



Software Technology Conference Tutorial – Part I

# VPKI Hits the Highway – Secure Communication for the US DOT Connected Vehicle Pilot Program

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Member COMSOC, ITS Societies

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Gaithersburg, MD  
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# Objectives of this Presentation

## **ITS Security for Vehicular Networks**

- A Writer's Life
- ITS Models (US DOT Connected Car, Use Cases, IEEE WAVE)
- Connected Car Pilot (NYC, THEA, WYO)
- Introduction to the Basic Safety Message

## **Show real-world examples**

- A Closer Look at the SCMS Approach – Connected Car Program
- SCMS Standards –VPKI Architecture and Security (1609.2) / SAE 2757 DSRC Messaging
- Vehicle Public Key Infrastructure (V-PKI)

## **Organizing Framework for Security Architecture**


- How to reduce Complexity for ITS Service Management Design
- 'What if' scenarios - Issues regarding large scale deployments
- Internet of Things (IoT) – Security Ecosystem

# Table of Contents

- ▶ Introduction – A Writer’s Life (ITS Security and the SCMS VPKI)
- ▶ Evolution of the Security Credential Management Systems (SCMS)
- ▶ SCMS Definition and Architecture
- ▶ Connected Car SCMS Use Cases and CAMP Wiki
- ▶ A Security Model for Automotive Networking (ITS Services)
- ▶ What If Questions for SCMS



# A Writer's Life –

 <p><b>Timothy Weil</b>          Editor - IEEE IT Professional magazine          Cloud Security, RBAC, Identity Management,          Vehicular Networks          Verified email at securityfeeds.com - <a href="#">Homepage</a></p>	<p><b>Citation indices</b></p> <table border="1"> <tr> <td></td> <td>All</td> <td>Since 2012</td> </tr> <tr> <td>Citations</td> <td>1148</td> <td>1086</td> </tr> <tr> <td>h-index</td> <td>7</td> <td>6</td> </tr> <tr> <td>i10-index</td> <td>7</td> <td>4</td> </tr> </table>		All	Since 2012	Citations	1148	1086	h-index	7	6	i10-index	7	4
		All	Since 2012										
Citations	1148	1086											
h-index	7	6											
i10-index	7	4											
	<p><b>Co-authors</b> <a href="#">View all...</a></p> <p>Georgios Karagiannis, D. Richard (Rick) Kuhn</p>												

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



## 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(InterSat), 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 \(ADC\)](#)
- [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 - DCCAS Recognizes Jerry Gibbon as Engineer of the Year](#)



EDITORS: Rick Kuhn, US National Institute of Standards and Technology, kuhn@nist.gov  
 Tim Weil, SCRAM Systems, weil@scram.com



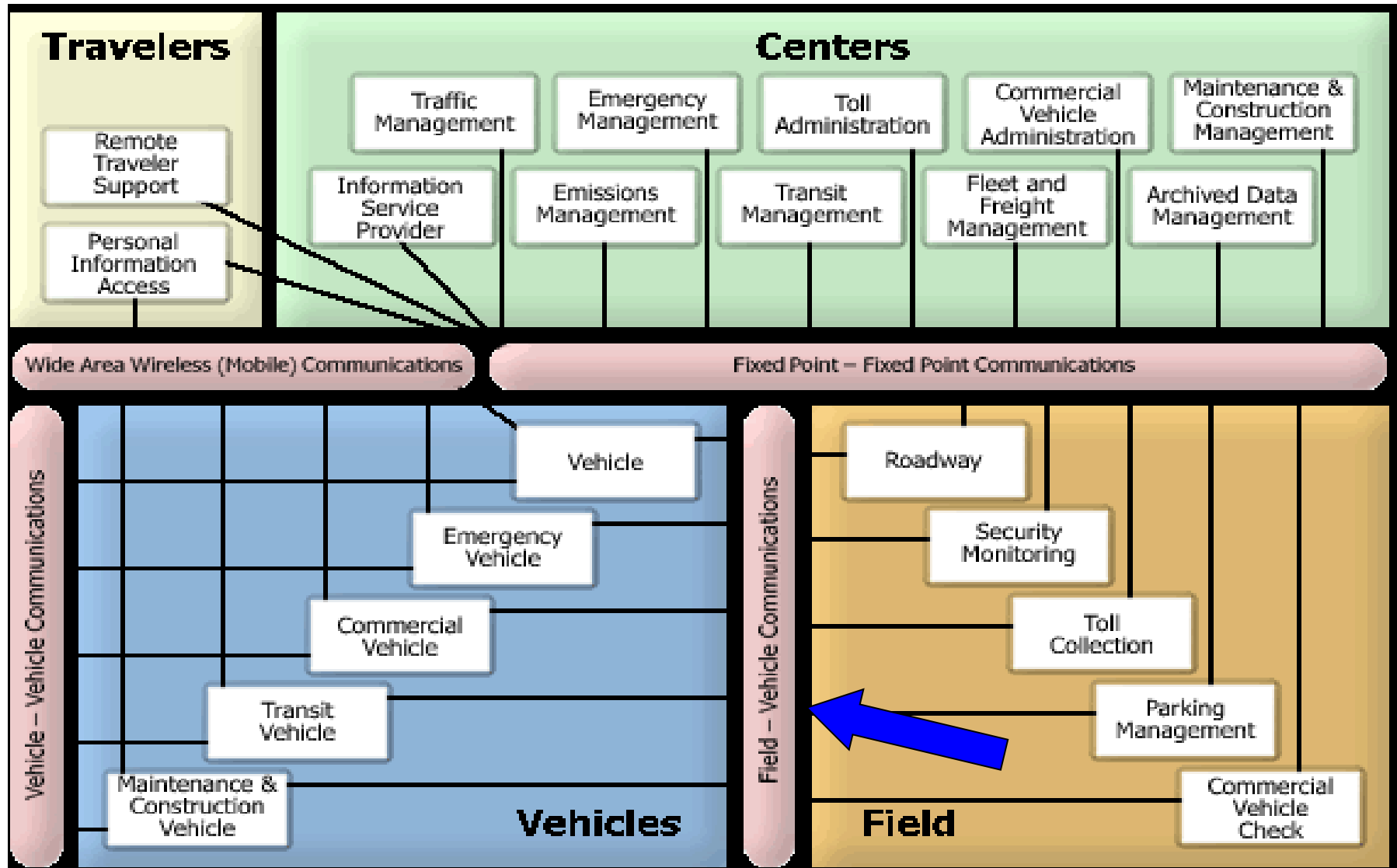
## VPKI Hits the Highway

### 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>

United States Department of Transportation

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## ARC-IT Version 8.0

Including the National ITS Architecture and CVRIA



Architecture ▼ Architecture Use ▼ Architecture Resources ▼ Architecture Terminology ▼ Contact The Architecture Team

[Home](#)

## Architecture Reference for Cooperative and Intelligent Transportation

The Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) provides a common framework for planning, defining, and integrating intelligent transportation systems. It is a mature product that reflects the contributions of a broad cross-section of the ITS community (transportation practitioners, systems engineers, system developers, technology specialists, consultants, etc.).

ARC-IT is a reference architecture: it provides common basis for planners and engineers with differing concerns to conceive, design and implement systems using a common language as a basis for delivering ITS, but does not mandate any particular implementation. ARC-IT includes artifacts that answer [concerns](#) relevant to a large variety of [stakeholders](#), and provides [tools](#) intended for transportation planners, regional architects and systems engineers to conceive of and develop regional architectures, and scope and develop projects.

To get started, begin with the menu bar above:

- [Architecture](#) contains links to all of the content inside the architecture, and describes the structure of the architecture. In particular:
  - [Service Packages](#) provide the most straightforward entry into ARC-IT content. Similar in appearance to CVRIA applications, these include all of the services defined in both CVRIA and the National ITS Architecture 7.1.
  - [Views](#) and its sub-menus provide view-specific content; if for example you are looking for a particular [information flow](#), or a particular [communications profile](#), browse the relevant physical and communications sections here.
  - [Methodology](#) and its sub-menus describe the structure of the architecture: how it is built, how the artifacts within are inter-related.
  - The [Security](#) section describes how security is addressed throughout the architecture and provides links to cross-cutting security content.
- [Architecture Use](#) describes how to use ARC-IT, from the perspective of a regional architect or project systems engineer.
- [Architecture Resources](#) provides access to all ARC-IT content in user-downloadable forms. Notably this also includes access to our tools: RAD-IT and SET-IT, that provide you with means to manipulate the architecture according to models' rules, customizing the reference architecture to your regional or project needs.
- [Architecture Terminology](#) provides those definitions that permeate these pages.
- [Contact the Architecture Team](#) gives you a direct line to the source. We want to hear from you! If you have questions, concerns or find an error (say it isn't so!) we'd like to know about it!

### Latest News

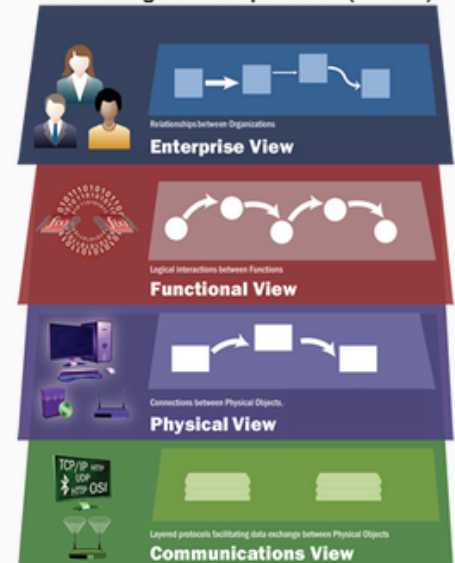
RAD-IT Version 8.0.47 is available as a download from the [Tools page](#). [Read more...](#)

ARC-IT Version 8.0 is a major release of the National ITS Architecture that merges, unifies, and enhances Version 7.1 of the National ITS Architecture and CVRIA Version 2.2. [Read more...](#)

SET-IT Version 8.0 is a major new release of the systems engineering software tool that includes all of the ARC-IT content, spanning all of ITS, and includes many fixes and upgrades. [Read more...](#)

The architecture team is planning workshops to be held this summer in San Jose and Detroit. We will provide an in-person overview of the changes to ARC-IT, demonstrate its use and answer any and all questions. [Read more...](#)

### Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT)



# Catalog of Services (CVRIA)

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

**ARC-IT** Version **8.0**

Including the National ITS Architecture and CVRIA



## 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	<a href="#">DM01</a>	<a href="#">ITS Data Warehouse</a>
AD2	ITS Data Warehouse	<a href="#">DM01</a>	<a href="#">ITS Data Warehouse</a>
AD3	ITS Virtual Data Warehouse	<a href="#">DM01</a>	<a href="#">ITS Data Warehouse</a>
APTS01	Transit Vehicle Tracking	<a href="#">PT01</a>	<a href="#">Transit Vehicle Tracking</a>
APTS02	Transit Fixed-Route Operations	<a href="#">PT02</a>	<a href="#">Transit Fixed-Route Operations</a>
APTS03	Demand Response Transit Operations	<a href="#">PT03</a>	<a href="#">Dynamic Transit Operations</a>
APTS04	Transit Fare Collection Management	<a href="#">PT04</a>	<a href="#">Transit Fare Collection Management</a>
APTS05	Transit Security	<a href="#">PT05</a>	<a href="#">Transit Security</a>
APTS06	Transit Fleet Management	<a href="#">PT06</a>	<a href="#">Transit Fleet Management</a>
APTS07	Multi-modal Coordination	<a href="#">PT14</a>	<a href="#">Multi-modal Coordination</a>
APTS08	Transit Traveler Information	<a href="#">PT08</a>	<a href="#">Transit Traveler Information</a>
APTS09	Transit Signal Priority	<a href="#">PT09</a>	<a href="#">Transit Signal Priority</a>
APTS10	Transit Passenger Counting	<a href="#">PT07</a>	<a href="#">Transit Passenger Counting</a>
APTS11	Multimodal Connection Protection	<a href="#">PT17</a>	<a href="#">Transit Connection Protection</a>

# Introduction – ITS Use Cases Services and Applications

## CONNECTED VEHICLE APPLICATIONS

V2I Safety	Environment	Mobility
<ul style="list-style-type: none"> <li>Red Light Violation Warning</li> <li>Curve Speed Warning</li> <li>Stop Sign Gap Assist</li> <li>Spot Weather Impact Warning</li> <li>Reduced Speed/Work Zone Warning</li> <li>Pedestrian in Signalized Crosswalk Warning (Transit)</li> </ul>	<ul style="list-style-type: none"> <li>Eco-Approach and Departure at Signalized Intersections</li> <li>Eco-Traffic Signal Timing</li> <li>Eco-Traffic Signal Priority</li> <li>Connected Eco-Driving</li> <li>Wireless Inductive/Resonance Charging</li> </ul>	<ul style="list-style-type: none"> <li>Advanced Traveler Information System</li> <li>Intelligent Traffic Signal System (I-SIG)</li> <li>Signal Priority (transit, freight)</li> <li>Mobile Accessible Pedestrian Signal System (PED-SIG)</li> <li>Emergency Vehicle Preemption (PREEMPT)</li> </ul>
V2V Safety	<ul style="list-style-type: none"> <li>Eco-Lanes Management</li> <li>Eco-Speed Harmonization</li> <li>Eco-Cooperative Adaptive Cruise Control</li> <li>Eco-Traveler Information</li> <li>Eco-Ramp Metering</li> <li>Low Emissions Zone Management</li> <li>AFV Charging / Fueling Information</li> <li>Eco-Smart Parking</li> <li>Dynamic Eco-Routing (light vehicle, transit, freight)</li> <li>Eco-ICM Decision Support System</li> </ul>	<ul style="list-style-type: none"> <li>Dynamic Speed Harmonization (SPD-HARM)</li> <li>Queue Warning (Q-WARN)</li> <li>Cooperative Adaptive Cruise Control (CACC)</li> <li>Incident Scene Pre-Arrival Staging</li> <li>Guidance for Emergency Responders (RESP-STG)</li> <li>Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)</li> <li>Emergency Communications and Evacuation (EVAC)</li> <li>Connection Protection (T-CONNECT)</li> <li>Dynamic Transit Operations (T-DISP)</li> <li>Dynamic Ridesharing (D-RIDE)</li> <li>Freight-Specific Dynamic Travel Planning and Performance</li> <li>Drayage Optimization</li> </ul>
Agency Data	Road Weather	Smart Roadside
<ul style="list-style-type: none"> <li>Probe-based Pavement Maintenance</li> <li>Probe-enabled Traffic Monitoring</li> <li>Vehicle Classification-based Traffic Studies</li> <li>CV-enabled Turning Movement &amp; Intersection Analysis</li> <li>CV-enabled Origin-Destination Studies</li> <li>Work Zone Traveler Information</li> </ul>	<ul style="list-style-type: none"> <li>Motorist Advisories and Warnings (MAW)</li> <li>Enhanced MDSS</li> <li>Vehicle Data Translator (VDT)</li> <li>Weather Response Traffic Information (WxTINFO)</li> </ul>	<ul style="list-style-type: none"> <li>Wireless Inspection</li> <li>Smart Truck Parking</li> </ul>



# US DOT ITS JPO – Connected Vehicle Pilot Deployment Program

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

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## ITS Deployment

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[Connected Vehicle Deployment Assistance](#)

[Connected Vehicle Applications](#)

[Sample Deployment Concepts](#)

[Connected Vehicle Publications](#)

[Deployment Resources](#)

[Smart City Challenge](#)

## Connected Vehicles Connected Vehicle Pilot Deployment Program



### CV Pilots News & Events

- The CV Pilot sites presented at the South by Southwest (SXSW) Conference on March 11, 2017 [3/20/17](#)
- The CV Pilot sites presented at the SAE Government Industry Meeting on January 26, 2017 [3/20/17](#)
- Connected Vehicle Pilot Deployment Program Phase 1 Lessons Learned Report is now available [3/20/17](#)

[More news »](#)



New York City DOT



Tampa-Hillsborough



Wyoming DOT Pilot

### CV Pilots Portal

- [Connected Vehicle Pilots Home Page](#)
- [Program Overview](#)
- [Pilot Sites](#)
  - [NYCDOT pilot](#)
  - [THEA pilot](#)
  - [WYDOT pilot](#)
- [Deployment Resources](#)
  - [Connected Vehicle Deployment Assistance](#)
  - [Connected Vehicle Applications](#)
  - [Sample Deployment Concepts](#)
  - [Lessons Learned](#)
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# Tampa-Hillsborough Expressway Authority (THEA) Pilot

