Connected Vehicle and Intelligent Transportation Systems

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

Tim Weil – CISSP/CCSP, CISA, PMP
Alcohol Monitoring Systems
IEEE Senior Member
Member COMSOC, ITS Societies

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 – Timothy Weil

**Editor, IEEE IT Professional magazine**

Cloud Security, RBAC, Identity Management, Vehicular Networks

Verified email at: secureit.ieee.org – Home page

<table>
<thead>
<tr>
<th>Title</th>
<th>Cited by</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicular networking: A survey and tutorial on requirements, architectures, challenges, standards and solutions</td>
<td>208</td>
<td>2011</td>
</tr>
<tr>
<td>Adding attributes to role-based access control</td>
<td>306</td>
<td>2010</td>
</tr>
<tr>
<td>ABAC and RBAC: scalable, flexible, and audituable access management</td>
<td>53</td>
<td>2013</td>
</tr>
<tr>
<td>Final report: Vehicle infrastructure integration (VI) proof of concept (POC) test: Executive summary</td>
<td>26</td>
<td>2009</td>
</tr>
<tr>
<td>Final report: Vehicle infrastructure integration (VI) proof of concept (POC) test: Executive summary</td>
<td>14</td>
<td>2009</td>
</tr>
</tbody>
</table>

IEEE Book Scanner: Above the Fold (Mostly)

**Stories in Engineering and Science (2005-2009)**

In my tenure as Washington DC Editor of the IEEE SCANNERS (2005-2009) and AdCom officer (2007-2009), I had the wonderful chance to tour the science, engineering, and technology world of IEEE as a touring reporter and editor of this newsletter. 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 journey of science and engineering.

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

- **Nov-Dec 2009 - Celebrating the 150th IEEE Anniversary Year (UCD)**
- **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 - Fasing The Giants**
- **Nov-Oct 2008 - A Tour of NASA Goddard Test and Integration Facility (pg. 4)**
- **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 PanelReviews Robo Technologies**
- **May-June 2005 - Globecom 2005 Conference Builds a Program**
- **Sept-Oct 2005 - COMSOC Members Tour the IntellSat Satellite Center**
- **May-June 2005 - DCSSA Recognizes Jerry Gibson as Engineer of the Year**

**VPKI Hits the Highway**

Secure Communication for the Connected Vehicle Program

Tim Weil, SCANNERS
Introduction – USDOT ITS National Architecture (legacy)

http://local.iteris/cvria/html/about/connectedvehicle.html
Introduction – USDOT ITS National Architecture (ARC-IT)

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

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 questions 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:
  - **Security 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 flow, 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 model 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!
# 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.

<table>
<thead>
<tr>
<th>National ITS Architecture 7.1 Service Package</th>
<th>ARC-IT 8.0 Service Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short Name ▲</td>
<td>Name</td>
</tr>
<tr>
<td>AD1</td>
<td>ITS Data Mart</td>
</tr>
<tr>
<td>AD2</td>
<td>ITS Data Warehouse</td>
</tr>
<tr>
<td>AD3</td>
<td>ITS Virtual Data Warehouse</td>
</tr>
<tr>
<td>APTS01</td>
<td>Transit Vehicle Tracking</td>
</tr>
<tr>
<td>APTS02</td>
<td>Transit Fixed-Route Operations</td>
</tr>
<tr>
<td>APTS03</td>
<td>Dynamic Demand Response Transit Operations</td>
</tr>
<tr>
<td>APTS04</td>
<td>Transit Fare Collection Management</td>
</tr>
<tr>
<td>APTS05</td>
<td>Transit Security</td>
</tr>
<tr>
<td>APTS06</td>
<td>Transit Fleet Management</td>
</tr>
<tr>
<td>APTS07</td>
<td>Multi-modal Coordination</td>
</tr>
<tr>
<td>APTS08</td>
<td>Transit Traveler Information</td>
</tr>
<tr>
<td>APTS09</td>
<td>Transit Signal Priority</td>
</tr>
<tr>
<td>APTS10</td>
<td>Transit Passenger Counting</td>
</tr>
<tr>
<td>APTS11</td>
<td>Multi-modal Connection Protection</td>
</tr>
</tbody>
</table>
# Introduction – ITS Use Cases Services and Applications

