SAE Standard Overview of Basic Safety Message (BSM)

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Basic Safety Message - History

VSC I
2002 - 2004

DSRC/WAVE Testing System

Vehicles - Vehicle
- Approaching Emergency Vehicle Warning
- Blind Spot Warning
- Cooperative Adaptive Cruise Control
- Cooperative Collision Warning
- Cooperative Forward Collision Warning
- Cooperative Vehicle Highway Automation System
- Emergency Electronic Brake Lights
- Highway Merge Assistant
- Highway/Rail Collision Warning
- Lane Change Warning
- Post-Crash Warning
- Pre-Crash Sensing
- Vehicle-Based Road Condition Warning
- Vehicle-to-Vehicle Road Feature Notification
- Visibility Enhancer
- Wrong Way Driver Warning

Vehicle - Infrastructure
- Blind Merge Warning
- Curve Speed Warning - Rollover Warning
- Emergency Vehicle Signal Preemption
- Highway/Rail Collision Warning
- Intersection Collision Warning
- In-Vehicle Amber Alert
- In-Vehicle Signage
- Just-In-Time Repair Notification
- Left Turn Assistant
- Low Bridge Warning
- Low Parking Structure Warning
- Pedestrian Crossing Information at Intersection
- Road Condition Warning
- Safety Recall Notice
- SOS Services
- Stop Sign Movement Assistance
- Stop Sign Violation Warning
- Traffic Signal Violation Warning
- Work Zone Warning

Real World V-V Communication Performance

Draft SAE Message Set
- Longitude
- Latitude
- Height
- Time
- Heading Angle
- Speed
- Lateral Acceleration
- Longitudinal Acceleration
- Yaw Rate
- Throttle Position
- Brake Applied Status
- Brake Applied Pressure
- Steering Wheel Angle
- Headlight Status
- Turn Signal Status
- Traction Control State
- Anti-Lock Brake State
- Vehicle Length
- Vehicle Width
The Basis for V2V Safety Communications Requirements

- Over a decade of research, involving multiple OEMs, academia, suppliers and the US DOT
  - Stable requirements (SAE and IEEE standards)
  - Requirements derived to support use cases that address prioritized set of crash scenarios

<table>
<thead>
<tr>
<th>Crash Scenarios</th>
<th>EEBL</th>
<th>FCW</th>
<th>BSW</th>
<th>LCW</th>
<th>DNPW</th>
<th>IMA</th>
<th>CLW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Lead Vehicle Stopped</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Control Loss without Prior Vehicle Action</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Vehicle(s) Turning at Non-Signalized Junctions</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Straight Crossing Paths at Non-Signalized Junctions</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Lead Vehicle Decelerating</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>6 Vehicle(s) Not Making a Maneuver – Opposite Direction</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Vehicle(s) Changing Lanes – Same Direction</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 LTAP/OD at Non-Signalized Junctions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Crash Scenario selected by US DOT based on 2004 General Estimates System (GES) data and Top Composite Ranking (High Freq., High Cost and High Functional Years lost).

**Legend:**
- **EEBL:** Emergency Electronic Brake Lights
- **FCW:** Forward Collision Warning
- **BSW:** Blind Spot Warning
- **LCW:** Lane Change Warning
- **IMA:** Intersection Movement Assist
- **DNPW:** Do Not Pass Warning
V2V Safety Standards Landscape

SAE J2945/1 (March 2016)
On Board System Requirements for V2V Safety Communications

SAE J2735 Data Dictionary (Mar. 2016)
IEEE 1609.12 Identifiers (2016)
IEEE 1609.2 Security Services (2016)
IEEE 1609.3 Networking Services (2016)
IEEE 1609.4 Multi-Channel Operation (2016)
IEEE 802.11 MAC and PHY (2012)
SAE DSRC Standards for V2V Safety

- SAE J2735 (March 2016) – Data and message set dictionary
  - Defines Data Elements, Data Frames and how to represent them Over-The-Air (OTA)
  - Introduces the Basic Safety Message (BSM)

- SAE J2945/1 (March 2016) – points to SAE J2735 for BSM data elements and data frames of interest for light vehicles and defines minimum performance requirements

- SAE J2945/1a (?) Recommended practice for minimum requirement compliance validation - work in progress, to be published in late 2019 or early 2020
Scope of the standard
- Minimum functional and performance requirements for transmitting and receiving the Basic Safety Message (BSM) by light vehicles

V2V interface requirements
- Functional
  - Standards profiles
    - DSRC requirements (based on IEEE 802.11, IEEE 1609)
    - BSM requirements: message content (based on SAE J2735), minimum transmission criteria
  - Positioning and timing
  - Radio characteristics (e.g. data rate)
  - Congestion control (DSRC bandwidth management)
  - Security and privacy
- Performance
  - Radio/RF (transmitter and receiver performance requirements)
  - Kinematic data (data accuracy requirements for position, speed, accelerations, yaw rate, etc.)
Reference Architecture

