Vehicle Safety Communications in the US

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October 11, 2006

Outline

- International V2I and V2V Support
- Vehicle Safety Communications Landscape in the U.S.
- Vehicle Safety Communications Project (VSC)
- Extended Emergency Brake Light (EEBL)
- Cooperative Intersection Collision Avoidance System (CICAS)
- Vehicle Infrastructure Integration (VII)
- Interaction between VII and CICAS
- Infrastructure Deployment (Strawman)
International V2I and V2V Support

U.S., Europe and Japan all show significant activities in the area of Vehicle to Infrastructure and Vehicle to Vehicle Communications (though with somewhat different starting positions and different focus):

<table>
<thead>
<tr>
<th>RF bands</th>
<th>Political Environment</th>
<th>Activities</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>20 MHz at 5.9 GHz allocation likely by 2010</td>
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<tr>
<td></td>
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<td>20 MHz at 5.8 GHz allocated since 1997</td>
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<tr>
<td></td>
<td></td>
<td>Rollout of infrastructure for vehicle safety communications ongoing</td>
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<td></td>
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<td>Focus of today’s presentation</td>
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<td>Strong political support by the European Union and most National Governments</td>
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<td>Sichere Intelligente Mobilität Testfeld Deutschland (SIM TD)</td>
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<td>COM eSafety</td>
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<td>Car2Car-Communications Consortium (C2C-CC)</td>
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<td></td>
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<td>CVIC, SAFESPOT</td>
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<td></td>
<td></td>
<td>Smartway (i.e. Vehicle Communications Infrastructure for Safety and Mobility)</td>
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<td>ASV-4 (i.e. Vehicle to Vehicle Communications for Safety)</td>
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Vehicle Safety Communications Landscape in the U.S.

[Diagram showing the V2I and V2V landscape with various projects and funding sources]
Vehicle Safety Communications Project (VSC)

2.5 year program started in May 2002, Ended in 2004

VSC Consortium Members: BMW, DaimlerChrysler, Ford, GM, Nissan, Toyota, and VW

Goals:

- Facilitate the advancement of vehicle safety through communication technologies
- Identify and evaluate the safety benefits of vehicle safety applications enabled or enhanced by communications
- Assess communication requirements, including vehicle-vehicle and vehicle-infrastructure modes
- Contribute to DSRC standards and ensure they effectively support safety
- Develop next generation DSRC testing system
- Test and evaluate of DSRC communications functionalities for potential vehicle safety implementations

VSC Results

- Brainstormed application scenarios enabled or enhanced by wireless communications
- Defined 45 application scenarios and their associated rough communication requirements
- Ranked Applications based on their estimated safety benefits
- Selected a subset of highest ranking applications for further research

![Graph showing potential functional years saved (10^5)]

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## Basic Communications Requirements for High-Priority Application Scenarios

<table>
<thead>
<tr>
<th>Types of Communication</th>
<th>Transmission Mode</th>
<th>Minimum Frequency (Hz)</th>
<th>Allowable Latency (milliseconds)</th>
<th>Estimated Message Size (bytes)</th>
<th>Maximum Required Range of Communication (meters)</th>
<th>Requires communication between Infrastructure &amp; vehicles</th>
<th>Requires communication between vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Crash Warning</td>
<td>one-way, point-multipoint</td>
<td>10</td>
<td>100</td>
<td>500</td>
<td>250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooperative Forward Collision Warning</td>
<td>one-way, point-multipoint</td>
<td>15</td>
<td>100</td>
<td>200</td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left Turn Assistant</td>
<td>event-driven</td>
<td>10</td>
<td>100</td>
<td>200</td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lane Change Warning</td>
<td>periodic</td>
<td>10</td>
<td>100</td>
<td>200</td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stop Sign Movement Assistance</td>
<td>periodic</td>
<td>10</td>
<td>100</td>
<td>200</td>
<td>150</td>
<td></td>
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### Extended Emergency Brake Light Project

The VSC I project established the basic technology and feasibility for Vehicle-to-Vehicle (V2V) communications but did not implement the applications. The OEMs decided to develop and evaluate the Extended Emergency Brake Light application (EEBL) as the first V2V cooperative active safety application in order to:

- Develop concepts of operation, system and communication requirements
- Establish V-V EEBL message set and interoperability
- Define & perform common engineering tests to conduct preliminary benefits assessment
- Report to the industry on results
- Guide future V-V safety applications development

The project was an OEM funded effort between BMW, DaimlerChrysler, Ford, GM, Nissan and Toyota.

Project duration: June 2005 to March 2006
EEBL Application Overview

Objective of the application: Provide an early notification to vehicle downstream of a Subject Vehicle (SV) braking hard, even when the lines of sight to the SV are obstructed by other vehicles.

- Too far away No alert
- Relevant Event, Alerting Driver
- Not my direction, No Alert
- I am braking hard: Vehicle ID Pos: Lat, Long Speed: $v$ Decel: $a$
- GPS Time Heading Path history
- Vehicle not equipped

Cooperative Intersection Collision Avoidance System (CICAS)

CICAS is a 4 year project to develop Cooperative Intersection Collision Avoidance Systems (CICAS) that
- Prevent crashes between vehicles due to violations of traffic signals
- Prevent crashes between vehicles due to violations of stop signs

This crash prevention applies to all types of crossing path crashes that have their origin in violations, such as Straight Crossing Path (SCP) crashes, Left Turn Across Path (LTAP) crashes, etc.