## CONNECTED VEHICLE APPLICATIONS

<table>
<thead>
<tr>
<th><strong>V2I Safety</strong></th>
<th><strong>Environment</strong></th>
<th><strong>Mobility</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Light Violation Warning</td>
<td>Eco-Approach and Departure at Signalized Intersections</td>
<td>Advanced Traveler Information System</td>
</tr>
<tr>
<td>Curve Speed Warning</td>
<td>Eco-Traffic Signal Timing</td>
<td>Intelligent Traffic Signal System (i-SIG)</td>
</tr>
<tr>
<td>Stop Sign Gap Assist</td>
<td>Eco-Traffic Signal Priority</td>
<td>Signal Priority (transit, freight)</td>
</tr>
<tr>
<td>Spot Weather Impact Warning</td>
<td>Connected Eco-Driving</td>
<td>Mobile Accessible Pedestrian Signal System (PED-SIG)</td>
</tr>
<tr>
<td>Reduced Speed/Work Zone Warning</td>
<td>Wireless Inductive/Resonance Charging</td>
<td>Emergency Vehicle Preemption (PREEMPT)</td>
</tr>
<tr>
<td>Pedestrian in Signalized Crosswalk Warning (Transit)</td>
<td>Eco-Lanes Management</td>
<td>Dynamic Speed Harmonization (SPD-HARM)</td>
</tr>
<tr>
<td><strong>V2V Safety</strong></td>
<td>Eco-Speed Harmonization</td>
<td>Queue Warning (Q-WARN)</td>
</tr>
<tr>
<td>Emergency Electronic Brake Lights (EEBL)</td>
<td>Eco-Cooperative Adaptive Cruise Control</td>
<td>Cooperative Adaptive Cruise Control (CACC)</td>
</tr>
<tr>
<td>Forward Collision Warning (FCW)</td>
<td>Eco-Traveler Information</td>
<td>Incident Scene Pre-Arrival Staging</td>
</tr>
<tr>
<td>Intersection Movement Assist (IMA)</td>
<td>Eco-Ramp Metering</td>
<td>Guidance for Emergency Responders (RESP-STG)</td>
</tr>
<tr>
<td>Left Turn Assist (LTA)</td>
<td>Low Emissions Zone Management</td>
<td>Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)</td>
</tr>
<tr>
<td>Blind Spot/Lane Change Warning (BSW/LCW)</td>
<td>AFV Charging / Fueling Information</td>
<td>Emergency Communications and Evacuation (EVAC)</td>
</tr>
<tr>
<td>Do Not Pass Warning (DNPW)</td>
<td>Eco-Smart Parking</td>
<td>Connection Protection (T-CONNECT)</td>
</tr>
<tr>
<td>Vehicle Turning Right in Front of Bus Warning (Transit)</td>
<td>Dynamic Eco-Routing (light vehicle, transit, freight)</td>
<td>Dynamic Transit Operations (T-DISP)</td>
</tr>
<tr>
<td><strong>Agency Data</strong></td>
<td>Eco-iCM Decision Support System</td>
<td>Dynamic Ridesharing (D-RIDE)</td>
</tr>
<tr>
<td>Probe-based Pavement Maintenance</td>
<td><strong>Road Weather</strong></td>
<td>Freight-Specific Dynamic Travel Planning and Performance</td>
</tr>
<tr>
<td>Probe-enabled Traffic Monitoring</td>
<td>Motorist Advisories and Warnings (MAW)</td>
<td><strong>Smart Roadside</strong></td>
</tr>
<tr>
<td>Vehicle Classification-based Traffic Studies</td>
<td>Enhanced MDSS</td>
<td>Wireless Inspection</td>
</tr>
<tr>
<td>CV-enabled Turning Movement &amp; Intersection Analysis</td>
<td>Vehicle Data Translator (VDT)</td>
<td>Smart Truck Parking</td>
</tr>
<tr>
<td>CV-enabled Origin-Destination Studies</td>
<td>Weather Response Traffic Information (WxTINFO)</td>
<td></td>
</tr>
<tr>
<td>Work Zone Traveler Information</td>
<td><strong>Mobility</strong></td>
<td></td>
</tr>
</tbody>
</table>

Connected Vehicle Pilot Deployment Program, V. Fessmann, US DOT ITS JPO

12/6/2017
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. 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 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.

Wyoming (WY) DOT Connected Car Pilot
https://wydotev.wyoroad.info/

Table 1. WYDOT Pilot Site Proposed CV Applications

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

Table 2. WYDOT Pilot Site Proposed CV Devices

<table>
<thead>
<tr>
<th>ICF/WYDOT - Devices</th>
<th>Estimated Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadside Unit (RSU)</td>
<td>75</td>
</tr>
<tr>
<td>WYDOT Fleet Subsystem On-Board Unit (OBU)</td>
<td>100</td>
</tr>
<tr>
<td>Integrated Commercial Truck Subsystem OBU</td>
<td>150</td>
</tr>
<tr>
<td>Retrofit Vehicle Subsystem OBU</td>
<td>25</td>
</tr>
<tr>
<td>Basic Vehicle Subsystem OBU</td>
<td>125</td>
</tr>
<tr>
<td>Total Equipped Vehicles</td>
<td>400</td>
</tr>
</tbody>
</table>

