INTEGRATED LIGHT VEHICLE MODEL DEPLOYMENT RESEARCH PROJECT UPDATE

ITS-JPO Public Workshop
September 24, 2013

Mike Lukuc, NHTSA Research
V2V MD Collaborative Research Overview

V2V-Model Deployment (MD) Project is a collaborative effort between the Crash Avoidance Metrics Partnership Vehicle Safety Communications 3 (CAMP VSC3) Consortium and the US DOT.

CAMP
Vehicle Safety Communications 3
Mercedes-Benz
GM
TOYOTA
HONDA
Ford
NISSAN
KIA
VOLKSWAGEN

Intelligent Transportation Systems

Virginia Tech Transportation Institute

RITA
Research and Innovative Technology Administration Volpe National Transportation Systems Center

DENSO North America

AUTOMOTIVE EVENTS
V2V Model Deployment Project

- Build and maintain sixty-four integrated light vehicles for Safety Pilot Model Deployment
- Harvest data monthly for the independent evaluation of safety applications
- Establish BSM minimum performance requirements based upon Safety Pilot data analysis
Integrated Vehicle Builds
## V2V Model Deployment Safety Applications

<table>
<thead>
<tr>
<th>OEM/Applications</th>
<th>Ford</th>
<th>GM</th>
<th>Honda</th>
<th>Mercedes</th>
<th>Toyota</th>
<th>Hyundai-Kia</th>
<th>Nissan</th>
<th>VW-Audi</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEBL</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>FCW</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>BSW / LCW</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>(BSW)</td>
</tr>
<tr>
<td>DNPW</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IMA</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>LTA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

EEBL: Emergency Electronic Brake Lights  
FCW: Forward Collision Warning  
BSW/LCW: Blind Spot Warning/Lane Change Warning  
DNPW: Do Not Pass Warning  
IMA: Intersection Movement Assist  
LTA: Left Turn Assist
Event Examples

FCW
Event Examples

BSW
ILV Data Harvest Summary

Data Export Facts:
- Database Size: 361 GB
- Video Size: 10.3 TB

<table>
<thead>
<tr>
<th>Harvest</th>
<th>Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>6335</td>
</tr>
<tr>
<td>02</td>
<td>10827</td>
</tr>
<tr>
<td>03</td>
<td>9399</td>
</tr>
<tr>
<td>04</td>
<td>9068</td>
</tr>
<tr>
<td>05</td>
<td>11937</td>
</tr>
<tr>
<td>06</td>
<td>7560</td>
</tr>
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<td>07</td>
<td>11318</td>
</tr>
<tr>
<td>08</td>
<td>9869</td>
</tr>
<tr>
<td>09</td>
<td>9053</td>
</tr>
<tr>
<td>10</td>
<td>In Queue</td>
</tr>
<tr>
<td>TOTAL</td>
<td>85366</td>
</tr>
</tbody>
</table>
Remote Monitoring

All vehicles are remotely monitored via cell link

- Study parameters are tracked to ensure exposure is sufficient
- Systems are scheduled for repair when anomalies detected
CAMP VSC 3 OEM Alert Analysis

Alerts are being classified into the following categories:

- True Positives
  - Valid
  - Nuisance Alert
- False Positives, with the following as potential root causes:
  - Algorithmic
  - Road Geometry (curved roads, overpass/underpass, cloverleaf)
  - Environmental (challenging GPS conditions, VAD/ASD installation misconfigurations, etc.)
  - System synchronization errors
  - Unknown

Model Deployment Data provides a rich set of connected vehicle naturalistic data that will guide future development

- Safety application and warning timing refinement
- Minimum performance requirements/standards
IMA improvements from Phase I to Phase II

Example IMA false alert scenarios observed during Phase I and eliminated in Phase II
VAD/ASD Performance Characterization

Safety Application Level Testing:
- Integrated Light Vehicle (ILV) application performance against ASDs / VADs
- Characterize w.r.t Basic Safety Message (BSM) elements
- Update of Minimum Performance Requirements (MPR)

Tests Conducted:
- Sep 2012 VAD Tests (Ann Arbor & Brooklyn)
  - Acceleration and Speed Filtering Recommendation
- April 2013 VAD/ASD Tests (Ann Arbor & Fowlerville)
  - Application Performance
  - Relative Positioning Performance
  - BSM Element Performance
Summary of Safety Application Tests

