Development of V2I Safety Applications

Carl Andersen
Federal Highway Administration, USDOT

SIS13: C-ITS for Traffic Accident Avoidance

Application Development

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:
  - MAP data from RSE
  - 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

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Application Development - RLVW

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)

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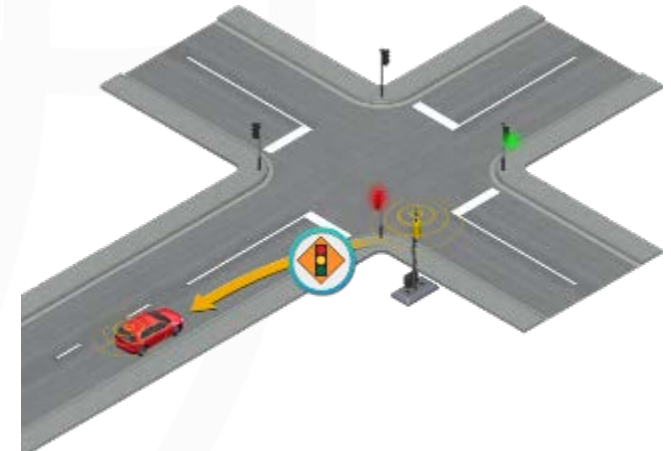
Application Development – CSW

Event Relevance

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

Map Matching

- Vehicle position with respect to curve approach road segment data points
  - Lane width
  - Reference position (start of curve)
  - 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
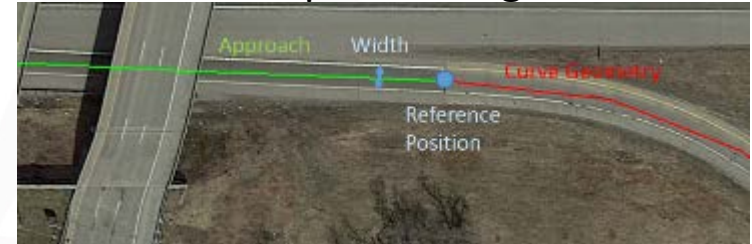
- Inform: upcoming curve
- Warning 1: Reduce speed warning (if necessary)
- Warning 2: Imminent reduce speed warning (if necessary)

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

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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
  - Road level for Reduced Speed
  - Lane level for Lane Change

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

Inform/Warning Generation
- Inform: Presence of Work/School zone / Lane closure
- Warning: Reduce speed / Lane closure warning (if necessary)

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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
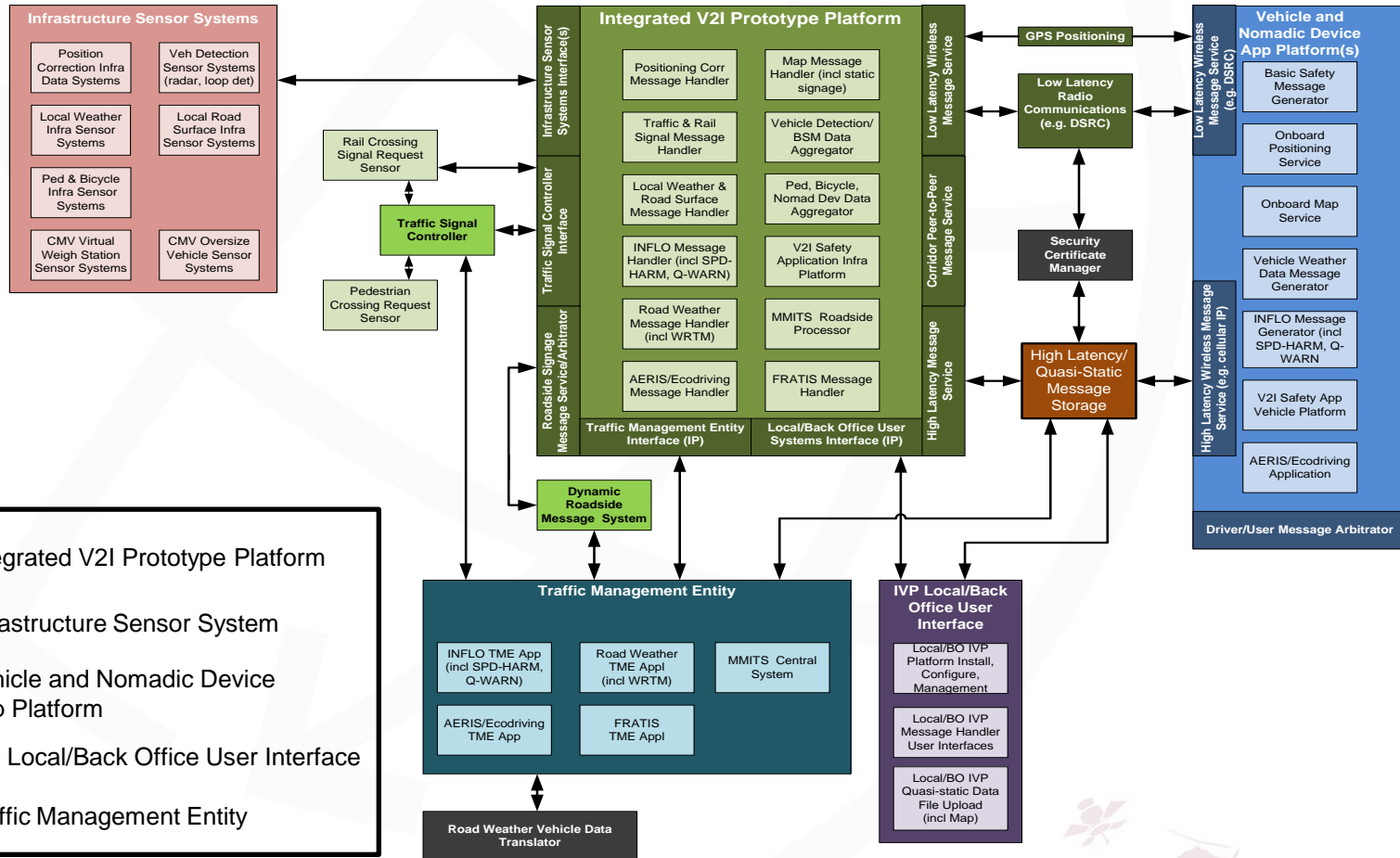- Five evaluators – GM, Honda, Nissan, Subaru and Volvo