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.
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. The deployment will include approximately 310 signalized intersections for vehicle-to-infrastructure (V2I) technology using DSRC technology.
# Applications by Connected Vehicle Test Bed

<table>
<thead>
<tr>
<th>Tech Day VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applications by Connected Vehicle Test Bed</td>
</tr>
</tbody>
</table>

## 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

## 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) *

## 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

## 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**

U.S. Department of Transportation

---

12/6/2017
### Federal Highway Administration Awards Nearly $54 Million in Advanced Transportation and Congestion Management Technologies Grants – Oct 2017 (1 of 2)

<table>
<thead>
<tr>
<th>State</th>
<th>Project Name</th>
<th>Recipient/Project Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AZ</td>
<td>Loop 101 Mobility Project</td>
<td>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.</td>
</tr>
<tr>
<td>CA</td>
<td>Global Opportunities at the Port of Oakland Freight Intelligent Transportation System</td>
<td>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.</td>
</tr>
<tr>
<td>FL</td>
<td>Connecting the East Orlando Communities</td>
<td>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.</td>
</tr>
<tr>
<td>ID</td>
<td>SMART Arterial Management</td>
<td>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.</td>
</tr>
<tr>
<td>MI</td>
<td>Improving Safety and Connectivity in Four Detroit Neighborhoods</td>
<td>City of Detroit. The funds will be used to increase mobility for residents in four target neighborhoods with high-traffic corridors.</td>
</tr>
<tr>
<td>OH</td>
<td>Connecting Cleveland Project</td>
<td>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.</td>
</tr>
</tbody>
</table>
Federal Highway Administration Awards Nearly $54 Million in Advanced Transportation and Congestion Management Technologies Grants – Oct 2017 (2 of 2)

<table>
<thead>
<tr>
<th>State</th>
<th>Project Name</th>
<th>Recipient/Project Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC</td>
<td>Greenville Automated (A-Taxi) Shuttles</td>
<td>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.</td>
</tr>
<tr>
<td>TX</td>
<td>The Texas Connected Freight Corridors Project</td>
<td>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.</td>
</tr>
<tr>
<td>VA</td>
<td>Truck Reservation System and Automated Work Flow Data Model</td>
<td>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.</td>
</tr>
<tr>
<td>WA</td>
<td>Multimodal Integrated Corridor Mobility for All</td>
<td>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.</td>
</tr>
</tbody>
</table>
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

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 to 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) and vehicle 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
Taxonomy of Use Cases

Vehicle-to-X

Non-Safety
- Comfort
  - Contextual Information
  - Entertainment
- Traffic Information Systems
  - Optimal Speed Advisory
  - Congestion, Accident Information

Situation Awareness
- Adaptive Cruise Control
- Blind Spot Warning
- Warning Messages
  - Traffic Light Violation
  - Electronic Brake Light

1). F. Dressler, C. Sommer, Vehicular Networking
Taxonomy of Use Cases

Vehicle-to-X

Non-Safety
- Many messages
- High data rate
- Low latency demands
- Low reliability demands

Safety
- Few messages
- Small packet size
- High latency demands
- High reliability demands

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

Vehicle Based Data and Availability, B. Cronin, US DOT ITS JPO, 2012
Today’s connected technologies are making transportation safer and more convenient. 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)

- **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

Source: FCC Report and Order FCC 03-321
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 Std 1609.0-2013** – IEEE Trial-Use Standard for Wireless Access in Vehicular Environments (WAVE) - Architecture


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 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

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.
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.


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)

Private Vehicles Receiving BSMs from DSRC and non-DSRC Sources

Vehicle Based Data and Availability, B. Cronin, US DOT ITS JPO, 2012
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