[https://www.its.dot.gov/pilots/pilots\\_thea.htm](https://www.its.dot.gov/pilots/pilots_thea.htm)

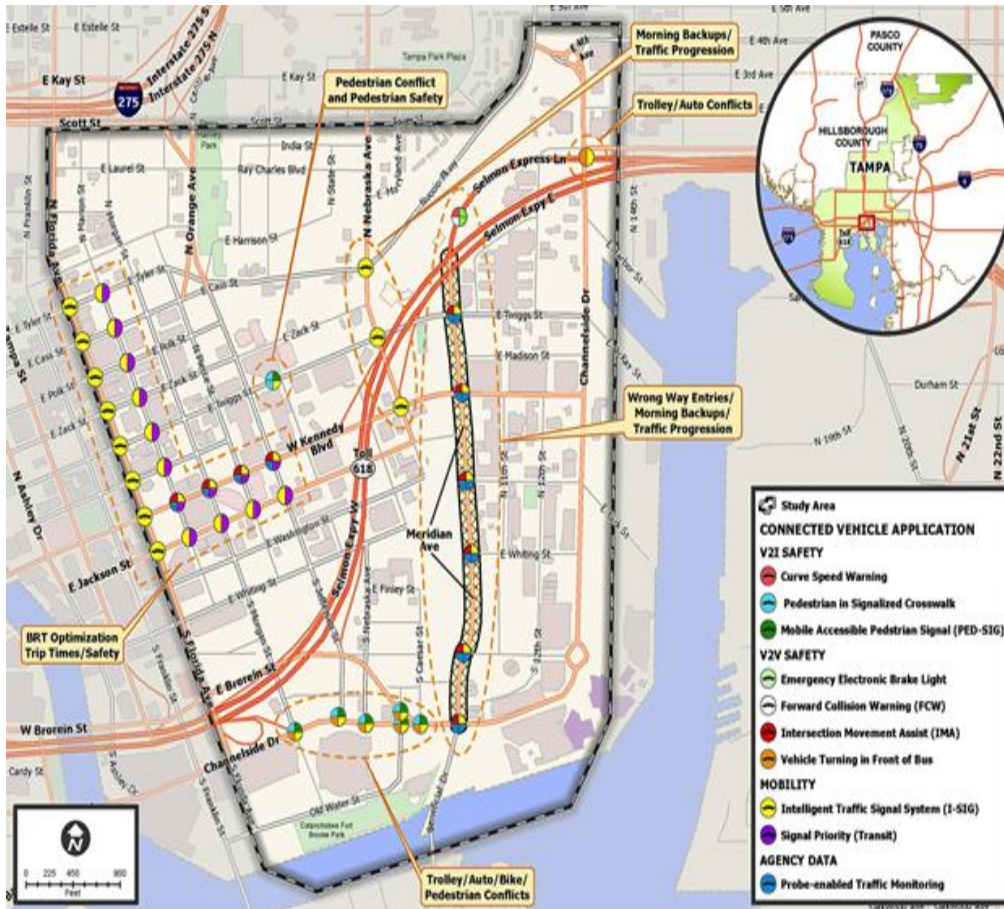


Table 1. Tampa (THEA) Pilot Site Proposed CV Applications

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://wydotcwp.wyroad.info/>

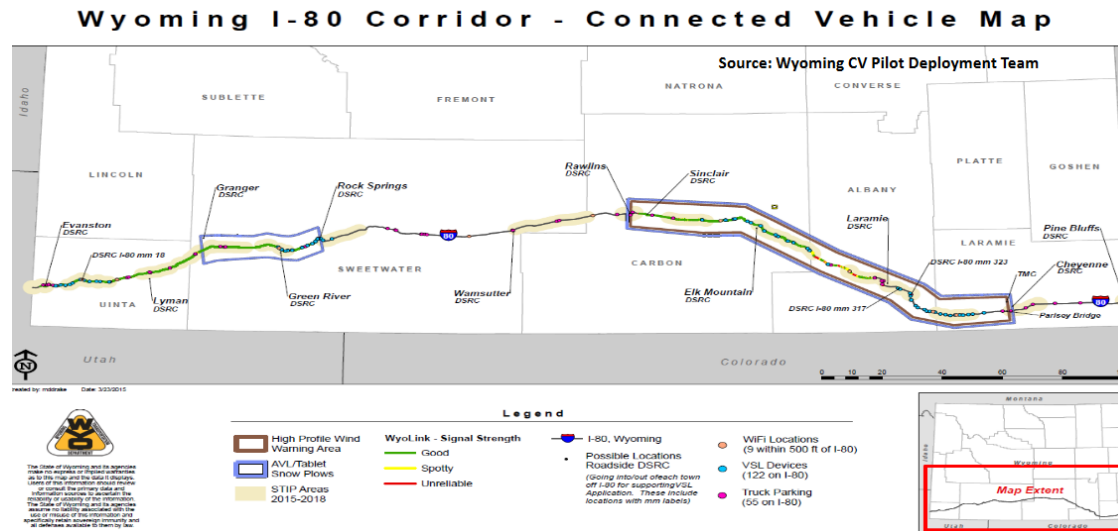


Table 1. WYDOT Pilot Site Proposed CV Applications

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

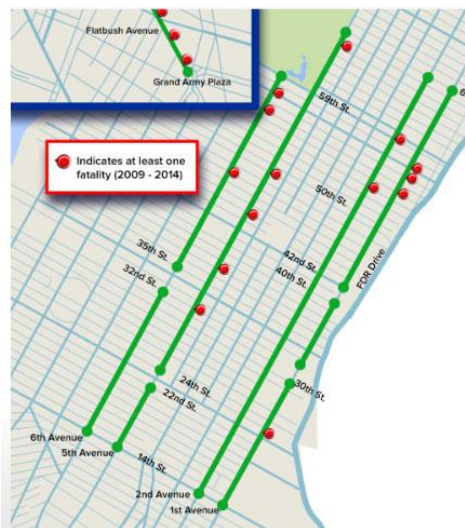
Table 2. WYDOT Pilot Site Proposed CV Devices

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
<b>Total Equipped Vehicles</b>	<b>400</b>

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

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.

# 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

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.

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

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



**NEW YORK CITY**  
**NYC Connected Vehicle Project**  
*For Safer Transportation*

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Mobile Device

Traffic Control System

Aftermarket Safety Device (ASD)

Roadside Equipment (RSU)

NYC Wireless Network

Data Collection

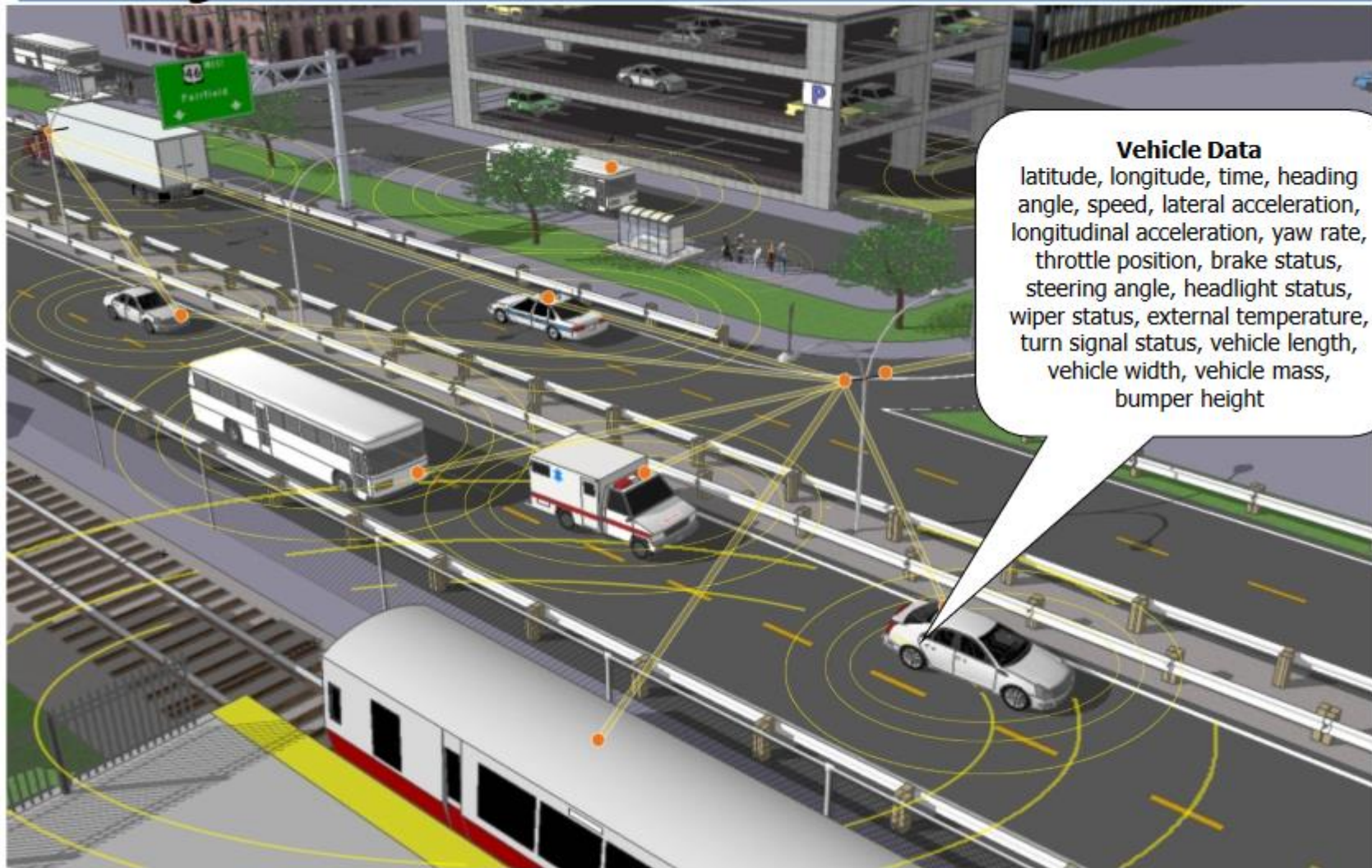
Pedestrian Detection

Advanced Traffic Controller

Security Credential Management System

Connected Vehicle technology is coming to the streets of New York City! This technology holds the potential to make our streets safer and smarter.

# Fully Connected Vehicle



**Vehicle Data**  
latitude, longitude, time, heading angle, speed, lateral acceleration, longitudinal acceleration, yaw rate, throttle position, brake status, steering angle, headlight status, wiper status, external temperature, turn signal status, vehicle length, vehicle width, vehicle mass, bumper height

# Basics of Dedicated Short Range Radio (DSRC)

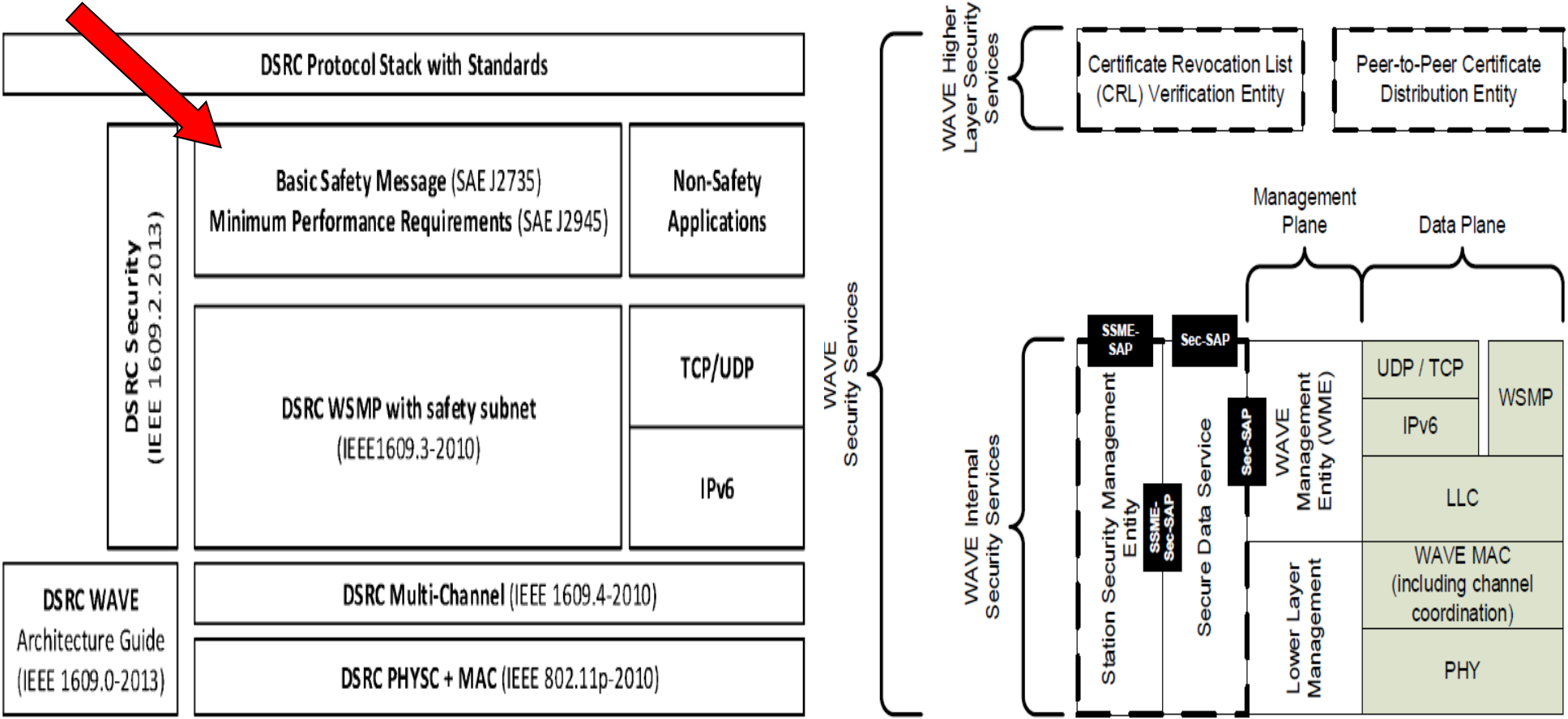
[https://www.its.dot.gov/presentations/world\\_congress2016/Leonard\\_DSRC\\_Spectrum2016.pdf](https://www.its.dot.gov/presentations/world_congress2016/Leonard_DSRC_Spectrum2016.pdf)

5.850 GHz		CH175			CH181			5.925 GHz
5850-5855	CH172	CH174	CH176	CH178	CH180	CH182	CH184	
reserve	service	service	service	control	service	service	service	
5 MHz	10 MHz	10 MHz	10 MHz	10 MHz	10 MHz	10 MHz	10 MHz	

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

# 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

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 1 is mandatory in the Basic Safety message*

