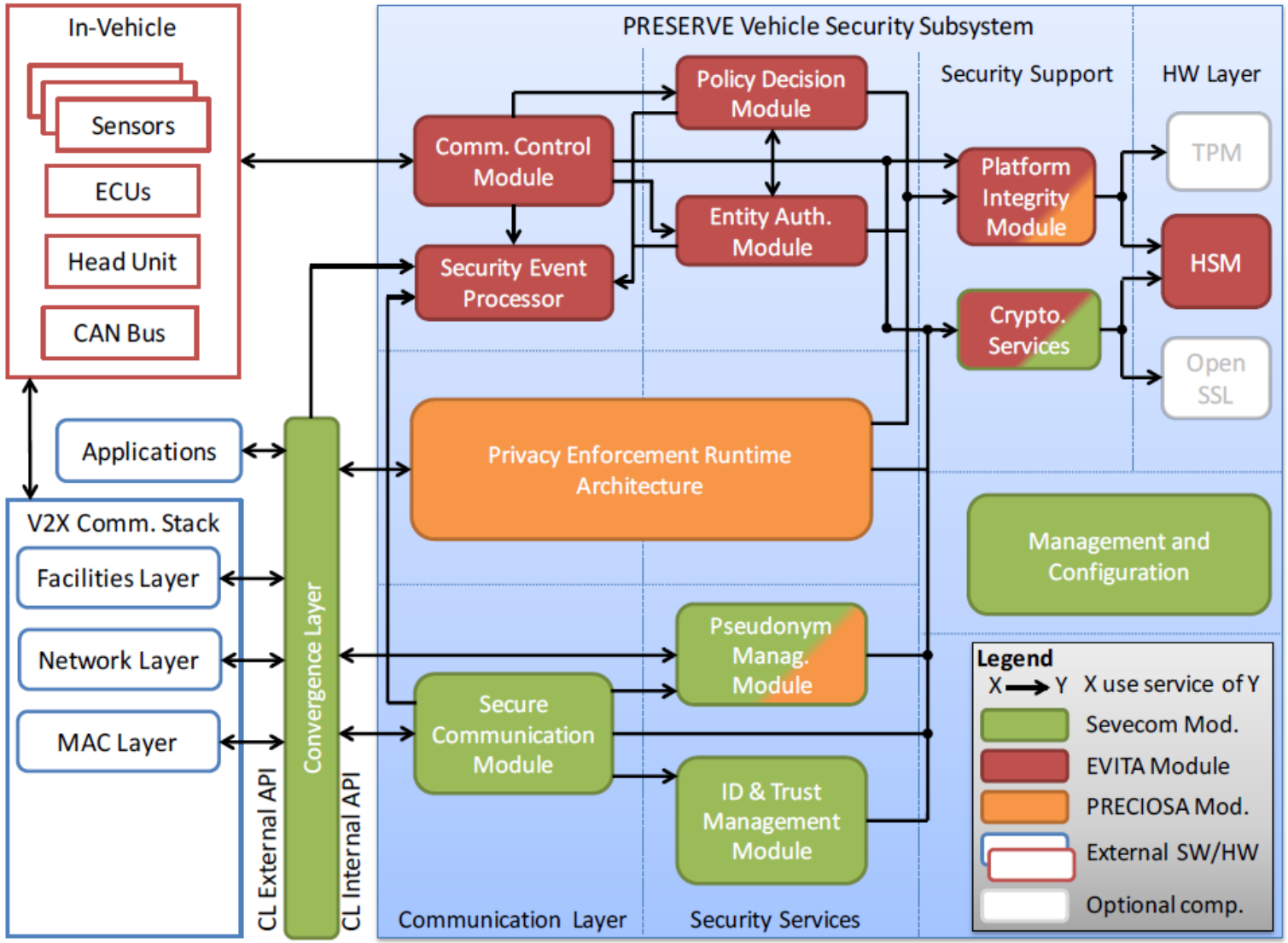
1) P. Papadimitratos, PRESERVE Overview, WC3 Meeting, Jan 2011 - https://www.w3.org/wiki/images/1/11/PRESERVE-Overview-.pdf