Primary focus is Application Testing:
- Integrated light vehicles as host vehicles
- Target Vehicles with ASD/VADs mounted as recommended in Model Deployment

Performance:

<table>
<thead>
<tr>
<th>VSC-A Application</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSW</td>
<td>10/10</td>
<td>10/10</td>
<td>10/10</td>
</tr>
<tr>
<td>LCW</td>
<td>10/10</td>
<td>10/10</td>
<td>6/10</td>
</tr>
<tr>
<td>DNPW</td>
<td>10/10</td>
<td>10/10</td>
<td>9/10</td>
</tr>
<tr>
<td>EEBL</td>
<td>10/10</td>
<td>10/10</td>
<td>9/10</td>
</tr>
<tr>
<td>FCW Stopped Same Lane</td>
<td>10/10</td>
<td>9/10</td>
<td>9/10</td>
</tr>
<tr>
<td>FCW Stopped Adjacent Lane</td>
<td>10/10</td>
<td>10/10</td>
<td>7/10</td>
</tr>
<tr>
<td>FCW Slow Same Lane</td>
<td>10/10</td>
<td>10/10</td>
<td>6/10</td>
</tr>
<tr>
<td>IMA Stopped</td>
<td>10/10</td>
<td>10/10</td>
<td>9/10</td>
</tr>
<tr>
<td>IMA Approach</td>
<td>10/10</td>
<td>10/10</td>
<td>8/10</td>
</tr>
</tbody>
</table>
Positioning Across Path
(In-Lane Target Classification)

- Classification based on relative lateral position
- Percentage of “Ahead” classification at speeds above 15mph:

<table>
<thead>
<tr>
<th>Route:</th>
<th>ILV2</th>
<th>X1 (VAD)</th>
<th>X2 (VAD)</th>
<th>Y (VAD)</th>
<th>Z (ASD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeway</td>
<td>95</td>
<td>93</td>
<td>83</td>
<td>94</td>
<td>87</td>
</tr>
<tr>
<td>Local 1</td>
<td>94</td>
<td>97</td>
<td>93</td>
<td>88</td>
<td>77</td>
</tr>
<tr>
<td>Local 2</td>
<td>94</td>
<td>96</td>
<td>91</td>
<td>94</td>
<td>84</td>
</tr>
</tbody>
</table>
Phase 2 Of Model Deployment
Over-the-Air Security Credential Management

- Sixteen vehicles were equipped with a Security Framework Access Device (SFAD)
  - 2 per OEM: 1 DSRC, 1 3G-based
- Forty-seven non-SFAD equipped vehicles
  - Use short term certificates preloaded on USB drives
- Vehicles configured for 28-day short term cert batches, subsequent batches requested starting at 21-days
- Security health monitoring being performed using a variety of data source
  - Local data harvested from vehicle SFAD (monthly)
  - Health checks provided by DAS over 3G modem (per drive cycle)
  - SCMS activity logs (monthly or on request to SAIC)
3G vs. DSRC Certificate Downloads

<table>
<thead>
<tr>
<th>Download Times</th>
<th>3G Avg (Total 21)</th>
<th>DSRC Avg (Total 31)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model Deployment(^1)</td>
<td>43s (12 – 325s)</td>
<td>76s (16 – 217s)</td>
</tr>
<tr>
<td>Benchmark Tests (Jan 2013)</td>
<td>51s</td>
<td>45s (moving) / 16s (static)</td>
</tr>
</tbody>
</table>

\(^1\) Harvests 6 – 9 (April – July)

- **Background**
  - 28-day certificate batches (~2.7MB)
  - Average download times do not include certificate generation time

- **Conclusions**
  - 3G/DSRC infrastructure reliability key to end user security performance
  - Phase 2 SCMS downtime biggest factor in failed certificate requests/downloads
  - Phase 2 RSE outages limited DSRC availability for security functions
  - Certificate batch download performance impacted by:
    - Vehicle in motion
    - Connection quality to infrastructure (distance / line-of-sight)
    - Peak hour congestion (rush hour commute / major thoroughfare)
  - 3G downloads on average 1.76x faster than DSRC
Summary

• Initial results show that VADs are capable of acceptable performance with obvious improvements possible.

• MD Data and Analysis is available for use by all OEMs for future V2V safety application development.

• MD environment characterization is critical to V2V safety application performance analysis.

• Certification procedures need to be developed based on MD experience for successful deployment.
Questions?
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