Vehicle Based Data and Availability

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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
Basic Safety Message (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
  - The BSM is transmitted over DSRC (range ~1,000 meters)

- The BSM is tailored for low latency, localized broadcast required by V2V safety applications
Key Elements of BSM Part 2 Needed for Mobility Applications

- BSM Parts 1 and 2 via DSRC provides the vehicle data needed to support some localized mobility applications

<table>
<thead>
<tr>
<th>MOBILITY APPLICATIONS (where roadside units deployed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Cooperative Adaptive Cruise Control</td>
</tr>
<tr>
<td>- Speed Harmonization</td>
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<tr>
<td>- Queue Warning</td>
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<tr>
<td>- Transit Signal Priority</td>
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<tr>
<td>- Incident Scene Work Alerts</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>KEY PART 2 DATA ELEMENTS TO SUPPLEMENT PART 1 DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Weather Data (with examples)</td>
</tr>
<tr>
<td>- Ambient Temperature</td>
</tr>
<tr>
<td>- Ambient Air Pressure</td>
</tr>
<tr>
<td>- Traction Control Status</td>
</tr>
<tr>
<td>- Wiper Status</td>
</tr>
<tr>
<td>- Vehicle Data (with examples)</td>
</tr>
<tr>
<td>- Exterior Lights Status</td>
</tr>
<tr>
<td>- Type</td>
</tr>
<tr>
<td>- Antilock Brake System Status</td>
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</tbody>
</table>

- HOWEVER: DSRC link burdened by redundant Part 2 elements, critical data elements and their required latencies may vary with operational conditions
Using Cellular Messages to Augment BSM for Mobility Applications

- Most mobility applications do not require BSMs 10 times per second
- Many applications require data captured over a wide area, not just localized data near a roadside unit (storage and/or wide-area communications needed)

Possible Approach:
- Vehicles transmit BSM Part 1 plus key Part 2 elements less frequently
- Transmit via DSRC when available, Cellular otherwise

Augmenting BSM with key Part 2 elements via Cellular provides the vehicle data needed to support nearly all mobility applications

- Cooperative Adaptive Cruise Control
- Speed Harmonization
- Queue Warning
- Intelligent Traffic Signal System
- Transit Signal Priority
- Mobile Accessible Pedestrian Signal System
- Emergency Communications and Evacuation
- Incident Scene Pre-Arrival Staging Guidance for Emergency Responders
- Incidents Scene Work Zone Alerts for Drivers and Workers
- Next Generation Integrated Corridor Management
- Transit Connection Protection
- Dynamic Transit Operations
- Dynamic Ridesharing
- Freight Traveler Information
- Traveler Information
## Weather Priority Vehicular Data

### BSM Part 1
- **Brake system status**
  - Brake applied status
  - Traction control status
  - Anti-lock brake status
  - Stability control status

### BSM Part 2
- **Vehicle status**
  - Exterior lights
  - Wipers
  - Brake system status
  - Roadway friction
  - Rain sensor
  - Ambient air temperature
  - Ambient pressure
  - Yaw rate

- “Black Ice” warning requires near-instantaneous information while other algorithms operate with data rates from once per second to once every 30 seconds.
- 15 observations per segment (e.g., 1 mile) per time step (e.g., 15 min) should be sufficient for confidence in the application outputs.
- Bandwidth required for data transmission is minimal (85-365 bytes).
# AERIS - BSM Assessment – Data Results

<table>
<thead>
<tr>
<th>HIGH PRIORITY</th>
<th>MEDIUM PRIORITY</th>
<th>NOT IN BSM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timestamp</td>
<td>SteeringWheel Angle</td>
<td>Fuel type</td>
</tr>
<tr>
<td>Position (lat/long/elev)</td>
<td>Positional Accuracy</td>
<td>Fuel consumption</td>
</tr>
<tr>
<td>Speed and heading</td>
<td>ABS, Traction status</td>
<td>Emissions</td>
</tr>
<tr>
<td>Acceleration</td>
<td>Stability control</td>
<td>Fuel level</td>
</tr>
<tr>
<td>Brake system status</td>
<td>Differential GPS</td>
<td>Road grade</td>
</tr>
<tr>
<td>Vehicle size</td>
<td>Lights status</td>
<td>Engine drive cycle</td>
</tr>
<tr>
<td>Recent braking</td>
<td>Wiper status</td>
<td>Operating mode</td>
</tr>
<tr>
<td>Path prediction</td>
<td>Brake level</td>
<td>Engine temperature</td>
</tr>
<tr>
<td>Throttle position</td>
<td>Coefficient of friction</td>
<td></td>
</tr>
<tr>
<td>Vehicle mass</td>
<td>Rain type</td>
<td></td>
</tr>
<tr>
<td>Trailer weight</td>
<td>Air temperature</td>
<td></td>
</tr>
<tr>
<td>Vehicle type</td>
<td>Air pressure</td>
<td></td>
</tr>
<tr>
<td>Vehicle description</td>
<td>Vehicle identification</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cargo weight</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GPS status</td>
<td></td>
</tr>
</tbody>
</table>