12/6/2017 35
<table>
<thead>
<tr>
<th>Project name</th>
<th>Period</th>
<th>External funding</th>
<th>Project information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car-to-Car Communication Consortium (C2C-CC)</td>
<td>Ongoing</td>
<td>N/A</td>
<td>Development of a European industry standard for VC communication systems, safety applications prototyping and demonstration, harmonisation of VC standards worldwide, realistic deployment strategies and business models, <a href="http://www.car-2-car.org">http://www.car-2-car.org</a></td>
</tr>
<tr>
<td>EU-ICT ICTV</td>
<td>Ongoing</td>
<td>N/A</td>
<td>Standards activities to support the development and implementation of intelligent transportation systems, <a href="http://portal.europa.eu/Portal_CommonEntry.asmx">http://portal.europa.eu/Portal_CommonEntry.asmx</a></td>
</tr>
<tr>
<td>MIRROR</td>
<td>Ongoing</td>
<td>N/A</td>
<td>Standard for smart access in vehicular environments (SAFE) — Resource-managed, physical and medium access control, security services, networking services, multimedia management for V2I and V2V communication, <a href="http://www.etsi.org/technologies/guidelines/charts/apz/chapter300.html">http://www.etsi.org/technologies/guidelines/charts/apz/chapter300.html</a></td>
</tr>
<tr>
<td>InVIdive (Previously Vehicular - VIG)</td>
<td>2005–2006</td>
<td>Department of Transportation USA</td>
<td>Initiative of the ITS Joint Program Office (JPO) at the Dept. of Transportation and Innovative Technology Administration (ITA): VC technologies and applications, V2X, V2X mobility, and policy research, <a href="http://www.invidive.org">http://www.invidive.org</a></td>
</tr>
<tr>
<td>CAMPSYS-2</td>
<td>2005–2009</td>
<td>Department of Transportation USA</td>
<td>Cooperative Intersection Collision Avoidance System — Violations (CICAS-V); Emergency Vehicle Electronic Brake lights (EEBEL); Vehicle Safety Communications — Applications (VSC-A)</td>
</tr>
<tr>
<td>Piacenta</td>
<td>2008–2011</td>
<td>European Union</td>
<td>Privacy Enabled Capability for Co-operative systems and Safety Applications (PREDOSA) is to demonstrate that co-operative systems can comply with future privacy regulations by demonstrating that an example application can be endowed with mechanisms for suitable privacy protection of location-related data, <a href="http://www.piacentra.org">http://www.piacentra.org</a></td>
</tr>
<tr>
<td>Oversee</td>
<td>2010–2012</td>
<td>European Union</td>
<td>Own Vehicular Secure Platform — 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 to vehicles; <a href="http://www.oversee-project.com">http://www.oversee-project.com</a></td>
</tr>
<tr>
<td>Dilare-C2X</td>
<td>2011–2014</td>
<td>European Union</td>
<td>The objective of the DRIVE C2X (Integrated Project) is to carry out a 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</td>
</tr>
<tr>
<td>Preserve</td>
<td>2011–2016</td>
<td>European Union</td>
<td>The goal of PRESERVE (Preparing Secure Vehicle-to-IC Communication Systems) is to bring secure and privacy protected V2X communication closer to reality by providing and field testing a secure, privacy and privacy sub-system for V2X system; <a href="http://www.preserve-project.eu">http://www.preserve-project.eu</a></td>
</tr>
<tr>
<td>Connected Car Safety Flex (CCS)</td>
<td>2012–2014</td>
<td>Department of Transportation USA</td>
<td>The objective of the SPMD was to support the evaluation of dedicated short-range communication technology for V2X safety applications, which operate at 5.9 GHz in an urban, non-urban, and rural environment. The main focus was to collect data to support (1) the functional evaluation of V2X 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 possibly operating concept</td>
</tr>
</tbody>
</table>

Recent EU ITS Security and Privacy Related Projects

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

PRESERVE Objectives

- Integrated V2X security architecture and implementation based on SeVeCom, EVITA, and PRECIOUSA results
- Meet performance and cost requirements of current FOTs and future products, esp. build security ASIC
- Provide “ready-to-use” V2X security subsystem
- Solve open deployment and technical issues hindering standardization and product development

PRESERVE Vehicle Security Subsystems (EU)

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 (Program

- VPKI Hits the Highway (IT Professional): T. Woll
- US Department of Transportation (US DOT)
  - Connected Vehicle (CV) 2017-Pilot Deployment Program (3 Venues)
  - 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 EL Requirements and Specifications Supporting SCMS Software Release 1.1

- National Highway Transportation Safety Administration (NHTSA)
  - 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
  - SCMS Wiki CV Pilot Documentation
  - SCMS Issue Tracing (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 Pilot-Implementation (2017)
  - SCMS CV Pilot-Requirements and Use Cases
  - SCMS POC Supported V2V Applications and PSDs
  - SCMS OBE Bootstrapping (Manual) Requirements
  - SCMS Backend Management – Use Case Example
  - SCMS Certificate Types
  - SCMS Anonymous Certificates-Projected by Year
  - SCMS Cryptographic Test Vectors

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

- EU-Security Architecture for Vehicular Communications
  - SeVeCom Security Architecture
  - Communication Access for Land Mobiles (CALM)
  - PRESERVE Security architecture (N. Blumeeyer)
  - PRESERVE-Secure V2X Communications (Frank Karg)

- 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)
References Used in This Presentation


- 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](https://www.regulations.gov/docketBrowser?rpp=50&so=DESC&sb=postedDate&po=50&s=SCMS&dct=PS&D=NHTSA-2016-0126)