The project is divided in 2 phases:
- **Phase I**: Development of the Field Operational Test (FOT) Prototype (May 1, 2006 to April 30, 2008)
- **Phase II**: Conducting the FOT and analyzing the data (May 1, 2008 to April 30, 2010)
Project goals for Phase I

Development of an FOT capable CICAS-V prototype that includes

- Definition of the Concept of Operations
- Development of the System Architecture
- Definition of the Performance Specifications and the test procedures to measure them
- Development of the CICAS-V message set
- Definition and development of intersection map specification
- Development of positioning correction methods
- Development of the CICAS-V application
- Development of a capable and user-friendly DVI, including warning timing
- System tests and user tests
- VDI development and POC support
- FOT definition and preparation
Project status

The project has developed:

- Concept of Operations document (to be finalized after the Nov 1 public workshop)
- Systems Engineering documentation
  - Functional Requirements
  - System Requirements
  - System Architecture
  - System Interfaces
- Design of an intersection data acquisition system for intersection approach data collection
- Intersection selection for prototype development
- Drafts of Signal Phase and Timing message sets and Geometric Intersection Description (GID) definition and message set
- Analysis of Intersection approaches in the Virginia Tech 100 Car database
- Instrumentation of stop sign controlled intersection and start of data collection

Vehicle Infrastructure Integration (VII)

One of nine major initiatives announced by USDOT in 2004

- **Vision:** “Nationwide deployment of a communications infrastructure on the roadways and in all production vehicles could improve transportation and the quality of American life in ways not imagined a generation ago.”
  
  (source: USDOT/ITS Joint Programs Office)

- VII involves communication between individual vehicles and between vehicles and the infrastructure to enable a variety of systems to be developed to significantly improve safety, operations and maintenance, and to enable a variety of applications to support the needs of Original Equipment Manufacturers (OEMs) (i.e., the automakers) and other commercial interests.

- The VII program is a cooperative effort involving State Departments of Transportation (DOT) through the American Association of State and Highway Transportation Officials (AASHTO), local government agencies, OEMs, and the US Department of Transportation (USDOT).

- National VII Coalition established to oversee program to assess deployment feasibility
VII High Level Overview

Control & Map Database
Private Sector Use
Traffic Management Center (TMC)

Satellite to Vehicle (GPS)
DSRC Vehicle to Hot Spot
DSRC Vehicle to Roadside

VII Business Case

VII stakeholders are vehicle OEMs, the Federal Department of Transportation (DOT), and State and Local DOTs.

Deployment model is a nationwide rollout of roadside infrastructure, followed by large scale deployment in the new vehicle fleet.
VII Rollout Plan

United States

2005
We know what we want to do
Planning Phase

2008
We know how to do it
Proof of Concept Phase

2010
Should we do it?
Deployment Decision

Deployment Phase

Goals of the Proof Of Concept (POC)

1. Testing and validation of technologies and functions for vehicle-to-vehicle and vehicle-to-infrastructure communications in a setup that exceeds a demonstrator status (scalability, proof of market suitability)

2. Preparation of the deployment decision for a country-wide introduction of vehicle-to-infrastructure- and vehicle-to-vehicle-communication-technologies.

3. Investigation of some categories of applications enabled by vehicle-to-infrastructure- and vehicle-to-vehicle-communications.
VII POC Applications

**Safety**
- Extended Emergency Brake Light
- Traffic Signal Violation Warning

**Present Traffic Information**
- Off-board navigation
- Dynamic traffic information
- Optimized routing
- Incident information
- Estimated travel times
- Weather information

**In-Vehicle Signage**
- Work zone warning
- School zone warning
- Speed limit
- Icy bridge ahead
- Icy road
- Clearance height
- Wrong way
- Curve ahead
- Next exit services

**Make Payments**
- Toll road
- Gasoline purchases
- Parking fees

Criteria for VII POC Application Selection

Likely to be the first VII production applications
Applications support diverse interests (safety, mobility, and consumer)
Test provides good coverage of VII capabilities
Important to have near term benefits even without high populations of VII-equipped vehicles
Test multiple concurrent applications to determine system reliability and performance
Starting point for evaluation of initial production deployments
VII Timeline (Conceptual)

OBU: On-Board Unit (vehicle)
RSU: Road-Side Unit (infrastructure)

Proof of Concept Phase:
- Key agreement quantity
- Key agreement date
- Deployment decision (end of validation phase)
- More production RSU's installed

Deployment Phase:
- First production OBU installed
- OBU Deployment
- RSU Deployment

Interaction between VII and CICAS

CICAS

VII

TIME
Infrastructure Deployment (Strawman)

Phase 1:
- 50% of all signalized intersections in urban areas containing 50% of the population
- All freeways and interstates in same urban areas (<2 minute delay)
- Every interstate interchange (<10 min delay)
- 131,800 total road side units
- Complete by 2011

Phase 2:
- 70% of all signalized intersections in 454 urban areas
- Extra 10,000 road side units for smaller communities
- Additional 14,000 on interstates
- 239,000 total road side units
- Installation for 2012 to 2017

Thank You!

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Infrastructure Deployment (Phase 1)

Legend:
- Interstate
- Strategic HWY Network
- Other NHS
- Interchange

Infrastructure Deployment (Phase 2)