Scope of J2945/1

Source: SAE J2945/1 Standard, March 2016
SAE J2945/1 Functional Requirements (Position and Time)

- Common reference frame for Position (GNSS) and Time (UTC)
Functional Requirements
(BSM Transmission Requirements)

BSM Contents:

- Time, Latitude, Longitude, Elevation
- Position Accuracy (estimate)
- Speed, Heading, Acceleration, Yaw Rate
- Steering Wheel Angle, Transmission State, Brake System Status
- Vehicle Size (Length and Width)

- Path History and Path Prediction
- Event Flags (e.g. hard braking, traction control, etc.)
- Exterior Lights
Functional Requirements (Radio, Congestion Control, Security/Privacy & RF Performance)

- DSRC Radio
  - Data rate: 6 Mbps
  - Channel: 172
  - Access category parameters (message priority)
    - Two levels used for BSMs (higher priority for critical events)
- Congestion Control and scheduling BSMs for transmission
  - Based on an implemented and tested algorithm
  - Uses channel utilization and vehicle density information to adjust message intervals and TX power
- Privacy
  - OTA identifiers regularly changed to new random values to maintain privacy
    - Whenever the certificate changes (based on elapsed time and distance traveled)
- Security – points to IEEE1609.2 standard
- RF Performance – for both Transmitter & Receiver
Performance Requirements
(Data Accuracy – sample set)

- Time accuracy (within 1 ms of UTC)
- Position accuracy (1.5 m, 1σ) – open sky test
- Elevation accuracy (3 m, 1σ) – open sky test
- Speed accuracy (1 kph, 1σ)
- Heading accuracy (2 – 3 degrees depending on speed, 1σ) – open sky test
- Steering wheel angle accuracy (5 degrees, 3σ)
- Acceleration accuracy (.3 m/s² longitudinal and lateral, 1 m/s² vertical; 1 σ) – open sky test
- Vehicle size (0.2 m)
Test Procedures to Verify Compliance with Minimum Performance Requirements

Certification Test Procedures are very important for ensuring full system interoperability (at the safety applications level)

- SAE J2735 (OTA Data Dictionary) enables OTA interoperability
- SAE J2945/1 (Min Perf Requirements) enables system and safety applications interoperability
## Test Procedures Sample Automated Output Report

<table>
<thead>
<tr>
<th>Test ID</th>
<th>DC Procedure</th>
<th>2945/1 Requirements</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATAACC-1</td>
<td>BASE</td>
<td>6.3.6-V2V-BSMTX-DATAACC-001</td>
<td>PASS</td>
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<td>DATAACC-2</td>
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<td>CDA</td>
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<td>UNAV: PASS</td>
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<td>CDA</td>
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<td>DATAACC-34</td>
<td>D-EVNT</td>
<td>6.3.6-V2V-BSMTX-DATAACC-034</td>
<td>PASS</td>
</tr>
</tbody>
</table>

### DATAACC 012: 2D Position

**2D Error Results:**
- 0 failures
- 7818 total points
- 100.0%

![2D Error Chart](image_url)
Current SAE V2X Communications Committee Structure
# SAE V2X Communications Technical Committees

<table>
<thead>
<tr>
<th>DSRC TC</th>
<th>C-V2X TC</th>
<th>Advanced Applications TC</th>
<th>Security TC</th>
<th>Cross Cutting TC</th>
<th>Infrastructure Applications TC</th>
<th>Traffic Signal Applications TC</th>
<th>Vehicular Applications TC</th>
<th>Tolling Applications TC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2945/1 2945/0</td>
<td>3161</td>
<td>3186</td>
<td>2945/5</td>
<td>2735 2945/7</td>
<td>2945/3 2945/4 2945/12</td>
<td>2945/10 2945/11</td>
<td>2945/2 2945/6 2945/8 2945/9</td>
<td>TBD</td>
</tr>
</tbody>
</table>

**Scope:**
- **DSRC Radio access-specific items**
  - DSRC Radio access-specific items
  - Lower layer-unknown applications that may require new communication technologies
- **C-V2X Radio access-specific items**
  - Over the air security
  - Common to multiple applications or communication technologies
- **Advanced Applications TC**
  - Infrastructure applications that do not require traffic signal data
  - Infrastructure applications that require traffic signal data or interface
- **Security TC**
  - Vehicle communication needs
  - Applications for tolling and financial transactions
Conclusions

• Over a decade of research work and real-world testing of V2V Safety System BSMs has led to a set of stable requirements.

• SAE 2945/1 documents required BSM content and corresponding minimum performance requirements.

• This standard could be used as the foundation for other safety communications development such as B2V, by focusing on specific crash scenarios and use cases.

• Stakeholders should create proper forum to jointly develop the B2V OTA message and its corresponding set of minimum performance requirements. This would greatly facilitate the adoption and publication through the SAE standards process.
Thank You!

Q&A

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