PRESERVE (Preparing Secure Vehicle-to-X Communication Systems)



1) P. Papadimitratos, PRESERVE Overview, WC3 Meeting, Jan 2011 - https://www.w3.org/wiki/images/1/11/PRESERVE-Overview-.pdf

PRESERVE Vehicle Security Subsystems (EU)



1) Security Architecture PRESERVE Project - https://www.preserve-project.eu/sites/preserve-project.eu/files/preserve-ws-02-security-architecture.pdf

Secure Automotive Networking – V-PKI Hits the Highway

http://securityfeeds.com/vpki.html

Vehicular Public Key Infrastructure (V-PKI) Secure Communications for the US DOT C Program

- VPKI Hits the Highway (IT Professional), T. Weil

US Department of Transportation (US DOT)

Connected Vehicle (CV) 2017-Pilot Deployment Program (3 Venues)

- US DOT Connected Vehicles Pilot Deployment (2016-2018)
- New York City (NYC) Connected Car Pilot
- Wyoming (WY) Connected Car Pilot
- Tampa-Hillsborough Expressway Authority (THEA) Pilot
- US DOT CV Pilot Applications
- US DOT CV Pilot Publications

Connected Vehicle (CV) 2017-Pilot SCMS Requirements Specifications (V-PKI)

- Secure Credential Management System RFP (2014)
- Secure Credential Management System (SCMS) POC Requirements for US DOT
- SCMS POC EE Requirements and Specifications Supporting SCMS Software Release 1.1

National Highway Transportation Safety Administration (NHTSA)

- V2V communications: Readiness of V2V technology for application, Harding, J.,Booz Allen, et al, (2014,
- NHTSA, US DOT Notice of Proposed Rulemaking, 'Federal Motor Vehicle Safety Standard (FMVSS), N (V2V) communications for new light vehicles and to standardize the message and format of V2V transmi Jan 12, 2017
- Regulations.Gov – Industry Response to the FMVSS NPRM
- NHTSA Office of Crash Avoidance: TechPubs

Crash Avoidance Metrics Partners (CAMP)

Connected Vehicle (CV) 2017-Secure Credential Management System (VPKI)-CAMP

- Technical Design of the Security Credential Management System (2014),W. Whyte, A. Weimerskirch et al
- SCMS Wiki-CV Pilot Documentation
- SCMS Issue Tracking (CAMP Jira Portal)
- SCMS Misbehavior Detection Workshop
- Misbehavior Detection in Large Networks of Heterogeneous Vehicles

Connected Vehicle (CV) 2017-Secure Credential Management System Implementation (CAMP Wiki)

- SCMS CV Pilots Documentation (2017)
- SCMS CV Pilots-Requirements and Use Cases
- SCMS POC Supported V2X Applications and PSIDs
- SCMS OBE Bootstrapping (Manual)-Requirements
- SCMS Backend Management – Use Case Example
- SCMS Certificate Types
- SCMS Pseudonymous Certificates-Projected by Year
- SCMS Cryptographic Test Vectors

ITERIS-US DOT ITS National Architecture (ARC-IT)

- US DOT National ITS Architecture
- Catalog of Services (CVRIA)
- V2V Basic Safety
- Security and SCMS PKI Credential Management

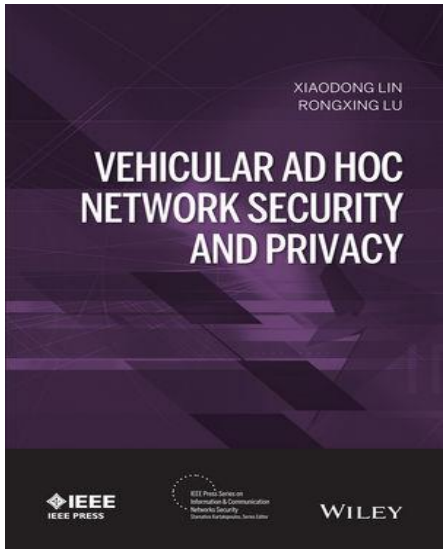
EU-Security Architecture for Vehicular Communications