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Integrated V2I Prototype
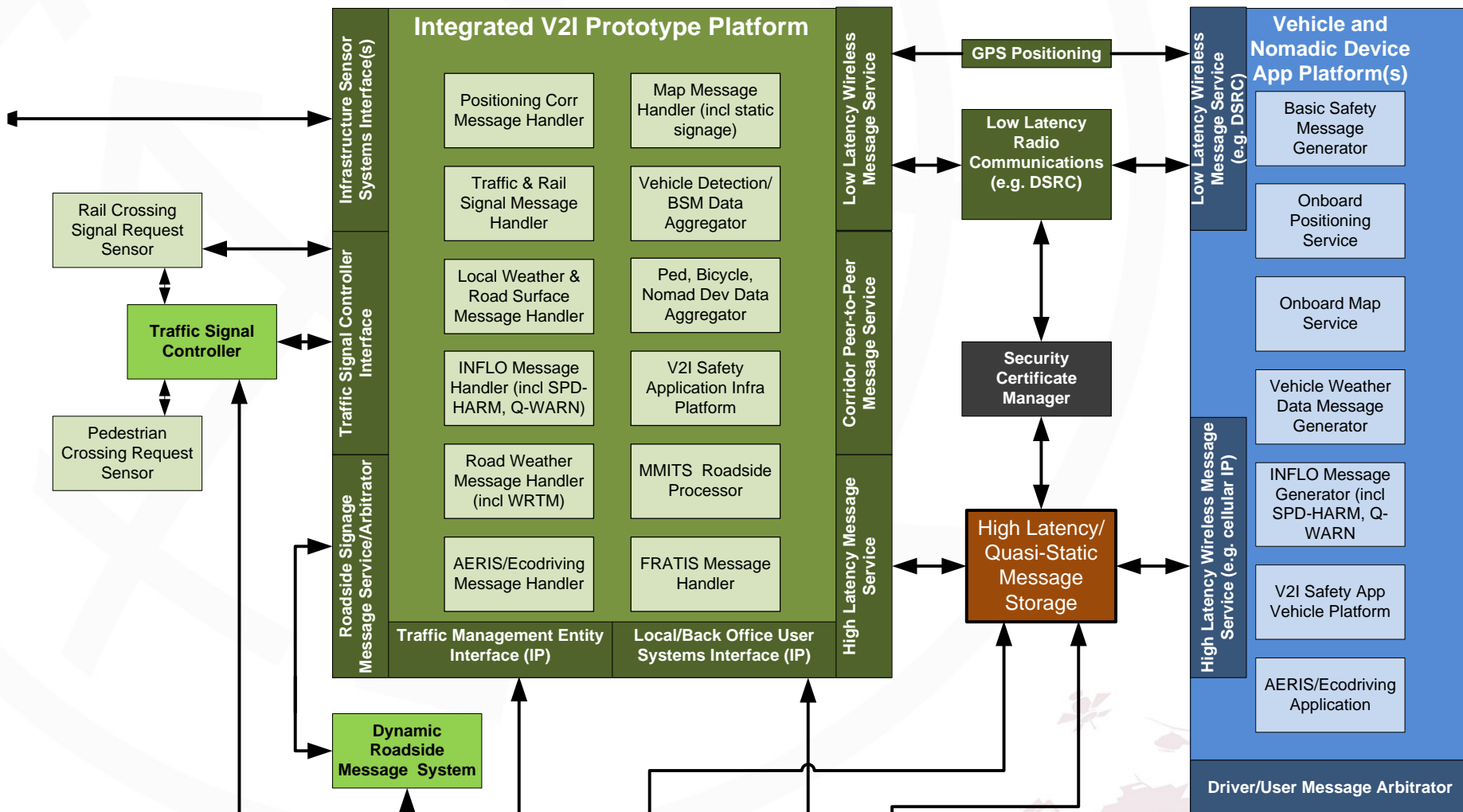
Battelle
The Business of Innovation