## 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

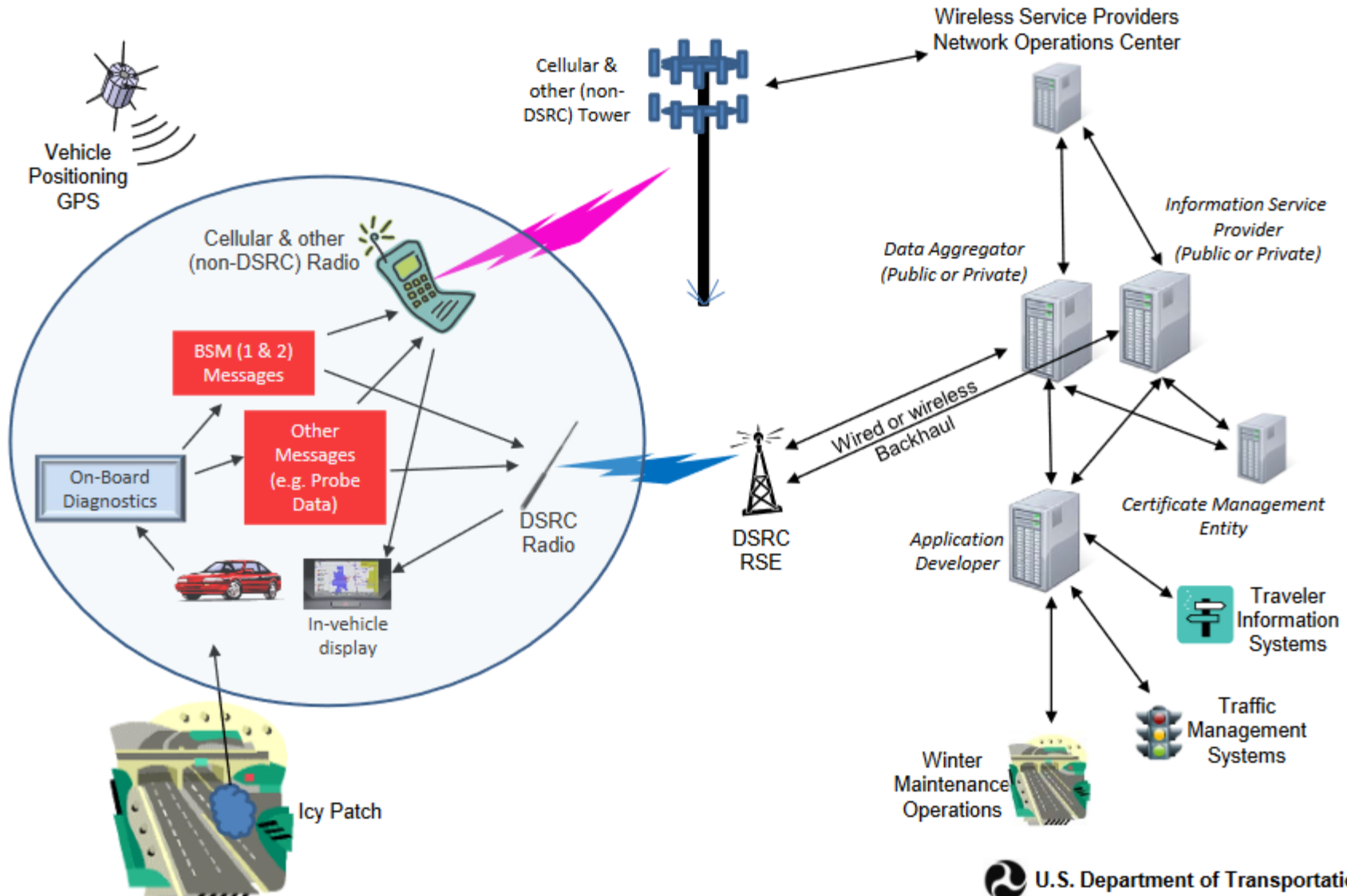
### Vehicle Safety Extension

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

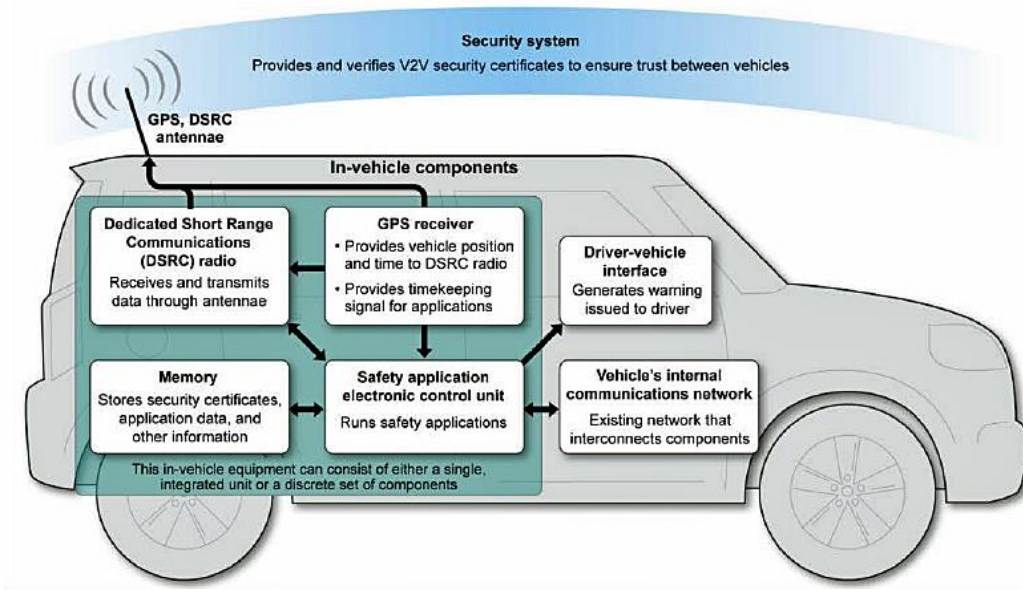
*Required for V-V safety applications,  
but not in every message*



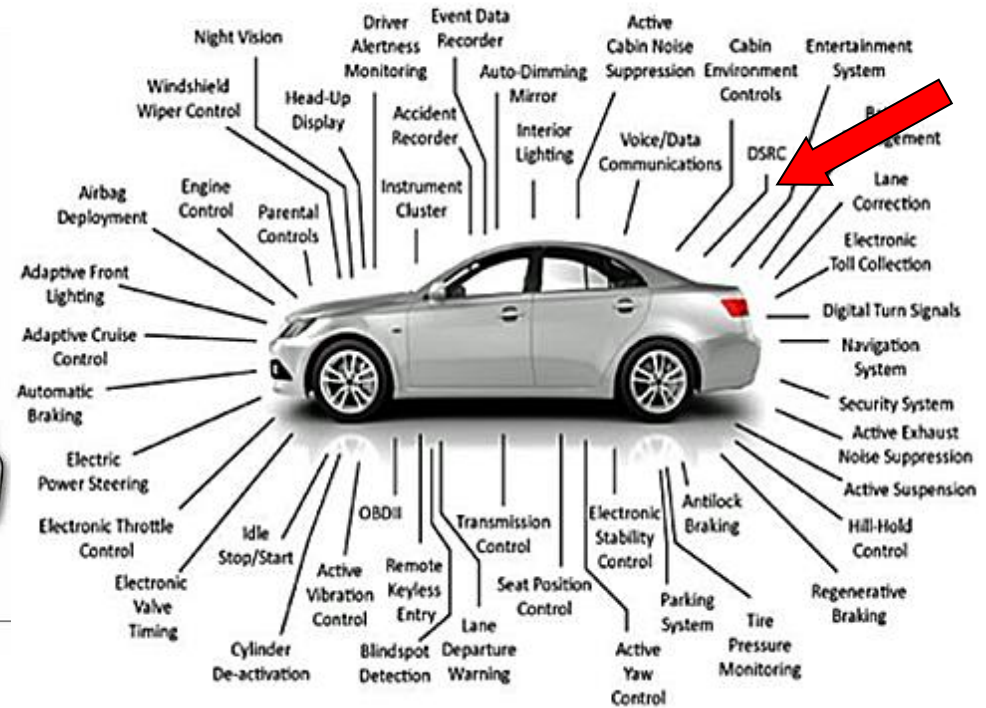
# Private Vehicles Receiving BSMs from DSRC and non-DSRC Sources



# Smart vehicle are *unsecure robots*



Sources: Crash Avoidance Metrics Partnership and GAO.



## ▶ Modern cars include:

- more than 80 ECUs
- many logically interacting subsystems

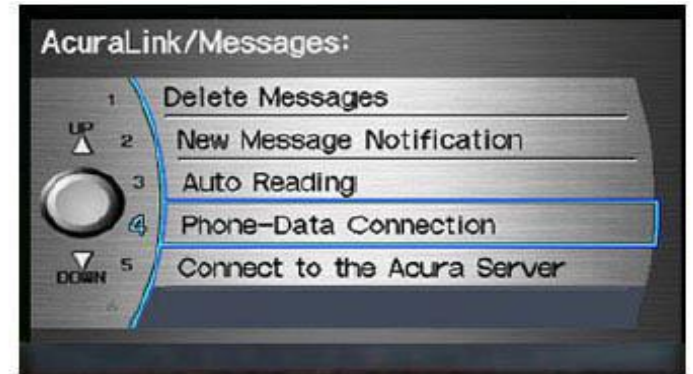
## ▶ ...sensors, actuators, and their intelligent interconnection

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

# ITS Security and Privacy – Data You Can Trust



**Privacy**



**Confidentiality**



**Availability**



**Integrity**



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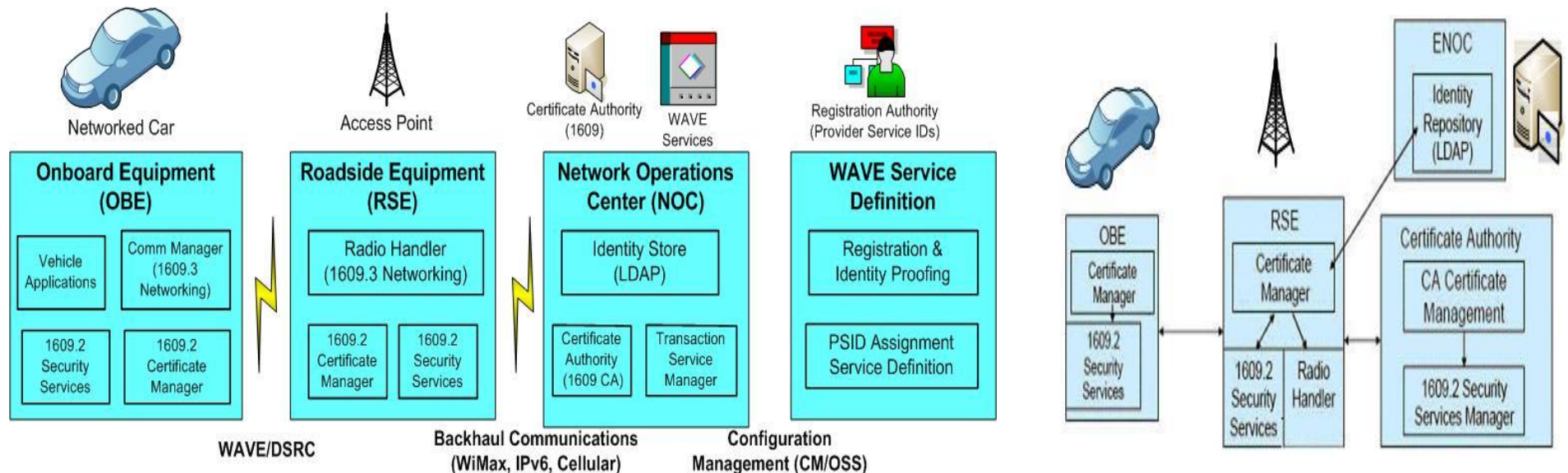
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# IEEE 1609.2 – Practical Internet of Things Security (Brian Russell)

The US Dept Transportation (USDOT), and academia have been developing CV technology for many years and it will make its commercial debut in the 2017 Cadillac. In a few years, it is likely that most new US vehicles will be outfitted with the technology. **The dedicated short range communications (DSRC) wireless protocol (based on IEEE 802.11p) is limited to a narrow set of channels in the 5 GHz frequency band. To accommodate so many vehicles and maintain security, it was necessary to 1) secure the communications using cryptography (to reduce malicious spoofing or eavesdropping attacks) and 2) minimize the security overhead within connected vehicle BSM transmissions.** The industry resolved to use a new, slimmer and sleeker digital certificate design.

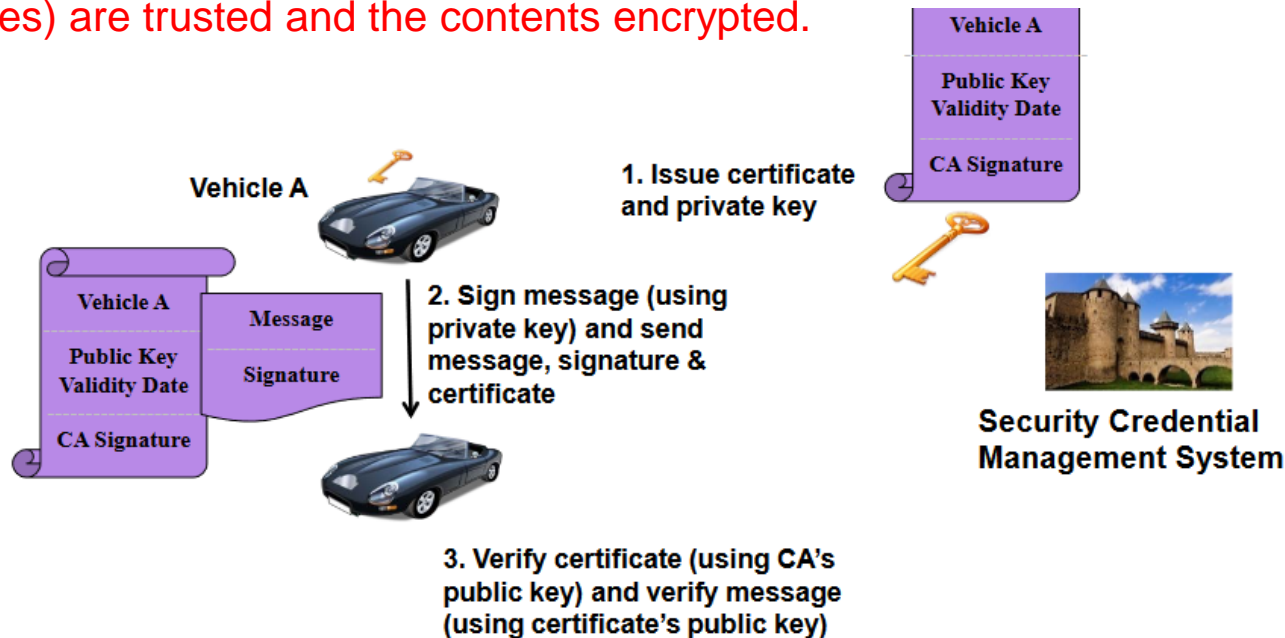
**The 1609.2 certificate format is advantageous in that it is approximately half the size of a typical X. 509 certificate while still using strong, elliptic curve cryptographic algorithms (ECDSA and ECDH).** The certificate is also useful for general machine-to-machine communication through its unique attributes, including explicit application identifier (SSID) and credential holder permission (SSP) fields. These attributes can allow IoT applications to make explicit access control decisions without having to internally or externally query for the credential holder's permissions. **They're embedded right in the certificate during the secure, integrated bootstrapping and enrollment process with the PKI.** The reduced size of these credentials also makes them attractive for other, bandwidth-constrained wireless protocol



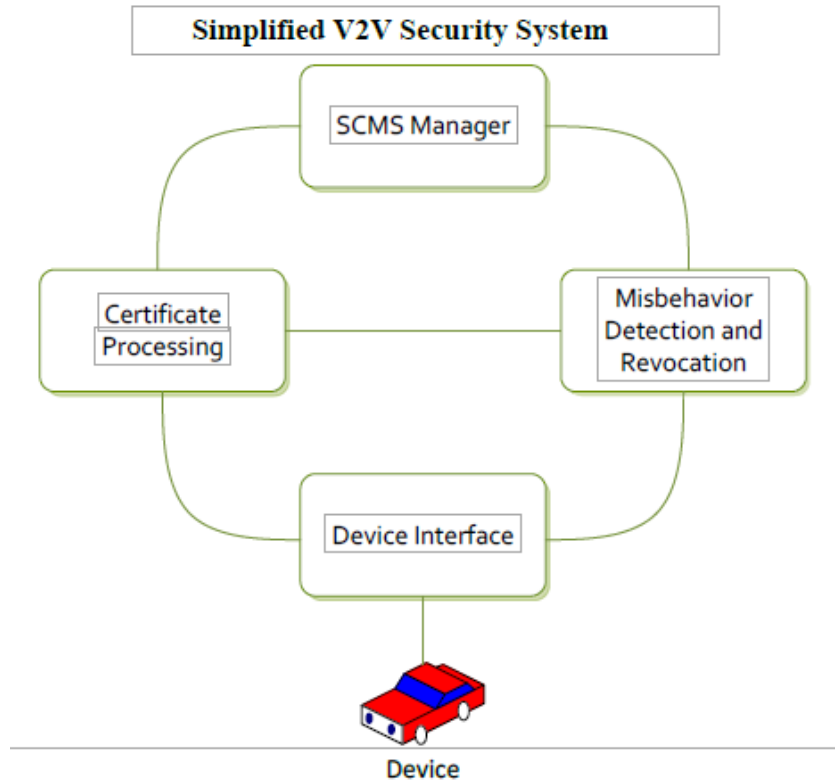
# Vehicular Public Key Infrastructure (VPKI)

V2V communications consists of **two types of messages: safety messages and certificate exchange messages**. The safety messages are used to support the safety applications, and the certificate exchange messages ensure that the safety message is from a trusted source. The safety messages are transmitted in a standardized format so that they can be read by all other vehicles participating in the network.

