Development of V2I Safety Applications

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SIS13: C-ITS for Traffic Accident Avoidance
The CAMP V2I Consortium is developing three prototype safety applications for test and evaluation:

1. Red Light Violation Warning (RLVW)
2. Curve Speed Warning (CSW)
3. Reduced Speed/Work Zone Warning (RSZW)
   a. Reduced Speed in Work and School Zone (RSZW-RS)
   b. Reduced Speed in Work Zone with Lane Closure (RSZW-LC)
Application Algorithms

Algorithms for each application consist of:

Event Relevance
- Determine relevance of the upcoming event based on vehicle approach

Map Matching
- Conduct map matching based on:
  o MAP data from RSE
  o Vehicle positioning
    - Determination at road level
    - Determination at lane level if RTCM correction available

Warning Level Assessment
- Vehicle speed
- Posted speed
- Requirements for the event (e.g. Intersection, Curve, Work/School zone, etc.)
- Vehicle dynamics

Inform/Warning Generation
- Inform – “Inform” the driver of upcoming event (e.g. Curve, Work zone, etc.)
- Warnings – “Warning 1 (reduce speed) and Warning 2 (imminent reduce speed)”
- Generate appropriate Inform/Warning(s) for DVI
Event Relevance
- Use vehicle approach to evaluate relevance of upcoming intersection
- Select the closest relevant intersection

Map Matching
- MAP data from RSU
- Vehicle positioning
  - When available use RTCM correction
  - Turn prediction algorithm to predict driver intent

Warning Level Assessment
- Distance from the stop bar
- Vehicle speed, lane position, turn signal
- Time remaining for signal phase change

Inform/Warning Generation
- Inform: upcoming traffic signal
- Warning: Warn driver to reduce speed for stopping at the stop bar (if necessary)
Application Development – CSW

Event Relevance
• Evaluate relevance of upcoming curve
  o Determination of relevant curve for the direction of travel
  o Is vehicle approaching the curve or passing on an adjacent lane?

Map Matching
• Vehicle position with respect to curve approach road segment data points
  o Lane width
  o Reference position (start of curve)
  o Curve geometry

Warning Level Assessment
• Distance from start of curve
• Vehicle speed
• Curve geometry
• Road surface material/condition (asphalt, concrete, icy, wet, etc.)
• Relevant event on curve (stopped traffic, low visibility)

Inform/Warning Generation
• Inform: upcoming curve
• Warning 1: Reduce speed warning (if necessary)
• Warning 2: Imminent reduce speed warning (if necessary)

Establish Relevance

Map Matching

In the case of multiple upcoming curves, “informs and warnings” will be suppressed for the next curve while the vehicle is travelling through the preceding curve.
Application Development – RSZW

Event Relevance
• Evaluate relevance of surrounding work/school zones
• Determine work zones based on vehicle approach

Map Matching
• Work/School zone map
• Determine vehicle position
  o Road level for Reduced Speed
  o Lane level for Lane Change

Warning Level Assessment
• For Reduced Speed
  o Vehicle speed
  o Distance from start of work/school zone
  o Speed limit in work zone / presence of workers
• For Lane Closure
  o Vehicle lane position
  o Lane closure
  o Vehicle speed
  o Distance to start of lane closure
  o Vehicle turn signal status

Inform/Warning Generation
• Inform: Presence of Work/School zone / Lane closure
• Warning: Reduce speed / Lane closure warning (if necessary)
Seven OEMs Building Test Vehicles

- GM – Buick LaCrosse
- Honda – Acura RLX
- Hyundai-Kia K-900
- Nissan – Infiniti M37
- Subaru Legacy
- Volvo Truck VNL 670S
- VW / Audi Audi A4

• All 7 vehicles will implement all 3 applications
• Two leaders – Hyundai-Kia and VW
• Five evaluators – GM, Honda, Nissan, Subaru and Volvo
Integrated V2I Prototype Platform

- **Infrastructure Sensor Systems**
  - Position Correction Infra Data Systems
  - Local Weather Infra Sensor Systems
  - Ped & Bicycle Infra Sensor Systems
  - CMV Virtual Weigh Station Sensor Systems