*Red text indicates BSM Part 1 Data Elements*

*Blue text indicates BSM Part 2 Data Elements*

*Black italic text indicates Data Elements not in BSM*
AERIS BSM Assessment Summary

- Assessment results:
  - The BSM Part I satisfies the major part of several AERIS applications that compute eco-trajectories for vehicles.
  - Additional environmental information can improve eco-trajectory computations, but is not required.
  - Many applications do not require low latency.
  - There are two approaches for collecting emissions data:
    - Estimate emissions using BSM Part I data
    - Collect emissions data from the vehicle (requires additions to J2735)
- The AERIS BSM Assessment Report was shared with the Europeans for consideration for their environmental standards.
- Environmental data needs are being introduced as part of the SAE J2735 Systems Engineering Project.
DSRC Deployment Scenario – Private Vehicles

DSRC Radio

Vehicle Positioning GPS

BSM (1 & 2) Messages

Other Messages (e.g. Probe Data)

On-Board Diagnostics

In-vehicle display

Icy Patch

Data Aggregator (Public or Private)

Certificate Management Entity

Application Developer

Traveler Information Systems

Winter Maintenance Operations

Traffic Management Systems

Wired or wireless Backhaul
Non-DSRC Deployment Scenario – Private Vehicles

Vehicle Positioning GPS

Cellular & other (non-DSRC) Tower

Wireless Service Providers
Network Operations Center

Data Aggregator (Public or Private)

Information Service Provider (Public or Private)

Certificate Management Entity

Traveler Information Systems

Traffic Management Systems

Application Developer

Winter Maintenance Operations

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Vehicle Positioning GPS
Combined Deployment Scenario – Private Vehicles

- Vehicle Positioning GPS
- Cellular & other (non-DSRC) Tower
- Wireless Service Providers Network Operations Center
- Data Aggregator (Public or Private)
- Information Service Provider (Public or Private)
- Wired or wireless Backhaul
- Certificate Management Entity
- Application Developer
- Traveler Information Systems
- Traffic Management Systems
- Winter Maintenance Operations
- On-Board Diagnostics
- In-vehicle display
- BSM (1 & 2) Messages
- Other Messages (e.g. Probe Data)
- DSRC Radio
- DSRC RSE
- Winter Maintenance Operations
- Icy Patch
- Information Service Provider (Public or Private)
Combined Deployment Scenario – State and Local DOT Fleets

Vehicle Positioning
GPS

Cellular & other (non-DSRC) Tower

Traffic Management Systems

Traveler Information Systems

Wireless Service Providers
Network Operations Center

Data Aggregator
(Public)

Information Service Provider
(Public)

Wired or wireless Backhaul

Certificate Management Entity

Application Developer

Traveler Information Systems

Traffic Management Systems

Winter Maintenance Operations

External sensors

In-vehicle display

OBD-II

DSRC Radio

Other Messages (e.g. Probe Data)

On-Board Diagnostics

BSM (1 & 2) Messages

Cellular & other (non-DSRC) Radio

Icy Patch

DSRC RSE

Certificate Management Entity
Research Questions

- What are the benefits and costs of alternative deployment scenarios?
  - What are the costs for cellular data to support applications?
- Which of the applications’ require RSEs and how many, where, by when?
- Are the deployment scenarios technically feasible end-to-end?
  - What is the feasibility of sending BSMs over cellular?
- What is the market feasibility of the deployment scenarios?
- What are the institutional models for vehicular data aggregation and information delivery?
- What are the fault tolerances for event detection (based on vehicular data) versus information delivery to vehicles?
- Can we have BSMs stored on-board the vehicle to support applications that don’t require immediate transmission?
- What are the business models for OEMs to provide probe data?