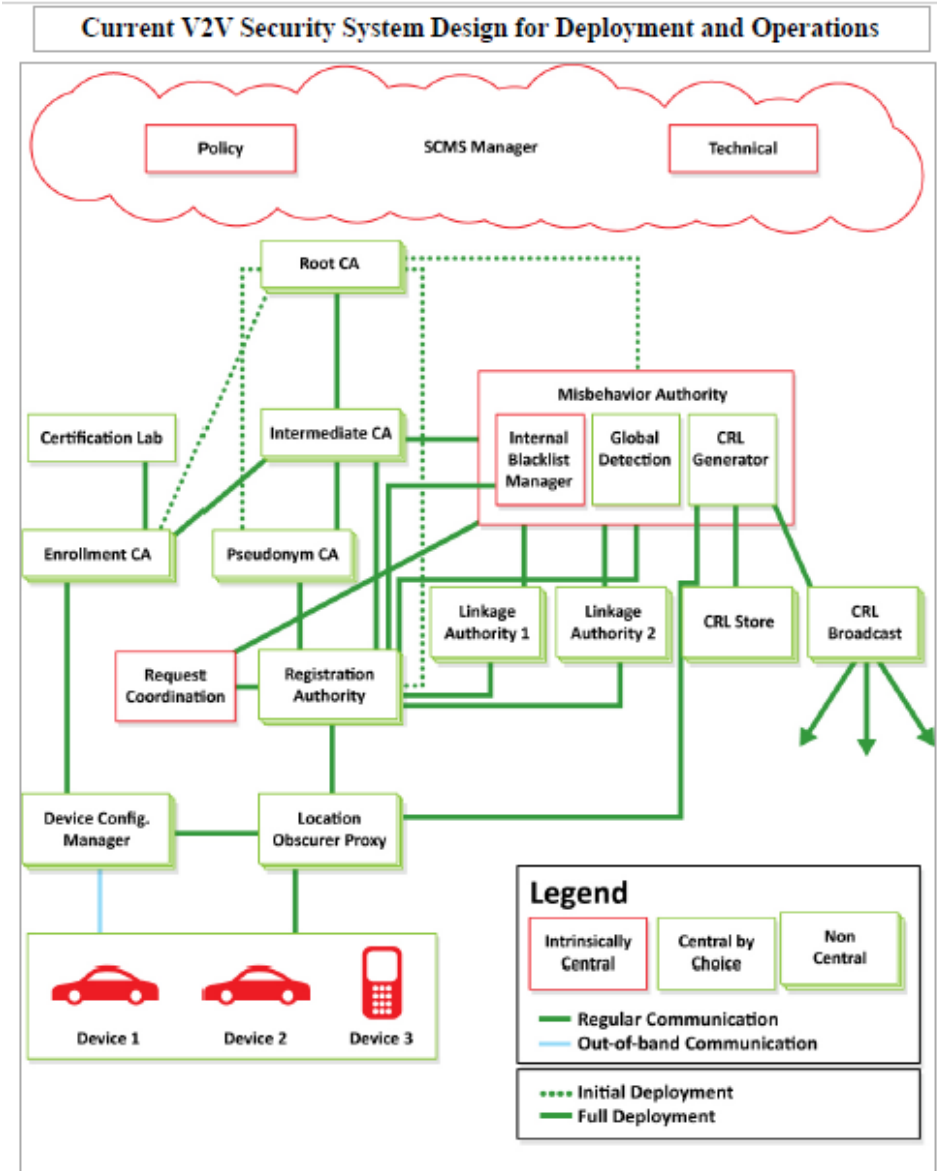
NHTSA's current research is based on the assumption that the V2V system will use a Public Key Infrastructure (PKI) to authenticate messages, so that other vehicles will trust the message. PKI uses certificates to inform a receiving device that the message is from a trusted source, and it uses cryptography to send encrypted message content. For V2V communications, **BSM messages are trusted but not encrypted, while messages that contain security information (e.g., certificates) are trusted and the contents encrypted**.



# Introducing the Security Credential Management Systems (VPKI)



This image presents both an initial deployment model as well as a full deployment model. Note that this diagram shows the initial deployment model where there is no Intermediate CA and the Root CA talks to the MA, PCA, and ECA (dotted lines). In the full deployment model, these entities communicate with the Intermediate CA instead of the Root CA to protect the Root CA from unnecessary exposure (solid line)



[1] W. Whyte, A. Weimerskirch et al, Crash Avoidance Metrics Partnership, Technical Design of the Security Credential Management System (Final Report),



# V2V Communications Security Research 2002 – 2015 (Booz Allen 2014 Report)

<https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/readiness-of-v2v-technology-for-application-812014.pdf>

Research Project	Time Period	Research Focus
Vehicle Safety Communications (VSC)	2002-2005	Secure communications that included identifying options for: <ul style="list-style-type: none"> <li>Trust mechanisms</li> <li>ID misbehaving devices</li> <li>PKI architecture</li> </ul>
Review by the National Institute of Standards and Technology (NIST)	2004	NIST reviewed the security options alternatives analysis, agreed with the security approach chosen (PKI), reviewed the emerging PKI configuration for V2V, and identified concerns that the research team would need to address as development moved forward.
Vehicle Safety Communications – Applications (VSC-A)	2006-2010	Development of high-level security design that covered: <ul style="list-style-type: none"> <li>Over-the-air performance of an authentication scheme</li> <li>Identification of privacy mechanisms</li> <li>Analysis of channel options for security</li> <li>Refinement of the attacker model</li> <li>Initial development of misbehavior detection schemes</li> </ul>

Research Project	Time Period	Research Focus
Vehicle-to-Vehicle-Communications Security (V2V-CS)	2010-2012	Research Objectives included: <ul style="list-style-type: none"> <li>Determined security requirements and derived communication channel requirements.</li> <li>Delivered a simplified initial and final deployment security model that identified the 3000/year certificate model with no infrastructure required for the first three years.</li> <li>Performed a system-based risk assessment using the proposed initial and full deployment models. Assessment identified both privacy and security risks.</li> <li>Began definition of the SCMS to understand the organizational and operational requirements; identified a need to research ownership/operations from a centralized versus non-centralized perspective.</li> <li>This version of the SCMS formed the basis for the Safety Pilot Model Deployment prototype.</li> </ul>

Vehicle-to-Vehicle-Interoperability, Phase 1 (V2V-I)	2010-2012	Research objectives for defining interoperability included further research into security from an operational perspective. The research covered: <ul style="list-style-type: none"> <li>Definition of a concept of operations for a V2V security; tested the operations with 200 vehicles to observe channel congestion using both cellular and DSRC.</li> <li>Definition of a process of certificate management and an initial process for misbehavior detection.</li> <li>Publication of design specifications on IP.com and licensing of the operational design for use in the Safety Pilot Model Deployment.</li> </ul>
Oak Ridge National Laboratories (ONRL)	2012	Before the launch of the Safety Pilot Model Deployment, ORNL tested the prototype security system.

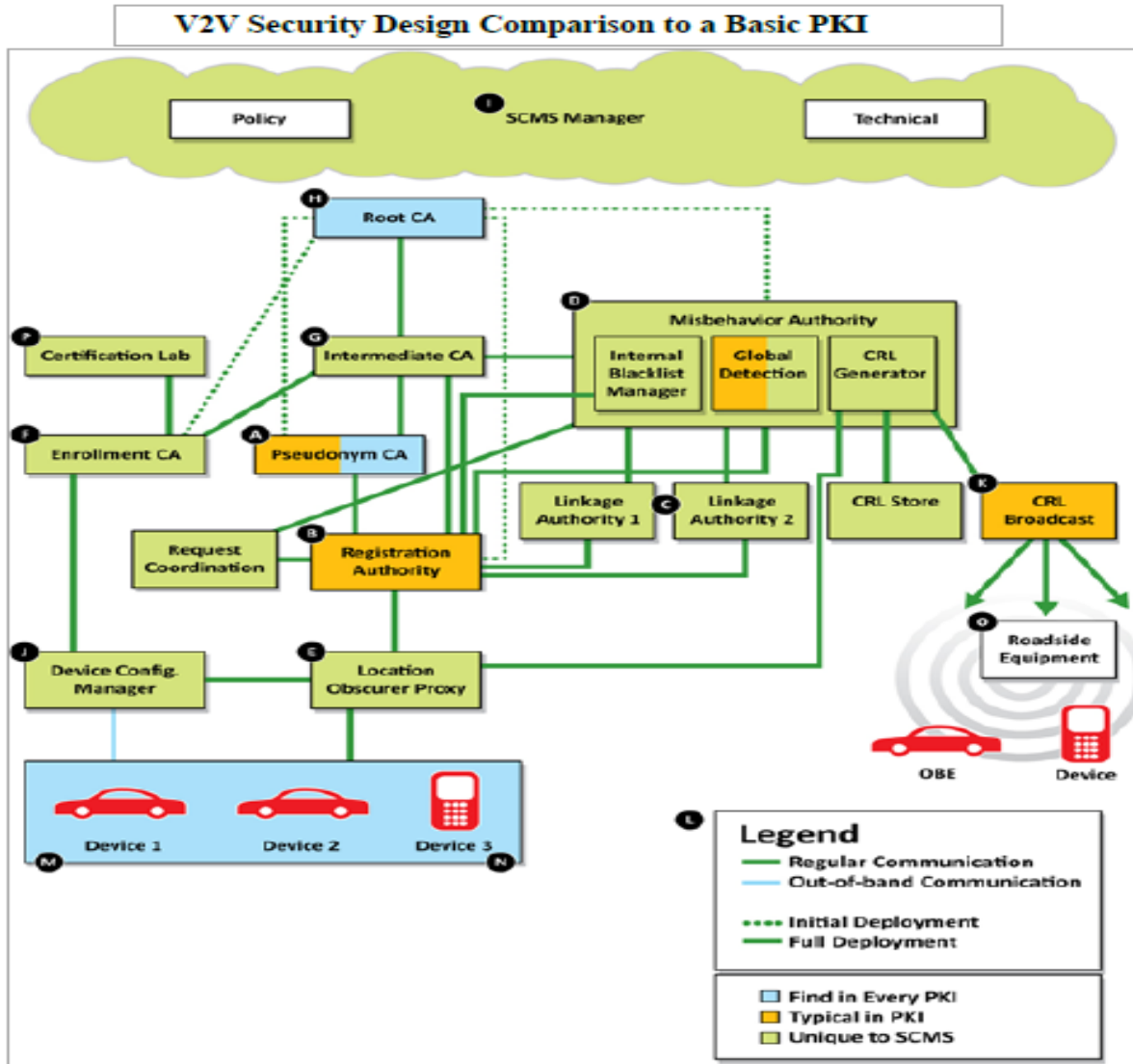
Research Project	Time Period	Research Focus
Safety Pilot Model Deployment (SPMD)	2012-2013	Implementation of a prototype that included: <ul style="list-style-type: none"> <li>Support for device initialization</li> <li>Pre-load of certificates onto devices</li> <li>Over-the-air certificate reload</li> <li>Testing of the certificate revocation list</li> <li>Testing of misbehavior reporting function</li> </ul>
Vehicle-to-Vehicle-Security Communications Security Studies (V2V-VSCS)	2012-2014	Research is underway and includes: <ul style="list-style-type: none"> <li>Finalization of the SCMS design with a focus on simplifying and optimizing operations</li> <li>Cost analysis of the SCMS with a sensitivity analysis on the assumptions associated with the current design concept.</li> <li>Identification of optional methods to link batches of on-board equipment devices to enrollment certificates</li> </ul>
V2V Interoperability Project/Phase 2 (V2V-I/Phase 2)	2012-2014	Research is underway and is focused on misbehavior detection and reporting – the algorithms and operational requirements needed to ensure that this function works under real-world conditions that will lead to development of a deployment use case.
Independent Evaluation of V2V Security System Design	2014-2015	To better understand the state of the current design, the DOT needs an independent entity's assessment to inform the DOT of the status of the design and provide a basis for future policy and technical decisions.

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# SCMS vs Traditional PKI Models



SCMS is a tailored public key infrastructure (PKI) that is designed to provision PKI certificates to vehicles and infrastructure. The SCMS employs components such as location obscurer proxies (LOPs) that shield vehicle identities from PKI components and by extension operators. Vehicles themselves employ a concept of rotating certificates taken from a pool, and then used to digitally sign messages.

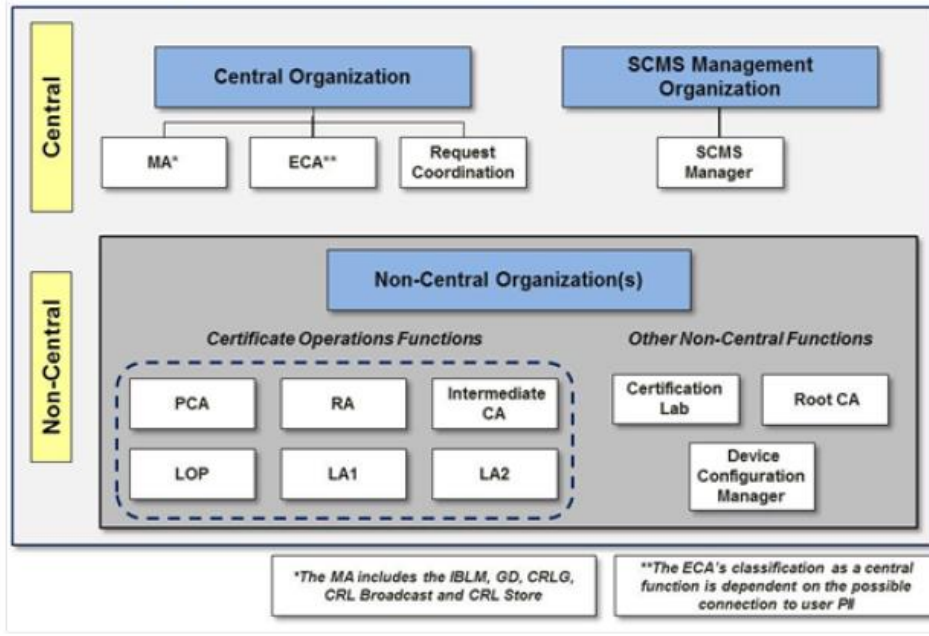
SCMS implements a PKI with some additional new features. This SCMS is currently the leading candidate design for the V2V security backend design in the US. It is distinguished from a traditional PKI in several aspects, the two most important ones being its size (i.e., the number of vehicles that it supports) and the balance among security, privacy, and efficiency. *At its full capacity, assuming 300 million vehicles, it will issue approximately 300 billion certificates per year<sup>1</sup>. The largest current PKI, deployed by the US Department of Defense, is several orders of magnitude smaller and issues under 10 million certificates per year.*

SCMS design is significantly different from any previously implemented PKI due to the underlying security objectives and size, however, it is somewhat similar to the design of the European V2X PKI [2]. The main differences to [2] include an increased focus on privacy against attacks from SCMS insiders, efficient handling of revocation, and an efficient method for updating certificates based on the butterfly key expansion algorithm.



# SCMS vs Traditional PKI Models (BAH Conceptual Diagram)

Security Certificate Management System Organizational Model



Function name	Activities
Certification Lab .....	Tests OBE and informs ECA that units of a particular type are eligible for enrollment certificates.
Device Configuration Manager .....	Coordinates initial distribution with OBE and enables OBE to request certificates from RA.
Enrollment Certificate Authority .....	Activates OBE and credentials users.
Intermediate Certificate Authority ..	Shields Root CA from system and provides more flexibility for trust management.
Linkage Authority .....	Each pair of LAs communicates with the RA to provide linkage values necessary for certificate production, and assists the MA in misbehavior processes.
Location Obscurer Proxy .....	Obscures the locations of requesting devices (e.g., OBE requesting certificates) from other functions, such as the RA.
Misbehavior Authority .....	Collects misbehavior reports from OBE and analyzes system-wide misbehavior. Coordinates with PCA and RA to produce CRL. Other activities include CRL generation, broadcast, and store; internal blacklist manager (IBLM); and global detection.
Pseudonym Certificate Authority ...	Generates and signs short-lived certificates.
Registration Authority .....	Coordinates certificate production with other functions; sends certificates to OBE (during full deployment).
Request Coordination .....	Coordinates certificate requests from OBE to RA.
Root Certificate Authority .....	Provides system-wide confidence through CME certificates issued to all CMEs; represents the basis of confidence in the system.
Security Credentials Management System Manager.	Defines and oversees standards and practices for the SCMS, related to both technical and policy issues.