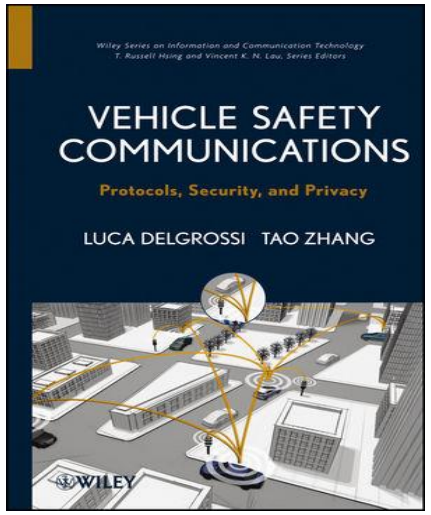
- SeVeCom Security Architecture
- Communications Access for Land Mobiles(CALM)
- PRESERVE Security architecture (N. Bissmeyer)
- PRESERVE-Secure V2X Communications (Frank Kargl)

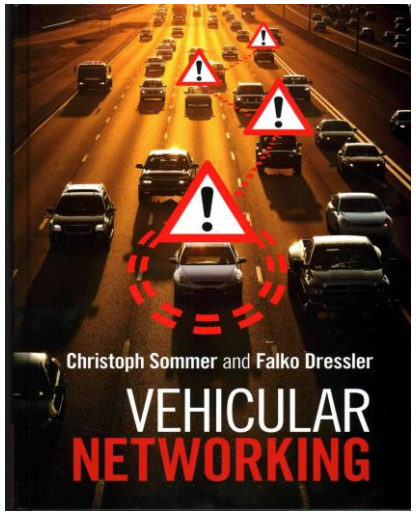
Anonymity and Privacy

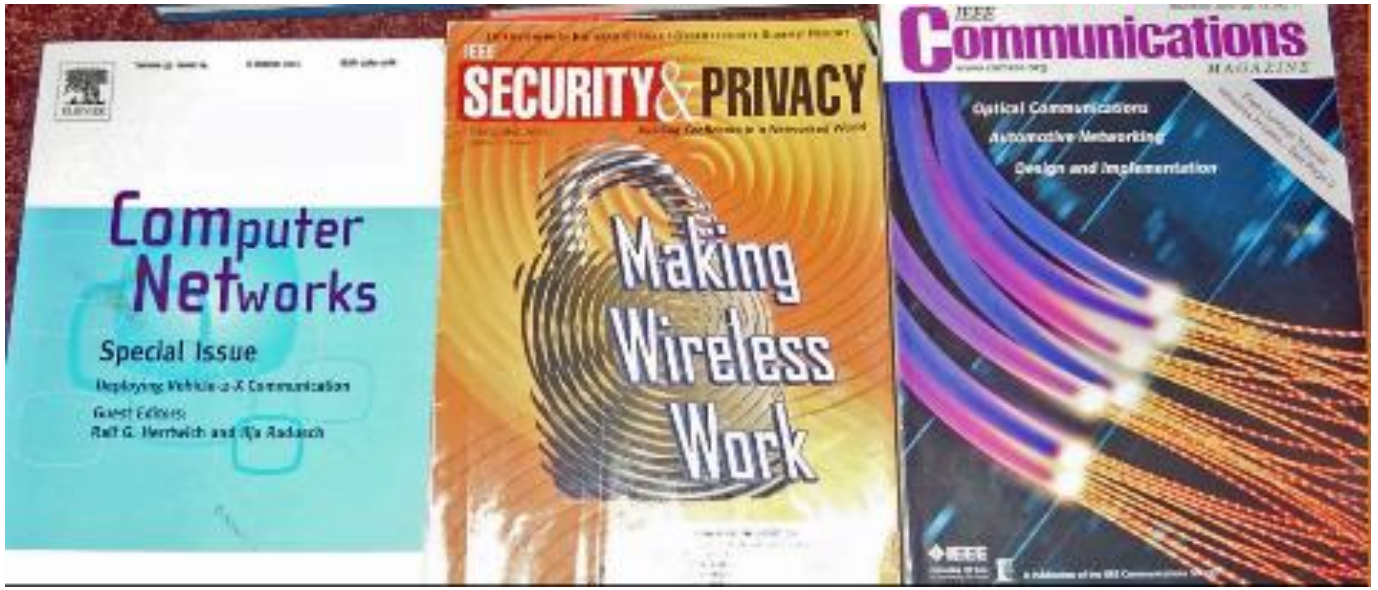
- Privacy Impact Assessment (NHTSA NPRM on V2V Communications)
- Privacy Technical Analysis Report

