DSRC COMMUNICATIONS SCALABILITY RESEARCH UPDATE

ITS-JPO Public Workshop
September 24, 2013

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V2V-Interoperability – Phase 2

- 2 year extension to the V2V-I Project: Oct 2012 – Aug 2014
- Collaborative effort between eight Automotive OEMs (Ford, General Motors, Honda, Hyundai-Kia, Mercedes-Benz, Nissan, Toyota, VW-Audi) and the USDOT
- Goal: Address remaining areas of interoperability research which are important to resolve in preparation for deployment of 5.9 GHz DSRC V2V crash avoidance safety applications
## Interoperability Project – Phases 1 and 2

### Interoperability – Phase 1

**Major Tasks**

- V2V Safety Communications interoperability
- V2V Safety Communications Scalability
- Security Management
- Data integrity and reliability
- DSRC Industry consensus standards development

### Interoperability – Phase 2

**Major Tasks**

- V2V Safety Communications Scalability
- Misbehavior detection and reporting
- Technical support for NTIA/FCC spectrum study
- DSRC Industry consensus standards development

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Communications Scalability for V2V Safety – Phase 2

• Goal
  • Finalize V2V safety communication protocol(s) that will support large-scale deployment level of vehicles while preserving the performance of V2V safety applications

• Activities
  • Algorithm refinement and, if necessary, development of alternate approaches
  • Field Testing
  • Calibration of communication simulation environments
  • Incorporate recommendations into relevant standards
PHASE 1 SCALABILITY TESTING

100 and 200 vehicle tests
Field Testing

• Have tested 200 OBEs, will test 400
• Used static OBE carts as well as vehicles
• OBE Deployment Scenarios
  • Straight Road – Spread Out
  • Straight Road – Compact
• Used increased transmit rates to emulate additional vehicles (potentially up to 5x)
• Three types of tests
  • Non-application
  • Application
  • Hardware-in-the-Loop
Static OBE Cart

- Field testing relied primarily on OBEs mounted on static carts
- Each cart represents six vehicles
- At a 5x transmit rate each cart represents 30 vehicles
- Carts were deployed according to scenario of interest (*compact* or *spread out*)
- Vehicles drove between rows of carts
OBE Deployment Scenarios (200 OBEs)

Spread Out
(1085m)

Compact
(525m)
High Density Vehicle Emulation for Compact Scenario

- Emulated 960 vehicles along a 525 m straight road
- This emulates 20 lanes of bumper-to-bumper traffic
- Application scenarios were performed between rows of carts
Testing – Non Application: Vehicle Configuration

- For each OBE deployment configuration, analyze:
  - 10Hz, Algorithm X, and Algorithm Y behavior
  - Effects of varying power, data rate, AIFS/N, etc.
- One remote vehicle (RV), three host vehicles (HVs)
- Each HV will follow at a fixed distance from the RV
- One of each supplier OBE placed on each vehicle
Safety Application Testing in a Congested Environment

• Testing the performance of the V2V safety applications
• Testing the following transmit configurations
  • Baseline – 10Hz fixed transmit rate and power
  • Algorithm X – Adaptive transmission rate and power
  • Algorithm Y – Adaptive transmission rate
• Executing a set of safety application scenarios
• Comparing the actual warning range / timing to
  • Nominal warning range / timing
  • Reference system warning / timing
Testing – Application: Scenarios

EEBL – Hard Braking RV

HV @ 60mph

RV @ 60mph, Hard Brake

100m

FCW – Stopped RV

HV @ 45mph

RV, Stopped

Virtual HV, with antenna offset

FCW – Decelerating RV

HV @ 60mph

RV @ 60mph, Decelerating @ 0.2G

Virtual HV, with antenna offset

FCW – Cut-in RV

HV @ 60mph

RV @ 45mph

Virtual HV, with antenna offset

RV cut-in (2s lane change)

BSW – Cut-in RV

HV @ 45mph

RV cut-in (starts in real blind zone)

Virtual HV, with antenna offset

RV @ 45mph
Simulation Calibration

• Contracted two universities to work independently to calibrate simulation to real-world field test results

• Will move beyond field data and provide simulation results for full-deployment levels of vehicles
  • Algorithm refinements through simulation
  • Channel break-point determination

• Initial results will be verified through field tests
• Simulation feeds into the Hardware-in-the-Loop testing
Simulation Calibration – Approach

- Simulation Calibration
- Approach

- NS-3 Simulator
  - Mobility Trace converter
  - Baseline Comm. Model
  - Algorithm x
  - Algorithm y

- Simulator Output files
- Simulation Analysis
  - PER
  - IPG
  - Position Error Estimation

- Fixes and Improvements
- Under development
- New Propagation model

- Field Results Analysis
  - PER
  - IPG
  - Position Error Estimation

- V2VI Logs
- V2VI Logs

- Under Testing

Compare results of the real world testing and the simulator
Testing and development
Using Hardware-in-the-Loop (HIL) Testing

**Step 1**
- Crash scenario executed in the field
- No background congestion (1 RV and 1 HV only)
- High RV transmit rate (>20Hz).
- **Create “high definition” log at HV**

**Step 2**
- Insert logged traces in simulator
- Introduce Heavy Congestion
- Transmit using **Baseline, Algorithm X, Algorithm Y**
- **Identify simulated BSMs actually received at HV**

**Step 3**
- Playback log on the VSC-A OBE
- **BSMs not received taken out**
- Evaluate application performance for given transmission control **algorithm**
For questions, please contact:
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