The CAMP SCMS design features a CA hierarchy, with:

- A root CA that issues certificates for other CAs but not for vehicles or other end-entities
- Optionally, intermediate CAs (ICAs), which obtain their certificates from other CAs above them and also issue certificates for other CAs rather than end-entities. The advantage of using intermediate CAs is that if an intermediate CA is compromised, it is less catastrophic than if the root CA is compromised, so this gives the system more flexibility to introduce new CAs without running the risks incurred by using the root CA key. It is possible to use intermediate CAs in a cascade, so an intermediate CA is either validated by the root CA or the intermediate CA above it.
- Enrollment authorities that issue enrollment certificates (long-term certificate signing requests) for the end-entities. These enrollment certificates are used only to communicate with the SCMS, not with other vehicles or end-entities. **Note: the lifetime of the certificate is currently assumed to be the lifetime of a car (e.g., 30 years). However, this still needs discussion as it influences the size of the internal blacklist and is hence a cost issue.** Note: the certificate lifetime and the lifetime of the actual CA do not have to be equal.
- Pseudonym CAs that issue certificates for the applications on the cars

The CAMP SCMS also distinguishes between the CA, which actually signs the certificate and the RA, which approves certificate requests.



# SCMS Component Functions – Federal Register v79/n199 (2014)

<https://www.gpo.gov/fdsys/pkg/FR-2014-10-15/pdf/2014-24482.pdf>

## Concepts

## Purpose

### Pseudonym Functions / Certificate

A short-term digital certificates used by a vehicle's on-board equipment to authenticate and validate sent and received basic safety messages that form the foundation for V2V safety technologies. These short-term certificates contain no information about users to protect privacy, but serve as credentials that permit users to participate in the V2V

### Intermediate CA

Authorize other Certificate Management Entities (CMEs) (or possibly an Enrollment Certificate Authority [ECA]) using authority from the Root CA, but does not hold the same authority as the Root CA in that it cannot self-sign a certificate.

### Linkage Authority

The linkage values provide the PCA with a means to calculate a certificate ID and a mechanism to connect all short-term certificates from a specific device for ease of revocation in the event of misbehavior

### Location Obscure Proxy (LOP)

Obscures the location of OBE seeking to communicate with the SCMS functions, so that the functions are not aware of the geographic location of a specific vehicle. All communications from the OBE to the SCMS components must pass through the LOP.

### Misbehavior Authority

The MA acts as the central function to process misbehavior reports and produce and publish the certificate revocation list. It works with the PCA, RA, and LAs to acquire necessary information about a certificate to create entries to the CRL through the CRL Generator.

### Pseudonym Certificate Authority

PCA Issues the short-term certificates used to ensure trust in the system. In earlier designs their lifetime was fixed at five minutes. The validity period of certificates is still on the order of "minutes" but is now a variable length of time, making them less predictable and thus harder to track.

### Registration Authority

The RA performs the necessary key expansions before the PCA performs the final key expansion functions. It receives certificate requests from the OBE (by way of the LOP), requests and receives linkage values from the LAs, and sends certificate requests to the PCA

### Root Certificate Authority

The ROOT CA - master root for all other CAs; it is the "center of trust" of the system. It issues certificates to subordinate CAs in a hierarchical fashion, providing their authentication within the system so all other users and functions know they can be trusted. The Root CA produces a self-signed certificate (verifying its own trustworthiness) using out-of-band communications

### SCMS Manager

Management and Control functions that will provide the policy and technical standards for the entire connected vehicle industry. Just as any large-scale industry ensures consistency and standardization of technical specifications, standard operating procedures, and other industry-wide practices such as auditing

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# SCMS CV Pilots Documentation Online (CAMP Wiki)

<https://wiki.campllc.org/display/SCP/SCMS+CV+Pilots+Documentation>



SCMS CV Pilots Documentation

Pages

Blog

PAGE TREE

- Environments documentation
- Requirements and Specifications
  - Common Requirements
    - SCMS PoC Supported V2X Applications
    - Certificate Types
    - Hardware, Software and OS Security Requirements
    - Root Management and Revocation Recovery
    - Cryptography
    - CRL Series Diagram
    - EE-RA Communications - General Guidance
    - EE-SCMS Core Communication Requirements
    - Overview of Used Error Codes
    - Re-enrollment
  - Requirements by Use Case
- Software Design Documents
- Test Vectors

Pages

## SCMS CV Pilots Documentation

Created by Benedikt Brecht, last modified on Apr 20, 2017



**Security Credential Management System Proof-of-Concept Implementation  
EE Requirements and Specifications Supporting SCMS Software Release 1.2**

*Made Available to the United States Department of Transportation*

*National Highway Traffic Safety Administration (NHTSA)*

*November 15, 2016*

*In Response to Cooperative Agreement Number*

*DTNH22-14-H-00449/0003*

# SCMS Requirements by Use Case (CAMP Wiki)

<https://wiki.campllc.org/pages/viewpage.action?pageId=58589462>

- Environments documentation
- ▼ Requirements and Specifications
  - › Common Requirements
  - ▼ Requirements by Use Case
    - Use Case 2: OBE Bootstrapping (Manual)
    - ▼ Use Case 3: OBE Pseudonym Certificates Provisioning
      - Step 3.1: Request for Pseudonym Certificates
      - Step 3.3: Initial Download of Pseudonym Certificate
      - Step 3.5: Top-off Pseudonym Certificates
    - Use Case 5: Misbehavior Reporting
    - Use Case 6: CRL Download
    - › Use Case 8: OBE Pseudonym Certificate Revocation
    - › Use Case 11: Backend Management
    - Use Case 12: RSE Bootstrapping (Manual)
    - › Use Case 13: RSE Application Certificate Provisioning
    - › Use Case 16: RSE Application and OBE Identification
    - › Use Case 18: Provide and Enforce Technical Policies
    - › Use Case 19: OBE Identification Certificate Provisioning
    - › Use Case 20: EE Re-Enrollment
  - › Software Design Documents
  - Test Vectors
  - Glossary

## Use Case 3: OBE Pseudonym Certificates Provisioning

Created by Benedikt Brecht, last modified by Roger Motz on Mar 27, 2017

Target release	Release 0.1
Document owner	@Virendra Kumar
Reviewer	@Roger Motz, @Benedikt Brecht

### Goals

The goal is to provide a freshly bootstrapped OBE with the very first batch of pseudonym certificates that it can use in applications like Basic Safety Message (BSM).

### Background and Strategic Fit

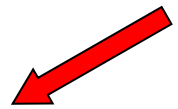
The initial provisioning of pseudonym certificates is the process by which an OBE receives its very first batch of pseudonym certificates. This use case also acts as a trigger for subsequent provisioning of pseudonym certificates. The OBE does not need to make any more requests, the RA automatically does everything necessary (such as doing the butterfly key expansion, getting pre-linkage values from the LAs, making individual certificate requests to the PCA, etc.) for the next batches of certificates.

Due to the time constraints imposed by the OEMs, shuffling requirements for the initial provisioning may be relaxed.

This use case involves the following SCMS components:

- Linkage Authorities (LAs)
- Location Obscure Proxy (LOP)
- Pseudonym Certificate Authority (PCA)
- Registration Authority (RA)

At the start of this use case, the OBE has no pseudonym certificates. At the end of this use case, the OBE has three years worth of pseudonym certificates, and the RA has everything it needs from the OBE for generating and providing subsequent pseudonym certificate batches for the OBE.





# SCMS Issue Tracking (CAMP Jira Portal)

<https://jira.campllc.org/projects/SCMS/issues/SCMS-2562?filter=allissues>

The screenshot displays the Jira issue tracking interface. At the top, the browser address bar shows the URL: <https://jira.campllc.org/projects/SCMS/issues/SCMS-2562?filter=allissues>. The Jira navigation bar includes 'Dashboards', 'Projects', and 'Issues' menus, along with a search bar and a 'Log In' button.

The left sidebar contains a list of issues under the heading 'All issues'. A 'Switch filter' dropdown menu is open, showing options: 'All issues' (selected), 'Open issues', 'Done issues', 'Viewed recently', 'Created recently', 'Resolved recently', and 'Updated recently'. Below the list, the issue SCMS-2562 is highlighted.

The main content area shows the details for issue SCMS-2562. The title is 'Verify change in number of certificate batches provisioned'. The status is 'TESTS FAILED' (indicated by a yellow box). The priority is 'Medium' (indicated by an upward arrow). The resolution is 'Unresolved'. The affects version is 'Software Release 1.1, ... (1)'. The component is 'RA'. The labels are 'MediumRisk' and 'UseCase3Step3'. The assignee is 'Avery Berchek (Inactive)'. The reporter is 'Avery Berchek (Inactive)'. The issue has 0 votes and 2 watchers.

The 'Details' section includes the following information:

- Type: Requirement Test Case
- Status: TESTS FAILED
- Priority: Medium
- Resolution: Unresolved
- Affects Version/s: Software Release 1.1, ... (1)
- Fix Version/s: None
- Component/s: RA
- Labels: MediumRisk, UseCase3Step3
- Pass/Fail Criteria: Tester is able to adjust the max\_available\_cert\_supply and see the number

The 'People' section includes the following information:


- Assignee: Avery Berchek (Inactive)
- Reporter: Avery Berchek (Inactive)
- Votes: 0 Vote for this issue
- Watchers: 2 Start watching this issue

The 'Dates' section includes the following information:

- Created: 8/28/2017 3:21 PM


# SCMS Issue Tracking per Component (CAMP Jira Portal)

<https://jira.campllc.org/projects/SCMS?selectedItem=com.atlassian.jira.jira-projects-plugin:components-page>

Component	Issues	Lead	Description	Default assignee
<a href="#">CRL Store</a>	<a href="#">48 Issues</a>			Project default
<a href="#">CRLG</a>	<a href="#">50 Issues</a>		CRL Generator	Project default
<a href="#">DCM</a>	<a href="#">79 Issues</a>		Device Configuration Manager	Project default
<a href="#">ECA</a>	<a href="#">66 Issues</a>		Enrollment CA	Project default
<a href="#">Elector</a>	<a href="#">8 Issues</a>			Project default
<a href="#">IBLM</a>	<a href="#">40 Issues</a>		Internal Blacklist Manager	Project default
<a href="#">ICA</a>	<a href="#">40 Issues</a>		Intermediate CA	Project default
<a href="#">Karaf</a>	<a href="#">0 Issues</a>			Project default
<a href="#">LA</a>	<a href="#">77 Issues</a>		Linkage Authority	Project default
<a href="#">LOP</a>	<a href="#">8 Issues</a>		Location Obscurer Proxy	Project default
<a href="#">MA</a>	<a href="#">50 Issues</a>		Misbehavior Authority	Project default
<a href="#">On-board Equipment (OBE)</a>	<a href="#">96 Issues</a>			Project default
<a href="#">OSS</a>	<a href="#">0 Issues</a>			Project default
<a href="#">PCA</a>	<a href="#">86 Issues</a>		Pseudonym CA	Project default
<a href="#">PG</a>	<a href="#">58 Issues</a>		Policy Generator	Project default
<a href="#">Protocols</a>	<a href="#">0 Issues</a>	 Erik Schetina	All the protocols docs	Project lead
<a href="#">RA</a>	<a href="#">231 Issues</a>		Request Authority	Project default
<a href="#">RCA</a>	<a href="#">19 Issues</a>		Root CA	Project default

# SCMS Certificate Types

<https://wiki.campllc.org/display/SCP/Certificate+Types>

A certificate is expected to be 117 bytes. The number of unique certs/year \* size of **one certificate**. ( $103680 * 117 = 12.13\text{MB}$  for **one vehicle for one year**). **\*300 million vehicles = 3,639,168,000,000,000. Or 3.6 exabytes.** 

## On-Board Equipment (OBE)

### OBE Enrollment

An enrollment certificate is like a passport for the OBE in that it uses the enrollment certificate to request other certificates: pseudonym and identification certificates. It does not have an encryption key. It is provided to the OBE during its **bootstrap** process.

### Pseudonym

Pseudonym certificates are used by an OBE primarily for BSM authentication and misbehavior reporting and do not have encryption keys.

### Identification

Identification certificates are used by an OBE primarily for authorization in V2I applications.

## Road-Side Equipment (RSE)

### RSE Enrollment

An enrollment certificate is like a passport for the RSE in that it uses the enrollment certificate to request application certificates.

### Application

Application certificates are used by an RSE for authentication and encryption; therefore, they might have **encryption keys**. As there are no privacy constraints for RSEs, an RSE has **only one** application certificate valid at a time for a given application.

The V2X system uses several types of certificates. SCMS components generate these and in many cases can also revoke them. All the EE certificates are of **implicit** type to save storage space and over-the-air bytes. All the SCMS component certificates are of **explicit** type.

## SCMS Component

The elector, root CA, PCA, and ICA certificates are of explicit type to support P2P distribution. There are no privacy constraints for any of the SCMS component certificates.

### Electors

Elector certificates are not part of the PKI hierarchy of the SCMS, i.e., verifying a certificate chain in the system does not involve verifying elector certificates. They are used primarily for root CA certificate management, including adding and removing a root CA. |

### Root CA

The root CA certificate is different from all other types of certificates in many ways:

1. It is the end of trust chain, i.e., verification of any certificate in the system ends at verifying this certificate
2. The signature on the root CA certificate does not have any cryptographic value as the signature is by the root CA itself, and, therefore, the trust in a root CA certificate is established through out-of-band means
3. Usually the root CA certificate has a long lifetime, as changing a root CA certificate is a time consuming, and potentially expensive operation
4. Only a quorum of electors can issue root management messages and add them to a CRL to revoke a root CA certificate

### ICA

ICA certificates can be used to only issue certificates to other SCMS components and nothing else. Only the root CA or the ICA can issue, or authorize someone to issue, a CRL to revoke an ICA certificate.

A root CA certificate does not have an encryption key as the root CA is mostly offline and does not accept any incoming messages, whether encrypted or not. The root CA certificate needs to be made available to everyone in the system. The initial provisioning of the root CA certificate is done through out-of-band means in a secure environment during enrollment

# SCMS Certificate Types and EE Certificate Type Features

<https://wiki.campllc.org/display/SCP/Certificate+Types>

## EE Certificate Type Features

The following table provides an overview of the EE certificate types. 'X' describes mandatory features, and '(x)' describes optional features. The table provides a comprehensive overview. The following are assumptions for the POC:

- All RSEs have regular connectivity. Hence, case 5.b is not implemented
- The response by the PCA is not encrypted for case 3 and case 5

	OBE Enrollment Certificate	OBE Pseudonym Certificate	OBE Identification Certificate	RSE Enrollment Certificate	RSE Application Certificate	
					RSE with Connectivity	RSE without Connectivity
Provisioning	1 per EE per PSID category	20 per week, up to 3 years, top-up refresh using butterfly keys	1 per time period, only issue very small number of certificates at a time, top-up refresh using butterfly keys	1 per EE per PSID category	1 per time period, only issue for short time periods, require frequent renewal. RSE generates public/private key pair and provides public-key to RA	1 per time period, issue longer time periods. RSE generates public/private key pair and provides public-key to RA
Revocation	RA blacklist	leverage linkage values	add certificate digests of all issued certificates (can be more than one)	RA blacklist	Cannot renew certificates, due to RA blacklist of enrollment certificate	Add certificate digest of all issued certificates (can be more than one)

**Table 1. Certificate types for testing.**

Issued to	Certificate name	Purpose
OBU*/ASD	Enrollment	Initializes the OBU to allow communication with the SCMS
OBU/ASD	Pseudonym	Used to sign all basic safety messages generated by an OBU
OBU	Authorization	Used to identify public sector vehicles for specific apps
RSU	Enrollment	Initializes the RSU to allow communication with SCMS
RSU	Application	Used to sign messages generated by the RSU

\*OBU: onboard unit; ASD: aftermarket safety device; RSU: roadside unit; SCMS: Security Credential Management System

## SCMS Component

### ECA

As mentioned above, ECA certificates are of **explicit** type as they do not need to be distributed through P2P distribution. ECA certificates can be used to only issue certificates to end-entities including OBEs and RSEs.

### PCA

PCA certificates can be used to only issue certificates to end-entities including OBEs and RSEs.

### CRL Generator

CRL generator certificates are issued by the root CA and can be used only to sign CRLs, and nothing else. As revocation of CRL generator certificates is difficult (i.e., can be done by either root CA or ICA), the validity period of the CRL generator certificates is kept as low as possible.