Privacy-Preserving Vehicular PKI (a very broad subject)





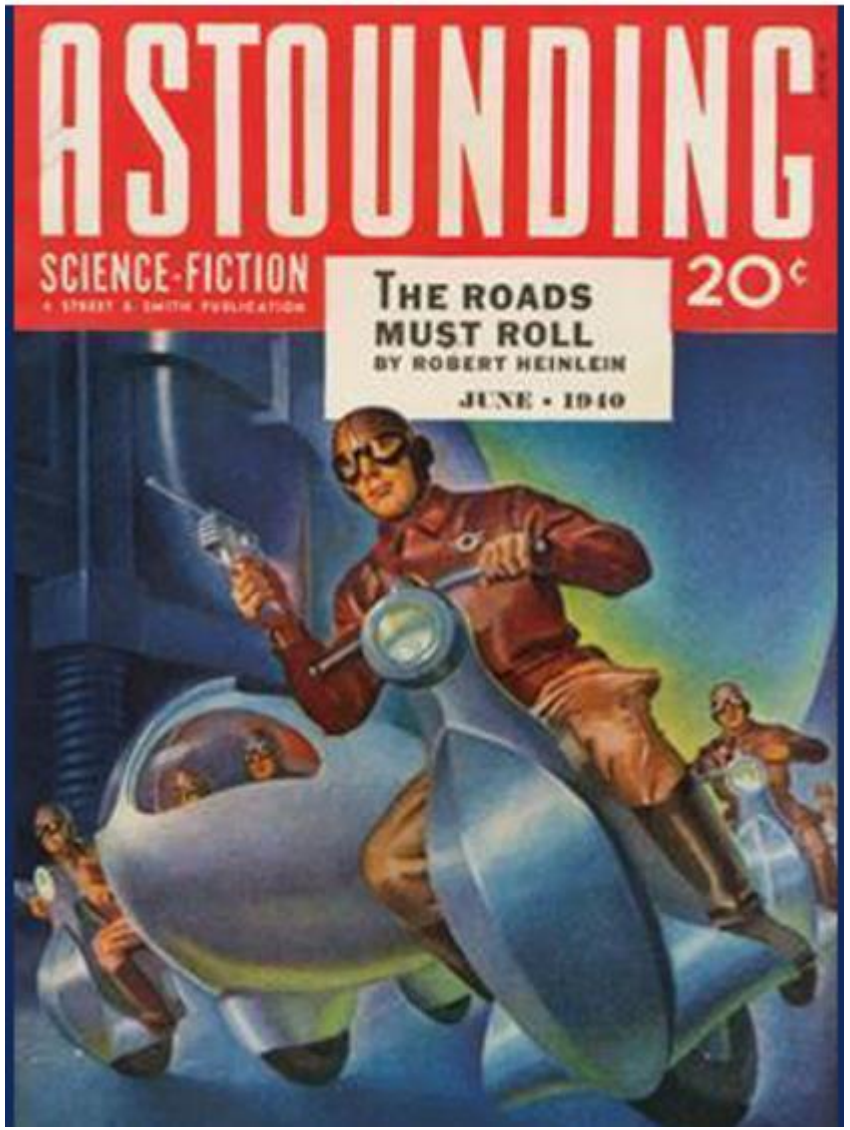


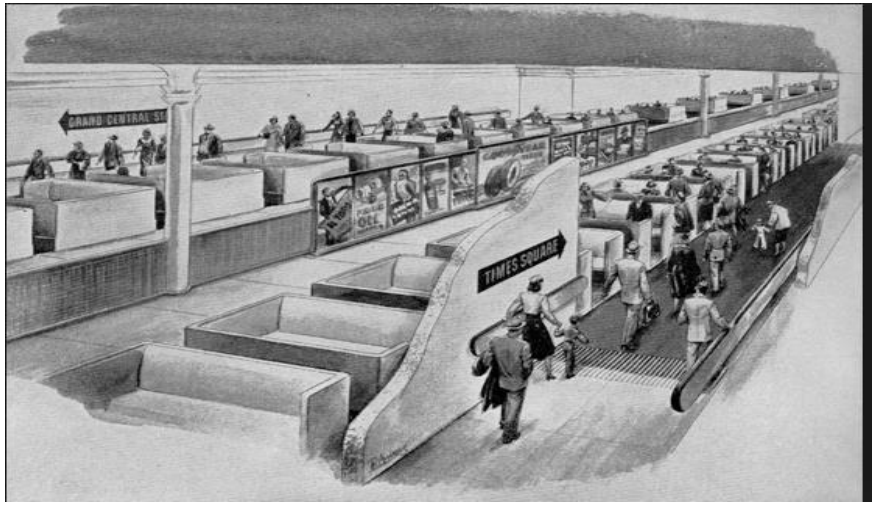


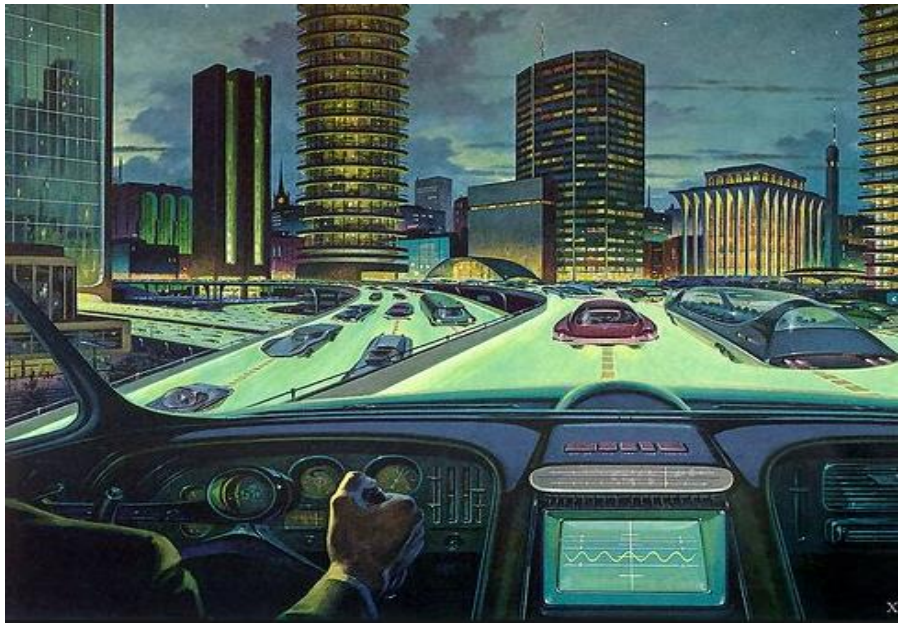
The real challenges of VC data sharing are policy and cultural issues

The Roads Must Roll – Robert Heinlein

GM Futurama – Connected Car (1956)







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- Regulations.Gov – Industry Response to the FMVSS NPRM https://www.regulations.gov/docketBrowser?rpp=50&so=DESC&sb=postedDate&po=50&s=SCMS&dct=PS&D=NHTSA-2016-0126
- Security architecture - Integrating security into the communicating vehicle, Norbert Bissmeyer, Fraunhofer SIT June 18th 2015 https://www.preserve-project.eu/sites/preserve-project.eu/files/preserve-ws-02-security-architecture.pdf
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- P. Papadimitratos, A. de La Fortelle, K. Evenssen, R. Brignolo, S. Cosenze, "Vehicular communication systems: Enabling Technologies, Applications and Future Outlook on Intelligent Transportation," IEEE Commun. Mag., vol. 47, no. 11, pp. 84-95, Nov. 2009.