Vehicle Safety Communications – Applications (VSC-A) Project:
Communications & Standards Status

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Goals of Communication Work

• Develop scalable, common vehicle safety communication architecture, protocols, and messaging framework necessary to achieve interoperability and cohesiveness among different vehicle manufacturers.

• Standardize this messaging framework and the communication protocols (including message sets) to facilitate future deployment.
Communication Focus Areas

• Message Composition
• Power Testing
• Message Dissemination
• Multi-channel Operation
• Standards Coordination and Validation
VSC-A team is working actively in green tinted areas (SAE, IEEE 1609, IEEE 802.11)
Message Composition

- One common message supports all safety applications.
- Exchange with neighboring vehicles.
- Send periodically (heartbeat) or event-triggered.

<table>
<thead>
<tr>
<th>SAE J2735 Basic Safety Message (BSM)</th>
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<tbody>
<tr>
<td><strong>Part I</strong></td>
</tr>
<tr>
<td>Basic Vehicle State Message Part I</td>
</tr>
<tr>
<td>(Veh. ID, Seq. #, time, position, motion, control, veh. size)</td>
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<tr>
<td><em>Part I is mandatory in BSM</em></td>
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<tr>
<td><strong>Part II</strong></td>
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<tr>
<td>Vehicle Event Object (hard braking, control loss, etc.)</td>
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<tr>
<td>Vehicle Path History Object</td>
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<tr>
<td>Vehicle Path Prediction Object</td>
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<tr>
<td>Relative Positioning RTCM 1002 data</td>
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Power Testing Objectives

• Characterization of relationship between distance and packet reception probability as a function of
  • Transmission Power
  • Propagation Environment
  • Modulation Technique

• Explore utility of:
  • high power (> 20 dBm) for enhanced safety application performance,
  • low power (< 20 dBm) for congestion control
Test Scenarios Performed

- Baseline Line of Sight
- Baseline Shadowing
- Urban Straight Line
- Freeway Line of Sight
- Freeway Shadowing
- Residential Line of Sight
- Expressway Shadowing
- Arterial Shadowing
- Curved Track
- Urban Closed Intersection
- Urban $\frac{3}{4}$ Open Intersection
- Suburban Closed Intersection
- Suburban $3/4$ Open Intersection
- Rural Closed Intersection
- Rural Open Intersection
- Rural Highway Line of Sight
- Rural Highway Shadowing

Test scenarios motivated by specific VSC-A Safety Applications
Urban Closed Intersection

Satellite Image of Urban Closed Intersection

- Market and Santa Clara Street
- Downtown San Jose
- Buildings on all four corners of intersection
- Transmitter at 5 fixed locations (0 to 150 meters)
Test Results for Urban Closed Intersection

Extra range at 33 dBm could be important for safety applications targeting intersection crashes (e.g. IMA)

Packet Error rate (PER) Versus distance for Urban Closed Intersection

33dBm Transmissions

20dBm Transmissions
Message Dissemination

**Objective:** Use power, rate, and other controls to mitigate network congestion and improve message delivery

**Approach:**
- Define Message Dissemination Framework
  - Cooperative, distributed action
  - Distinguish between important and routine messages
- Define appropriate channel load metric
- Develop specific controls
- Validate and refine via simulation
- Test in vehicles
Multi-Channel Operation

Objectives:

• Analyze IEEE 1609.4 Channel Switching
• Develop alternatives and evaluate
• Consider effect of FCC ruling on Channel 172
US DSRC Bandplan

Shared Public Safety/Private
Control Med Rng Service Short Rng Service

Dedicated Public Safety
Vehicle safety Intersections

Power Limit

44.8 dBm

33 dBm

23 dBm

40 dBm

Power Limit

Public Safety Veh-Veh Ch 172
Public Safety/Private Ch 174
Public Safety/Private Ch 176
Public Safety/Private Ch 178
Public Safety/Private Ch 180
Public Safety/Private Ch 182
Public Safety/Private Ch 184

Control Channel

Frequency (GHz)

5.825 5.830 5.835 5.840 5.845 5.850 5.855 5.860 5.865 5.870 5.875 5.880 5.885 5.890 5.895 5.900 5.905 5.910 5.915 5.920 5.925
IEEE 1609.4 Channel Switching

- Defines channel switching between control and service channels
- Safety messages sent on Control Channel during CCH Interval

Guard Interval

Sync Interval

CCH Interval SCH Interval

Start of every UTC second

Start of every UTC second

CCH: Control Channel SCH: Service Channel
Multi-channel issues to consider

- Performance (safety, general DSRC services)
- Efficiency
- FCC designated Channel 172 exclusively for V2V safety communications – July 2006
- Single-radio and optional dual-radio systems

\textit{VSC-A is exploring a wide range of potential solutions}
DSRC Standards Status


- **IEEE 1609.x (Middle layers):** 1609.2, 1609.3, and 1609.4 planning to move from Trial Use status to Full Use status in 2009.

- **SAE J 2735 (Message Set Dictionary):** Planning to start ballot process Dec. 2008, will move from Recommended Practice to Standard
Thank You