### Policy Generator

Policy generator certificates are issued by the root CA and can be used only to sign the global policy configuration files that are distributed to SCMS components. The policies around validity are the same as for CRL generator certificates.

### LA Certificates

Can be short as LAs do not interact with end-entities.

### RA Certificates

Must be long enough so that end-entities can successfully make a certificate provisioning request after being bootstrapped.

### MA Certificates

Needs to be long so that end-entities do not need to retrieve these certificates very often.

# SCMS POC Supported V2X Applications and PSIDs

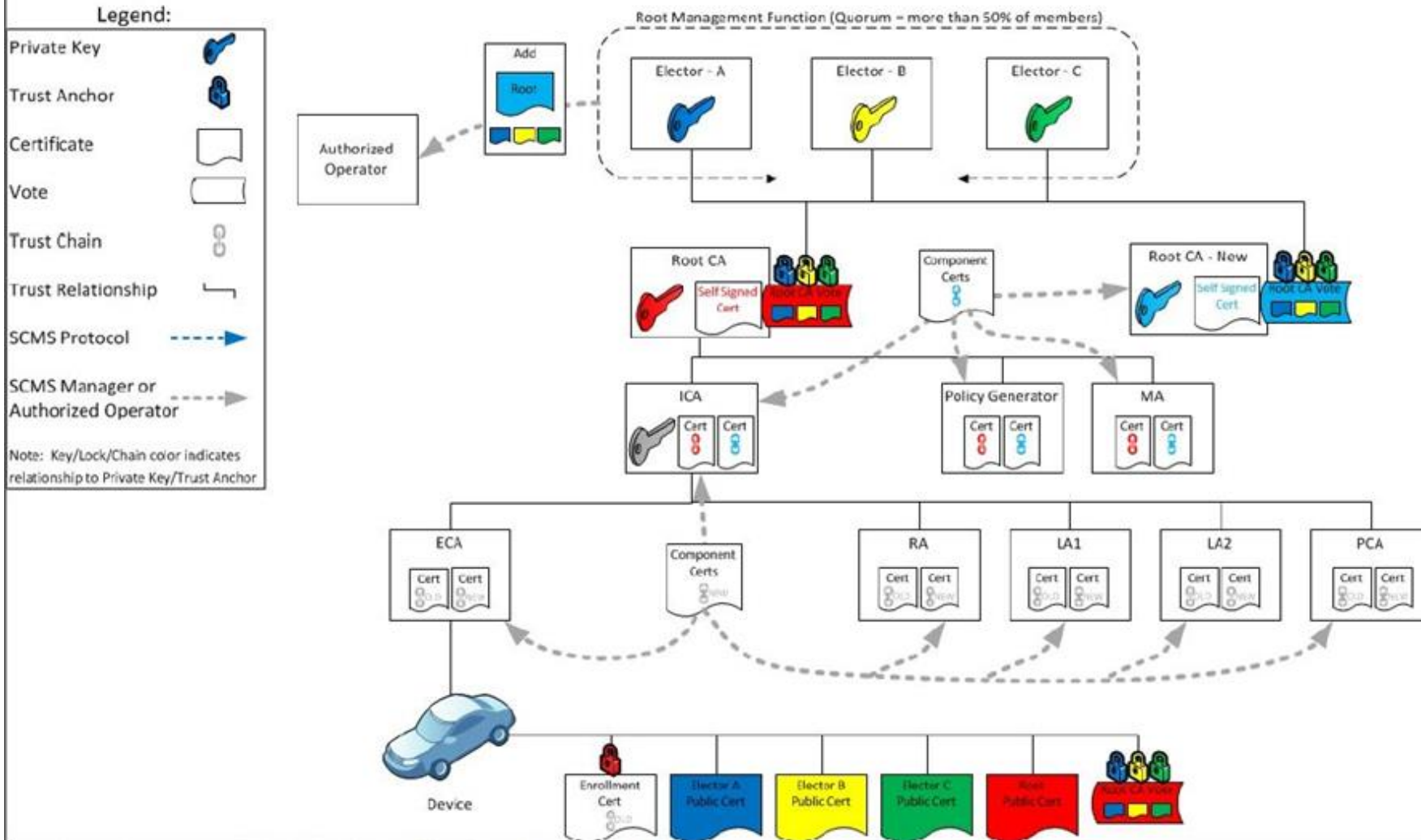
<https://wiki.campllc.org/display/SCP/SCMS+PoC+Supported+V2X+Applications>

Application	Application Category	PSID Decimal	Application	Application Category	PSID Decimal
Basic Safety Message (BSM)	BSM inputs	32	Misbehavior Reporting for Common Applications	Support	38
Vehicle Turning Right in Front of Bus Warning	BSM inputs	32	Differential GPS Corrections, Uncompressed	Support	128
Intelligent Traffic Signal System (I-SIG) In-Vehicle Information Potential	BSM inputs	32	Differential GPS Corrections, Compressed	Support	129
Forward Collision Warning (FCW)	BSM inputs	32	Red Light Violation Warning/RSE	3 - Signal Violation Warning	130
Emergency Electronic Brake Light (EEBL)	BSM inputs	32	Pedestrian in Signalized Crosswalk Warning/RSE	16 - Pedestrian Warnings	130
Blind Spot Warning (BSW)	BSM inputs	32	Mobile Accessible Pedestrian Signal System (PED-SIG)	16 - Pedestrian Warnings	130
Lane Change Warning/Assist (LCA)	BSM inputs	32	Transit Signal Priority/ Special Vehicles	1 - Signal Pre-emption/Priority	130
Intersection Movement Assist	BSM inputs	32	<a href="#">Modified Eco-Speed Harmonization/RSE</a>	2 - Speed Harmonization	131
Stationary Vehicle Ahead (SVA)	BSM inputs	32	<a href="#">Modified Eco-Speed Harmonization/TMC</a>	2 - Speed Harmonization	131
Do Not Pass Warning	BSM inputs	32	Curve Speed Warning	8 - Curve Speed Warning	131
Probe Enabled Traffic Monitoring	BSM inputs	32	<a href="#">Reduced Speed/Work Zone Warning/RSE</a>	9 - Temporary Situation Warning	131
			<a href="#">Reduced Speed/Work Zone Warning/TMC</a>	9 - Temporary Situation Warning	131
			<a href="#">Spot Specific Weather Warnings/RSE</a>	9 - Temporary Situation Warning	131
			<a href="#">Spot Specific Weather Warnings/TMC</a>	9 - Temporary Situation Warning	131
			<a href="#">Variable Speed Limits/RSE</a>	10 - Speed Zone	131
			<a href="#">Variable Speed Limits/TMC</a>	10 - Speed Zone	131
			<a href="#">Speed Harmonization/RSE</a>	2 - Speed Harmonization	131
			<a href="#">Speed Harmonization/TMC</a>	2 - Speed Harmonization	131
			<a href="#">Work Zone Alerts/RSE</a>	9 - Temporary Situation Warning	131
			<a href="#">Work Zone Alerts/TMC</a>	9 - Temporary Situation Warning	131
			<a href="#">Truck Restrictions/RSE</a>	11 - Special Vehicle Warning	131
			<a href="#">Truck Restrictions/TMC</a>	11 - Special Vehicle Warning	131
			Automatic Alerts for First Responders	11 - Special Vehicle Warning	131
Application	Application Category	PSID Decimal			
CV-enabled Weather-Responsive Variable Speed Limits	9 - Temporary Situation Warning	131			
Road Weather Advisories for Trucks and Vehicles	9 - Temporary Situation Warning	131			
Emergency Communications and Evacuation (EVAC)	9 - Temporary Situation Warning	131			
WAVE Service Advertisement	Support	135			
Certificate Revocation List Application	Support	256			
CV Pilot Application 1		2,113,672			
CV Pilot Application 2		2,113,673			
CV Pilot Application 3		2,113,674			
CV Pilot Application 4		2,113,675			
CV Pilot Application 5		2,113,676			

# SCMS Backend Management – Use Case Examples (1 of 2)

<https://wiki.campllc.org/display/SCP/Use+Case+11%3A+Backend+Management>

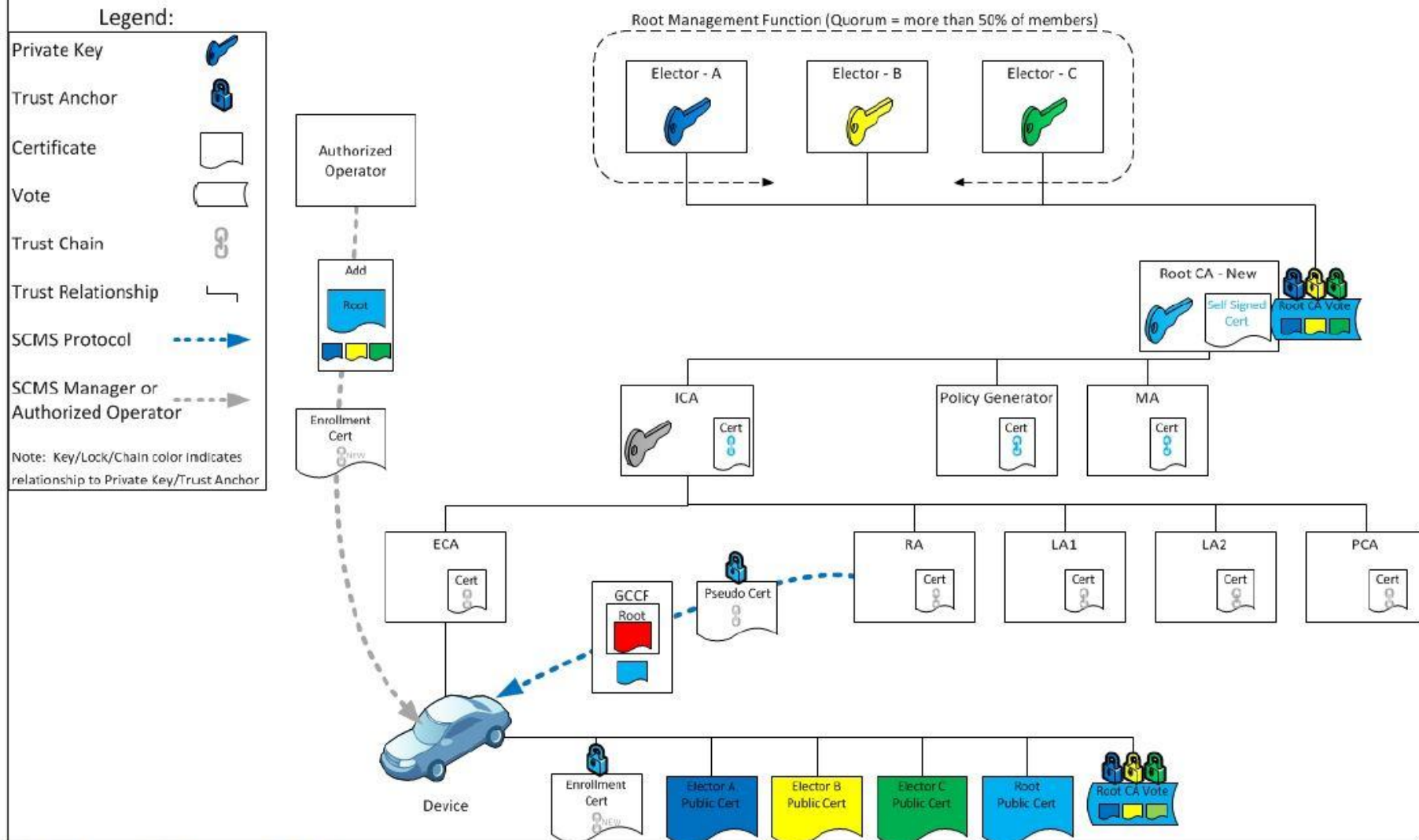
## Introduce Replacement Root CA Before Revoking Current Root CA



# SCMS Backend Management – Use Case Examples (2 of 2)

<https://wiki.campllc.org/display/SCP/Use+Case+11%3A+Backend+Management>

## Update EEs with new certificates

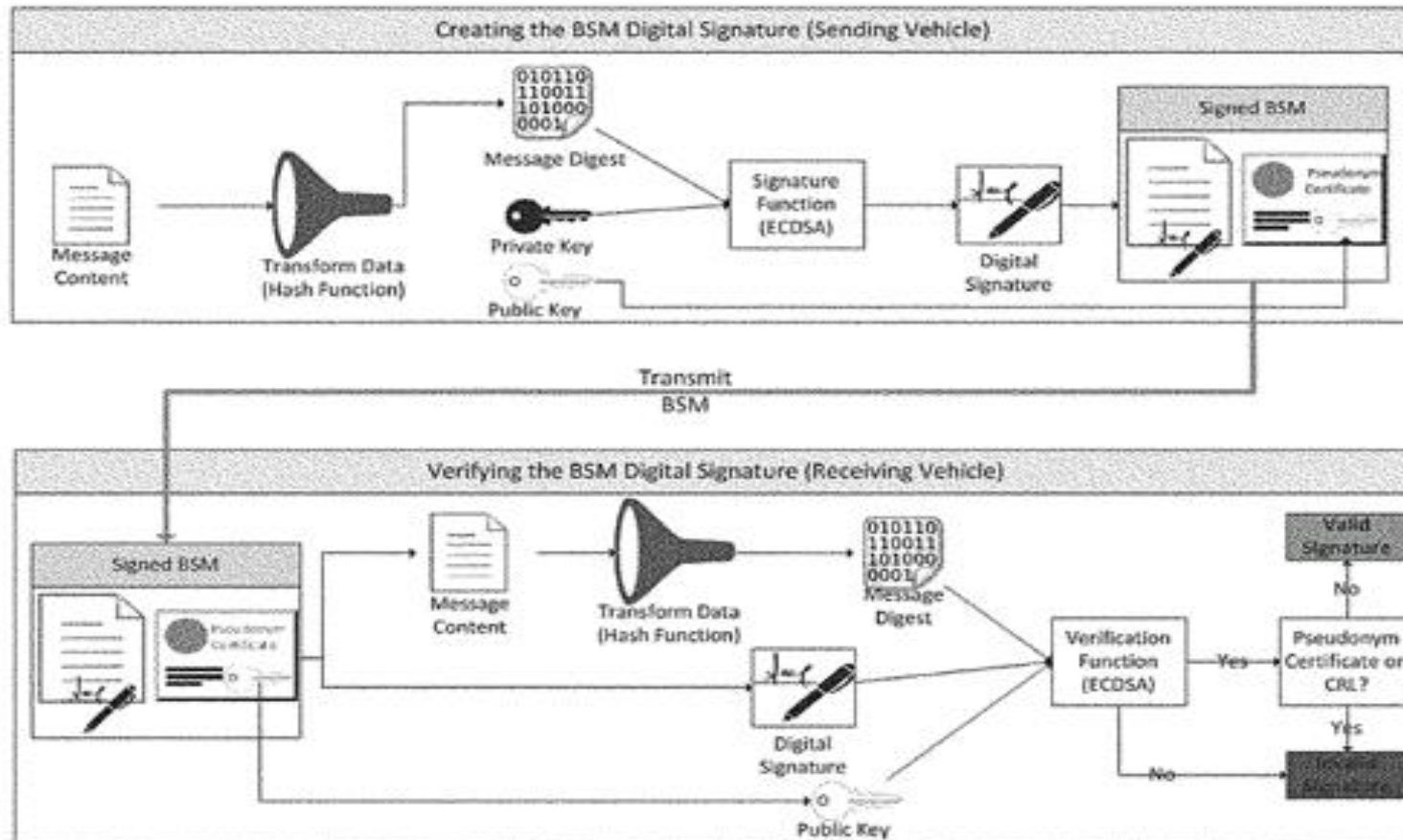


Update EEs with New Certificates

# SCMS Cryptographic Methods (NHSTA NPRM pg 3908)

## Transmitting a digitally signed Basic Safety Message

Federal Register / Vol. 82, No. 8 / Thursday, January 12, 2017 / Proposed Rules



The V2V device generates the private key & public keys. The public key is sent to the SCMS to incorporate into a certificate that is signed by the PCA. The private key is always kept secret with the V2V device. The private key is vital to the signing process and must be kept secured at all times. 8/28/2017 39



# SCMS Cryptographic Test Vectors

<https://stash.campilc.org/projects/SCMS/repos/crypto-test-vectors>

**Linkage Values** - To support efficient revocation, end-entity certificates contain a linkage value (LV), which is derived from (cryptographic) linkage seed material. Publication of the seed is sufficient to revoke all certificates belonging to the revoked device, but without the seed an eavesdropper cannot tell which certificates belong to a particular device.