- **Vehicle and Nomadic Device App Platform**
  - Veh Detection Sensor Systems (radar, loop det)
  - Local Road Surface Infra Sensor Systems
  - CMV Oversize Vehicle Sensor Systems

- **Traffic Management Entity Interface (IP)**
  - Traffic & Rail Signal Message Handler
  - Local Weather & Road Surface Message Handler
  - INFLO Message Handler (incl SPD-HARM, Q-WARN)
  - Road Weather Message Handler (incl WRTM)
  - AERIS/Ecodriving Message Handler

- **Traffic Management Entity**
  - INFLO TME App (incl SPD-HARM, Q-WARN)
  - Road Weather TME App (incl WRTM)

- **Integrated V2I Prototype Platform**
  - Map Message Handler (incl static signage)
  - Vehicle Detection/BSM Data Aggregator
  - Ped, Bicycle, Nomad Dev Data Aggregator
  - V2I Safety Application Info Platform
  - MMITS Roadside Processor
  - FRATIS Message Handler

- **Onboard Map Service**
  - Onboard Map Service
  - V2I Safety App Vehicle Platform

- **Security Certificate Manager**

- **Driver/User Message Arbitrator**
  - V2I Safety Application Infra Platform

- **Low Latency/Quasi-Static Message Storage**
  - GPS Positioning
  - Low Latency Radio Communications (e.g. DSRC)
  - Onboard Positioning Service
  - Onboard Map Service
  - Vehicle Weather Data Message Generator
  - INFLO Message Generator (incl SPD-HARM, Q-WARN)
  - MMITS Roadside Processor

- **TOWARDS INTELLIGENT MOBILITY**
  - Better use of space
Example – IVP Support for RLVW

• RTCM/GPS position correction usage / support
  o RTCM v3.0
  o Broadcast at 1Hz, over-the-air format
  o Broadcast on Ch. 172

• SPaT + MAP support and interoperability testing
  o Broadcast on Ch, 172
  o MAP: 1Hz, SPaT: 10Hz (ASN.1 encoded per J2735:2015)

• SCMS security certificates for RSE & OBE
  o Long term, location independent certificates for testing
Objective Test Procedures

Purpose of Application:
- Based on the Concept of Operations
  - Overview of intended actions and timing

Data elements:
- Based on System Requirements
  - Are data flows appropriate and timely?
  - Are data correctly interpreted?

Action:
- Based on Performance Requirements
  - Does application provide appropriate inform/warning messages?
Application validation at test track
  • Ensure reference application works, test scenarios are developed for:
    o Various speed profiles and maneuvers
    o Turn prediction

Real-world interoperability evaluation
  • 1 Dedicated lane for right turn
  • 1 Lane for straight across and right turn
  • 1 Lane for straight across only
  • Right turn on red permitted during specific hours of the day
  • No direct left turns are permitted. Left turns require first to execute a right turn then a U – turn
Application validation at test track:
• Variable speed approaches
• Warning suppression entering a curve
• Warning suppression when passing a curve
• Variable friction
• Variable super elevation
• Low visibility event
• Stopped vehicle (obstacle) in curve event

Real-world interoperability evaluation
• Public road validation test
Validate time & location of the issuance and/or suppression of the application’s “Inform” and “Warning” messages to the driver under various test conditions and approach speeds.
Objective: “This project will develop and evaluate selected V2I Safety Applications”

<table>
<thead>
<tr>
<th>Task</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>Deliverables</th>
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<td>Sep</td>
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<td>Nov</td>
<td>Technical Project Management</td>
<td>Quarterly progress report &amp; risk log</td>
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<td>Feb</td>
<td>Mar</td>
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<td>Coordination with Stakeholders</td>
<td>Report on meetings with stakeholders</td>
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<td>Application system documentation</td>
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<td>Method to develop and validate intersection maps</td>
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Connected Vehicle Pilot Deployment Program

- Spur Early CV Tech Deployment
- Measure Deployment Benefits
- Resolve Deployment Issues

- Wirelessly Connected Vehicles
- Safety
  - Limit 35
- Technical
- Institutional
- Financial

- Mobile Devices
- Mobility
- Environment
- Infrastructure
- Financial

TOWARDS INTELLIGENT MOBILITY
Better use of space