**Butterfly Expansion Function** - Butterfly Keys are a novel cryptographic construction that allow a device to request an arbitrary number of certificates, each with different signing keys and each encrypted with a different encryption key, using a request that contains only one verification public key seed and one encryption public key seed and two “expansion functions.

**Key Derivation Function, KDF2 with SHA-256** - test vectors of HMAC-SHA-256

**Message Authentication Code, MAC1 (HMAC) with SHA-256 - Message Authentication Code (MAC)** is a short piece of information used to authenticate a message and to provide integrity and authenticity assurances on the message.

**AES-CCM-128 Symmetric Authenticated Encryption [IEEE-1609.2] - Advanced Encryption Standard (AES)**, also known as Rijndael (its original name), is a specification for the encryption of electronic data established by the U.S. National Institute of Standards and Technology (NIST) in 2001

**ECDH Key Agreement** - Elliptic Curve Diffie-Hellman is a public-key primitive where two parties can compute a shared secret by exchanging public keys and employing them and the corresponding private keys in the computation

**ECIES Public-Key Encryption [IEEE-1609.2] - Elliptic Curve Integrated Encryption Scheme**, or **ECIES**, is a hybrid encryption system proposed by Victor Shoup in 2001. ECIES combines a Key Encapsulation Mechanism (KEM) with a Data Encapsulation Mechanism (DEM). The system independently derives a bulk encryption key and a MAC key from a common secret. Data is first encrypted under a symmetric cipher, and then the cipher text is MAC'd under an authentication scheme. Finally, the common secret is encrypted under the public part of a public/private key pair

**Implicit Certificate Generation and Public/Private Keys Reconstruction** - Implicit certificates are employed for pseudonym certificates, enrollment certificates, etc. They do not contain the subject's public key and are not signed by the issuer, as is the case with explicit certificates, rather they contain a public key reconstruction point that is used to reconstruct the public key of the subject knowing the public key of the issuer

# Table of Contents

- ▶ Introduction – A Writer’s Life (ITS Security and the SCMS VPKI)
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- ▶ Connected Car SCMS Use Cases and CAMP Wiki
- ▶ **A Security Model for Automotive Networking (ITS Services)**
- ▶ What If Questions for SCMS



# The ITS Automotive Networking Landscape

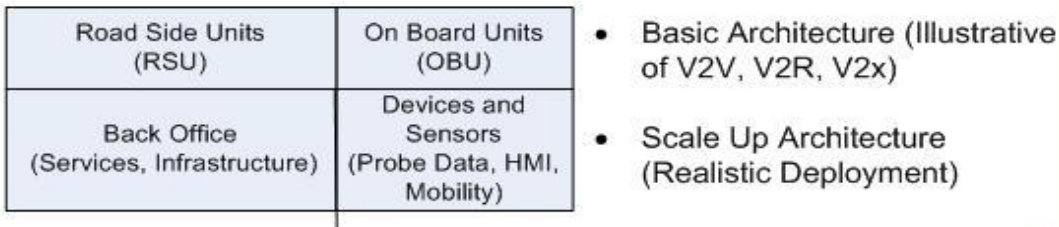
## ITS Services and Applications



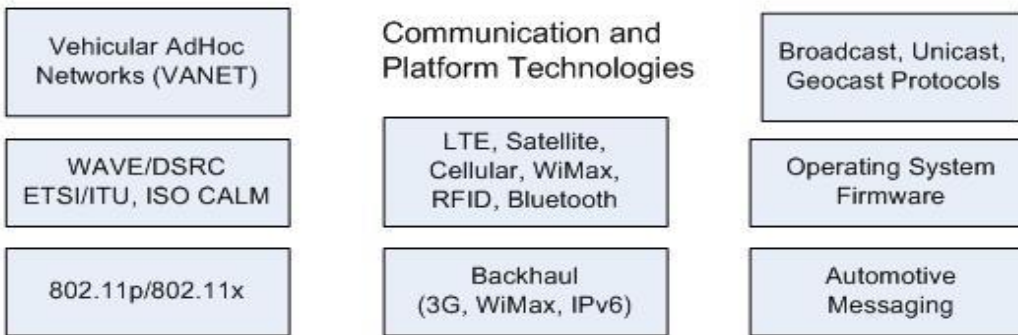
## Communication Platform



Include four basic components



Platform Characteristics across V2V, V2I, V2x  
(Why it is different and more challenging from traditional network platform?)



## ITS Implementations



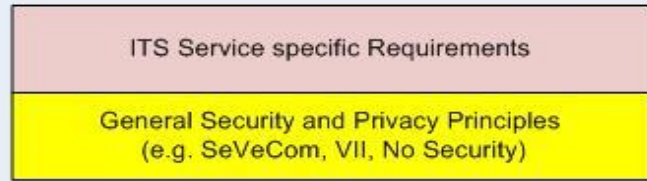
**ILLUSTRATIVE**

# Security and Privacy Framework

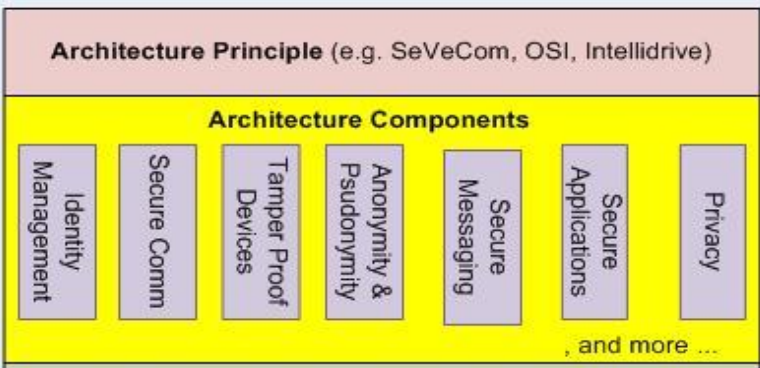
**Threat Models and Risk Assessment** (What are the risks and impact if security and privacy of a specific ITS Service is compromised?)

**Assurance Levels** (Defined criticality levels)

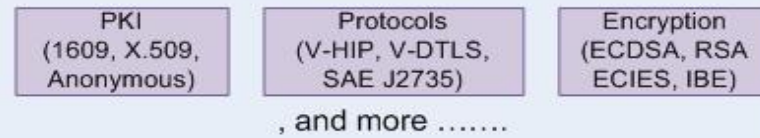
**Security and Privacy Requirements** (What needs to be done?)



**Security Architecture** (Solution Decision Blueprint)



**Technical Solutions** (incl. research contributions)



**Security Testing Methods**

# Secure Automotive Networking – an information portal

<http://securityfeeds.com/dwd.html>



## Secure Automotive Networking for ITS - A Work in Progress



### ITS (Vehicular Networks) Industry Around the World

- [ITS Automotive Networking Landscape \(Weil\)](#)

#### National Projects (US)

- [US DOT ITS Joint Program Office](#)
- [US DOT Connected Vehicle](#)
- [Connected Vehicle Reference Implementation Architecture \(CVRIA\)](#)
- [ITS ePrimer - Connected Vehicle](#)

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

- [US DOT CV Research 2017](#)
- [US DOT CV Pilot - New York City DOT Pilot](#)
- [US DOT CV Pilot - Tampa Bay THEA Pilot](#)
- [US DOT CV Pilot - Wyoming DOT Pilot](#)
- [US DOT CV Pilot Applications](#)
- [US DOT CV Pilot Publications](#)

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

- [SCMS CV Pilots Documentation \(2017\)](#)
- [SCMS CV Pilots - Requirements and Use Cases](#)
- [SCMS Misbehavior Detection Workshop](#)
- [A security credential management system for V2V communications](#)
- [VPKI Hits the Highway \(IT Professional\)](#)

### Connected Vehicle (CV) 2011 - Safety Pilot Program (6 Venues)

- [US DOT Safety Pilot \(Connected Vehicle\)](#)
- [US DOT CV Standards](#)
- [DOT Safety Pilot - V2V Communications for Safety](#)
- [CV Certificate Management Entities](#)
- [CV Secure Environment - AASHTO CV Deployment Analysis Report](#)

### Vehicle Safety Communications (VSC-A) 2009 Project Results (US)

- [NHTSA Office of Crash Avoidance: TechPubs](#)
- [VSC-A Final Report: September 2011](#)
- [VSC-A System Design & Objective Test: September 2011](#)
- [VSC-A Communications and Positioning: September 2011](#)
- [VSC-A Security: September 2011](#)

### Vehicle Infrastructure Integration (VII) 2009 Project Results

- [US IntelliDrive Project \(VII\)](#)
- [VII POC Results and Findings - Infrastructure\(HTML\)](#)
- [VII POC Results and Findings Summary-Vehicle\(HTML\)](#)
- [Vehicle Infrastructure Integration Proof-of-Concept Executive Summary](#)
- [Final Report: Vehicle Infrastructure Integration Proof-of-Concept Results and Findings](#)

### State Projects

- [US ITS Resources](#)
- [Michigan ITS](#)
- [California PATH](#)
- [ITS Florida - Connected Vehicle](#)
- [ITS Virginia](#)
- [Rocky Mountains ITS](#)



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# What If – SCMS Functional Requirements for all use cases are met?

<https://wiki.campilc.org/display/SCP/Requirements+by+Use+Case>

To support implemented from an end entities ([EE](#)) perspective to fulfill a major feature of the SCMS. A use case might comprehend multiple steps from a system's architecture perspective that can be run without interference with each other to return a partial result of the overall use case. In general, steps need to be executed in the given order to fulfill the use case. For example, [Use Case 3: OBE Pseudonym Certificates Provisioning](#) describes all necessary processes to equip an OBE with pseudonym certificates. It comprehends five steps that are coherent but self-contained:

[Step 3.1: Request for Pseudonym Certificates](#)

[Step 3.2: Pseudonym Certificate Generation](#)

[Step 3.3: Initial Download of Pseudonym Certificates](#)

[Step 3.4: Schedule Generation of Subsequent Batch of Pseudonym Certificates](#)

[Step 3.5: Top-off Pseudonym Certificates](#)

## **OBE Use Cases**

The following chapters are about OBE requirements. These are the main use cases for OBEs, but there are requirements throughout all chapters for [11. Backend Management](#) are requirements about what an OBE needs to do if a root CA is revoked or a new root CA is introduced to the system.

[Use Case 2: OBE Bootstrapping \(Manual\)](#)

[Use Case 3: OBE Pseudonym Certificates Provisioning](#)

[Use Case 8: OBE Pseudonym Certificate Revocation](#)

[Use Case 19: OBE Identification Certificate Provisioning](#)

## **RSE Use Cases**

The following chapters are about RSE requirements. These are the main use cases for RSEs, but there are requirements throughout all chapters for [11. Backend Management](#) are requirements about what an RSE needs to do if a root CA is revoked or a new root CA is introduced to the system.

[Use Case 12: RSE Bootstrapping \(Manual\)](#)

[Use Case 13: RSE Application Certificate Provisioning](#)

[Use Case 16: RSE Application and OBE Identification Certificate Revocation](#)

**Common EE Use Cases**th EE types should implement the following chapters:

[Use Case 5: Misbehavior Reporting](#)

[Use Case 6: CRL Download](#)

[Use Case 11: Backend Management](#) (CA compromise recover strategy)

[Use Case 18: Provide and Enforce Technical Policies](#)

[Use Case 20: EE Re-Enrollment](#)

# How are Provider Service IDs (PSIDs) Provisioned and Deployed?

[https://www.its.dot.gov/pilots/pdf/TechAssistWebinar\\_Template\\_SCMSIIv4.pdf](https://www.its.dot.gov/pilots/pdf/TechAssistWebinar_Template_SCMSIIv4.pdf)

## Applications Supported by PSID



### SPaT & MAP

Red Light Violation Warning

Pedestrian in Signalized Crosswalk Warning

Mobile Accessible Pedestrian Signal System

### Basic Safety Message

Probe Enabled Traffic Monitoring

Intelligent Traffic Signal System In-Vehicle Information Potential

Vehicle Turning Right in Front of Bus Warning

Forward Collision Warning

Emergency Electronic Brake Light

Blind Spot Warning

Lane Change Warning / Assist

Intersection Movement Assist

Stationary Vehicle Ahead

Do Not Pass Warning

### Traffic Signal Preemption

Transit Signal Priority / Special Vehicles

### Speed Harmonization

Modified Eco-Speed Harmonization

Speed Harmonization

### Basic Information Message

Curve Speed Warning

Reduced Speed / Work Zone

Spot Specific Weather Warning

Variable Speed Limits

Work Zone Alerts

Truck Restrictions

Provider Service Identifiers (PSIDs) & SCMS

- PSID values are included in the security certificates generated by the SCMS
- PSID values indicate which applications a message is authorized to support
- PSIDs are described in IEEE1609 standards

# Applications by Connected Vehicle Test Bed

## ICF/Wyoming

Work Zone Warnings
Spot Weather Impact Warning
<b>Situational Awareness</b>
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) *
<b>Stationary Vehicle Ahead (SVA) *</b>
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

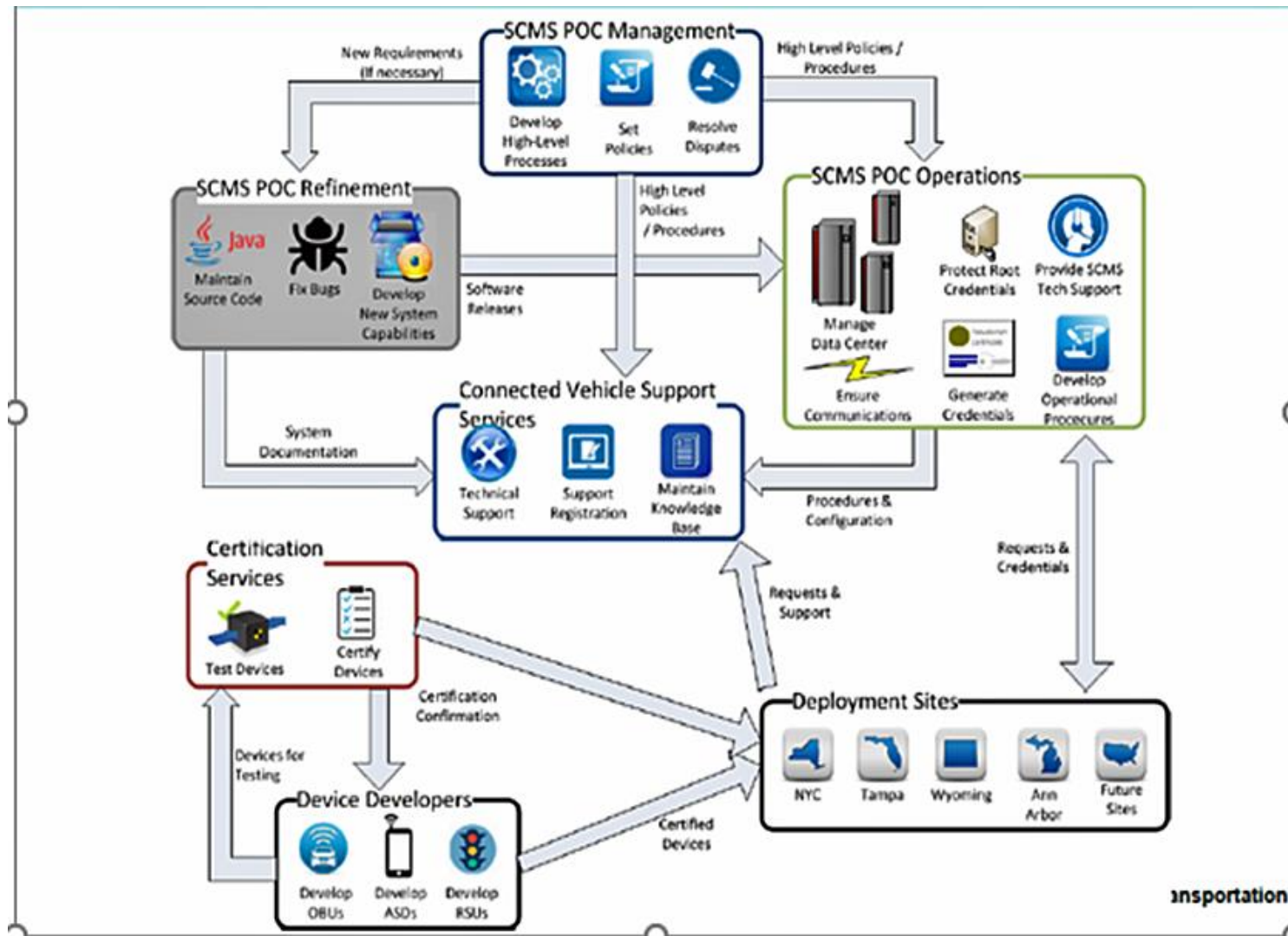
•\*Deployment of applications is dependent upon Final ConOps and funding





# What do SCMS Management and Operations Look Like?

[https://www.its.dot.gov/pilots/pdf/TechAssistWebinar\\_Template\\_SCMSIIv4.pdf](https://www.its.dot.gov/pilots/pdf/TechAssistWebinar_Template_SCMSIIv4.pdf)



# If they build it, will they come?

## Green Hills Software Integrity Security Services (ISS)

<http://www.ghs.com/go/iss-ces>



## Leading the Embedded World



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### News & Press

#### INTEGRITY Security Services Delivers Certificates for V2V Communication

ISS launches new service for secure generation and delivery of production V2X/C2X certificates

**SANTA BARBARA, CA — December 13, 2016 —** In response to the US Department of Transportation (US DOT) announcement of New Proposed Rule Making (NPRM), Docket no. NHTSA-2016-0126, INTEGRITY Security Services (ISS), a Green Hills Software company, today announced the launch of the ISS V2X/C2X Certificate Managed Service (CMS). The ISS CMS is the first and only production-grade system available to deliver vehicle-to-anything (V2X) and European car-to-anything (C2X) certificates to automotive and smart city product manufacturers and operators worldwide.

The ISS CMS incorporates several years' experience developing the Security Credential Management Systems (SCMS) for US DOT / Crash Avoidance Metrics Partners LLC (CAMP)—making it the de facto standard in V2X credentials. The ISS service eliminates SCMS overhead by providing direct delivery of CAMP, IEEE 1609.2-2016, ETSI TS 103 097 compliant certificates to devices in manufacturing, as well as, over-the-air certificate top-offs over the vehicles' lifetime.

"Certificates are required to securely communicate safely between different vehicle makes and models. The ISS CMS is an out-of-the-box solution for production certificates, so the safety benefits of V2X communication may be realized as soon as possible," said David Sequino, vice president and general manager of INTEGRITY Security Services. "The ISS team provides the expertise OEMs need to meet the NPRM guidance at the lowest risk and cost."

ISS CMS is being launched as part of a complete V2X networking solution including all hardware, protocols stacks, and certificates required for V2V and C2C On Board Units (OBUs). OBUs are pre-provisioned by CMS with enrollment certificates, initial pseudonym certificates blocks, and current CRL. Wireless connectivity provides the link between the OBUs and the ISS CMS for all certificate top-offs and CRL updates.

ISS plans to demonstrate ISS CMS and the V2V networking at CES 2017, in Las Vegas, Nevada. The demonstration features the provisioning of certificates over wireless networks. Visit [www.ghs.com/go/iss-ces](http://www.ghs.com/go/iss-ces) to request a meeting.

#### **To Request More Information**

Visit [www.ghsiss.com/v2x](http://www.ghsiss.com/v2x) to request a quote for certificates.

# If they build it, will they come?

onBoardSecurity(Aerolink) - <https://www.onboardsecurity.com/products/aerolink>



## SECURITY & PRIVACY FOR CONNECTED CARS

**A**erolink is the industry-leading implementation of high speed communications security for connected vehicles based on the IEEE 1609.2 standard. First deployed in 2007, Aerolink has been continually evolving in parallel with the evolving standards, to remain the most up-to-date implementation of message authentication and user privacy for the Connected Vehicle system.

### KEY FEATURES

OnBoard Security works within the key sectors of Intelligent Transportation Systems, from standards bodies to chip designers to on board equipment manufacturers, infrastructure providers and vehicle manufacturers. As an active and influential practitioner in this field, and as members of organizations such as **ITS America, OmniAir, Car2Car Communications Consortium** and **ETSI**, we have a deep understanding of the technical specifications and interoperability required to make highly secure platforms for Vehicle-to-Vehicle and Vehicle-to-Infrastructure solution providers.

### BATTLE TESTED

Aerolink was used in the majority of light vehicles in the Safety Pilot Model Deployment and is securing communications in the 2017 Cadillac CTS, the first production deployment of V2V technology.

### HIGH SPEED SECURITY

Aerolink's patent-pending technology provides the optimal mix of security and performance.

### PORTABLE & INTEROPERABLE

### Unrivaled Expertise

As the editor of the IEEE 1609.2 standard for Connected Vehicle security, OnBoard Security has considerable experience in the development of security standards and is uniquely placed to ensure conformance with this very important specification from day one of the program.

# NXP Roadtrip - June 2015

<http://www.nxp.com/pages/roadlink-technology:ROADLINK-TECH?fsrch=1&sr=3&pageNum=1>



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## RoadLINK™ Technology



### RoadLINK – embracing intelligent transport's future

Intelligent transport system (ITS) technology allows cars to communicate with each other as well as with intelligent traffic infrastructures. The IEEE802.11p Wireless Access in Vehicular Environments (WAVE) standard allows cars to securely connect to each other as well as to infrastructure, helping to reduce road accidents, saving people's lives, reducing CO2 emissions and improving traffic flow.

RoadLINK technology, developed by NXP® and [Cohda Wireless](#), exchanges messages reliably across an extended range at high speed, cutting 'time to react' and communicating potential hazards and safety-critical scenarios significantly faster than conventional applications.

The leader in V2X trials, RoadLINK offers the robust and secure foundation for creating ITS all around the world. Supporting both DSRC (IEEE 802.11p) and Wi-Fi (802.11abgn) wireless standards, RoadLINK can upload and access data via home Wi-Fi and hotspot connections.

### Safety and security combined

Technological innovations often lead to changes in our driving styles, whether it's start-stop technology, parking assist or blind-spot detection. Fast becoming the proven ITS technology of choice, RoadLINK V2V and V2I implementations will make driving safer, smoother, less frustrating and more eco-friendly, as well as open up fruitful commercial services.

The robust RoadLINK platform supports accepted standards (such as IEEE802.11p) and various OEM configurations, and offers a high level of security. Flexible and scalable, it enables a diverse range of applications, from traffic control to commercial use-cases such as toll collection and driver services.

### Related Technologies

- [Software-defined-radio Technology](#)

- If vehicles could talk to each other
- Convenience & economy of V2I systems
- A driver for novel services

# NXP Roadtrip - June 2015

Freescale [-http://cache.nxp.com/docs/en/supporting-information/ftf-acc-f1106.pdf?fsrch=1&sr=5&pageNum=1](http://cache.nxp.com/docs/en/supporting-information/ftf-acc-f1106.pdf?fsrch=1&sr=5&pageNum=1)



## DSRC Standards

- DSRC applicable Standards are:
  - IEEE 1609.2 Security
  - IEEE 1609.3 Networking Services
  - SAE J2735 DSRC Message Set Dictionary
- J2735 performance/operation requirements covered by J2945
  - J2945.0 will cover general requirements
  - J2945.1 will cover Basic Safety Message requirements
    - e.g. sensor accuracy requirements to populate the BSM
  - J2945.2 will cover other messages

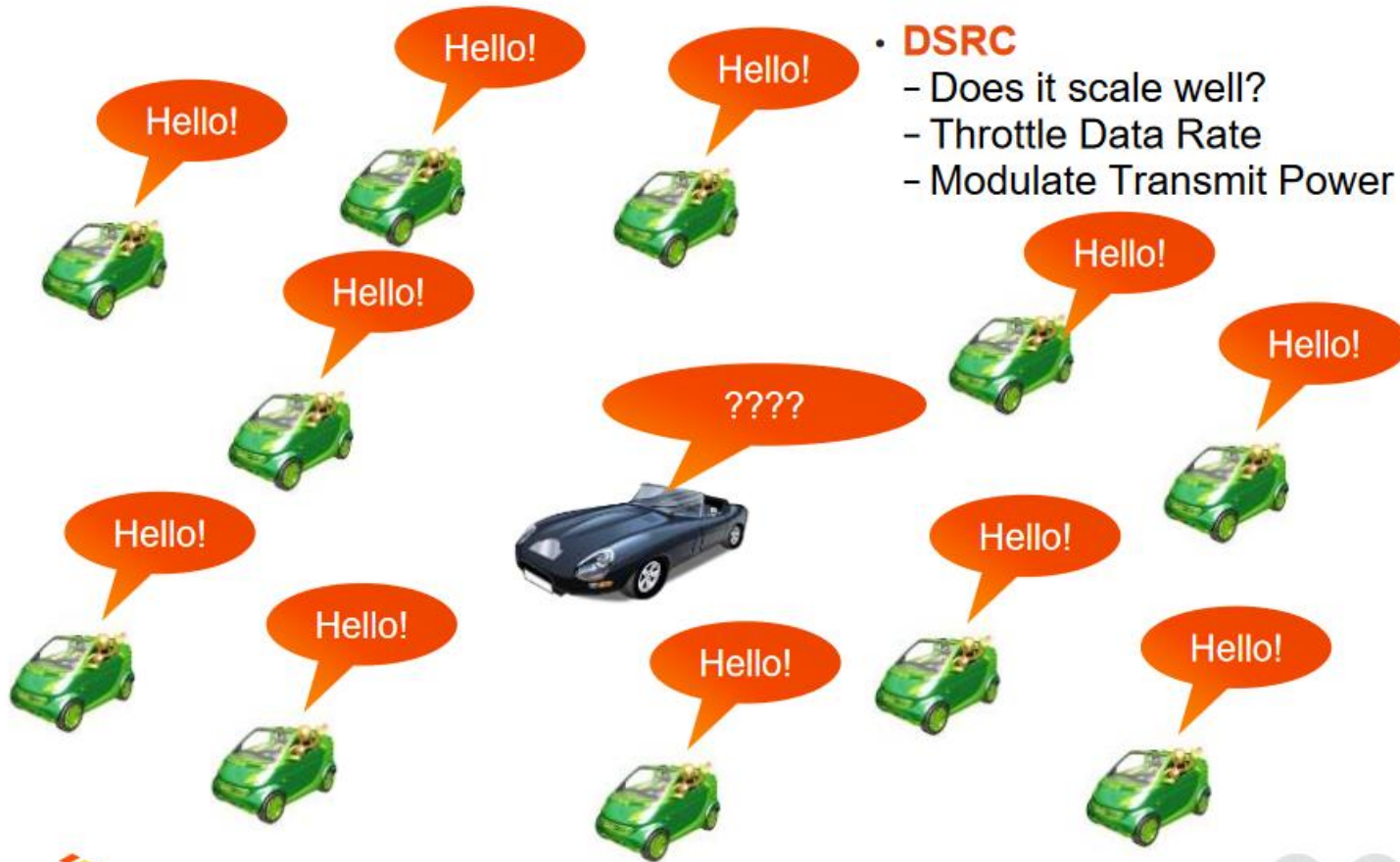
Protocol Overhead
<b>J2735 Basic Safety Message</b>
Part I – Mandatory position, motion, control, veh. size
Part II – Optional Reduced data rate, event based flags, OEM options
ECDSA Signature and Certificate

# Does it scale?

Freescale - <http://cache.nxp.com/docs/en/supporting-information/ftf-acc-f1106.pdf?fsrch=1&sr=5&pageNum=1>



## Vehicle-to-Vehicle (Internet of Cars)



- **DSRC**
  - Does it scale well?
  - Throttle Data Rate
  - Modulate Transmit Power



External Use | 18

#FTF2015

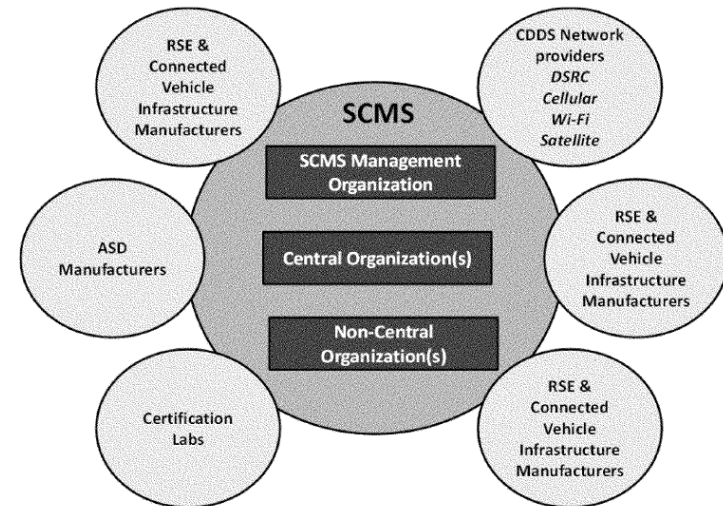


# What If – Models for Industry Self Regulation (Risk Models)?

In analyzing SCMS governance options, NHTSA and its research partners have investigated a variety of industries with characteristics similar to those seen as critical for a V2V SCMS governance model, including security, privacy protection, stability, sustainability, multi-stakeholder representation and technical complexity. How risk was managed in the context these models. Some of the industries researched included:

- Internet Corporation for Assigned Names and Numbers (ICANN)
- DTE Energy Company
- Aeronautical Radio Incorporated (ARINC)
- End of Life Vehicle Solutions Corporation (ELVS)
- The FAA's Next Gen Air Transportation System
- The FRA's Positive Train Control
- Smart Grid
- The Rail/Transit Train Control Systems (ATC and CBTC)
- Medical Devices failure and liability
- Security in nuclear industry and liability
- Warning/Signal Failures
- UAVs
- HIPAA/Health Care industry/
- Electronic Health Records (EHRs)
- CONNECT system

Federal Register / Vol. 82, No. 8 / Thursday, January 12, 2017 / Proposed Rules



\*\* National Highway Traffic Safety Administration (NHTSA), Department of Transportation (DOT) Notice of Proposed Rulemaking, 'Federal Motor Vehicle Safety Standard (FMVSS), No. 150, to mandate vehicle-to-vehicle (V2V) communications for new light vehicles and to standardize the message and format of V2V transmissions', Federal Register Vol 82, No 87, Jan 12, 2017,

**Thank you for joining us!**

Security for Vehicular Networks Website - <http://securityfeeds.com/dwd.html>





# References Used in This Presentation

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# Denver COMSOC Chapter – Vehicular Networks

<http://sites.ieee.org/denver-com/vehicular-networks-workshop-globecom-2015/>



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## Welcome

**Mission : Promote knowledge and growth of communication technologies in the Denver-Boulder Area.**

The Denver ComSoc is a community comprised of a diverse group of industry professionals with a common interest in advancing all communications technologies.

## Vehicular Networks Workshop – GLOBECOM 2015

[GLOBECOM 2015 Vehicular Networks Workshop – Tim Weil, Principal, SecurityFeeds, LLC](#)

With the prospect of deployment of vehicular networks, there are challenges and debates. Viable deployment models, pros and cons of different air interfaces, spectrum sharing issues and security a privacy concerns are but a few. The recent Vehicular Networks Industry Workshop at IEEE GLOBECOM 2015 was an covered multiple aspects of opportunities and challenges with vehicular networks by first describing the near-term opportunities for deployment, not only with Dedicated Short Range Communications (DSRC) but also with evolving concepts in LTE, spectrum sharing across unlicensed technologies, up to and including 5G. other topics included network security and privacy issues, and and presentations describing current research in network simulation, vehicular cloud computing and vehicle telematics. This was the fourth Vehicular Networks program I have hosted at GLOBECOM. Previously workshops (2007-2009) had focused primarily on the technology of Dedicated Short Range Communication (DSRC/802.11p) and the emerging IEEE 1609 standards for Wireless Access to Vehicular Environments (WAVE). This year's program was attended by twenty five international members of industry and academia and featured 6 speakers at the workshop, including these presentations –

- [Dedicated Short Range Communication \(DSRC\) – Ready for Prime Time \(Walton Fehr – US DOT\)](#)
- [5.9 GHz Spectrum Sharing – \(John Kenney – Toyota ITC\)](#)
- [Is there LTE in V2V? \(Jim Misener – Qualcomm\)](#)
- [Why We Need a New Paradigm for Securing the Internet of Vehicles \(Tao Zhang – Cisco\)](#)
- [Research and Prototyping Activities of Dedicated Short Range Communications \(DSRC\) at the University of Michigan \(Weidong Xiang – University of Michigan\)](#)
- [Towards the Vehicular Cloud – Falko Dressler: Professor of Computer Science, University of Paderborn](#)

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