Infrastructure Sensor Systems
- Position Correction Infra Data Systems
- Veh Detection Sensor Systems (radar, loop det)
- Local Weather Infra Sensor Systems
- Local Road Surface Infra Sensor Systems
- Ped & Bicycle Infra Sensor Systems
- CMV Virtual Weigh Station Sensor Systems
- CMV Oversize Vehicle Sensor Systems

- Rail Crossing Signal Request Sensor
- **Traffic Signal Controller**
- Pedestrian Crossing Request Sensor

Integrated V2I Prototype Platform

Infrastructure Sensor Systems Interface(s)

- Positioning Corr Message Handler
- Map Message Handler (incl static signage)
- Traffic & Rail Signal Message Handler
- Vehicle Detection/ BSM Data Aggregator
- Local Weather & Road Surface Message Handler
- Ped, Bicycle, Nomad Dev Data Aggregator
- INFLO Message Handler (incl SPD-HARM, Q-WARN)
- V2I Safety Application Infra Platform
- Road Weather Message Handler (incl WRTM)
- MMITS Roadside Processor
- AERIS/Ecodriving Message Handler
- FRATIS Message Handler

Traffic Signal Controller Interface

Roadside Signage Message Service/Arbitrator

Traffic Management Entity Interface (IP)

Local/Back Office User Systems Interface (IP)

Low Latency Wireless Message Service

Corridor Peer-to-Peer Message Service

High Latency Message Service

GPS Positioning

Low Latency Radio Communications (e.g. DSRC)

Security Certificate Manager

High Latency/ Quasi-Static Message Storage

Vehicle and Nomadic Device App Platform(s)

Low Latency Wireless Message Service (e.g. DSRC)

- Basic Safety Message Generator
- Onboard Positioning Service
- Onboard Map Service
- Vehicle Weather Data Message Generator
- INFLO Message Generator (incl SPD-HARM, Q-WARN)
- V2I Safety App Vehicle Platform
- AERIS/Ecodriving Application

High Latency Wireless Message Service (e.g. cellular IP)

Driver/User Message Arbitrator

Dynamic Roadside Message System

Traffic Management Entity
- INFLO TME App (incl SPD-HARM, Q-WARN)
- Road Weather TME Appl (incl WRTM)
- MMITS Central System
- AERIS/Ecodriving TME App
- FRATIS TME Appl

Road Weather Vehicle Data Translator

IVP Local/Back Office User Interface
- Local/BO IVP Platform Install, Configure, Management
- Local/BO IVP Message Handler User Interfaces
- Local/BO IVP Quasi-static Data File Upload (incl Map)

Legend
- Integrated V2I Prototype Platform
- Infrastructure Sensor System
- Vehicle and Nomadic Device App Platform
- IVP Local/Back Office User Interface
- Traffic Management Entity

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Integrated V2I Prototype

Example – IVP Support for RLVW

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

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

- SCMS security certificates for RSE & OBE
  - 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?

RLVW Testing & Evaluation

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

Test Track

300 m

3.6 m

Telegraph @ W. 12 Mile Road

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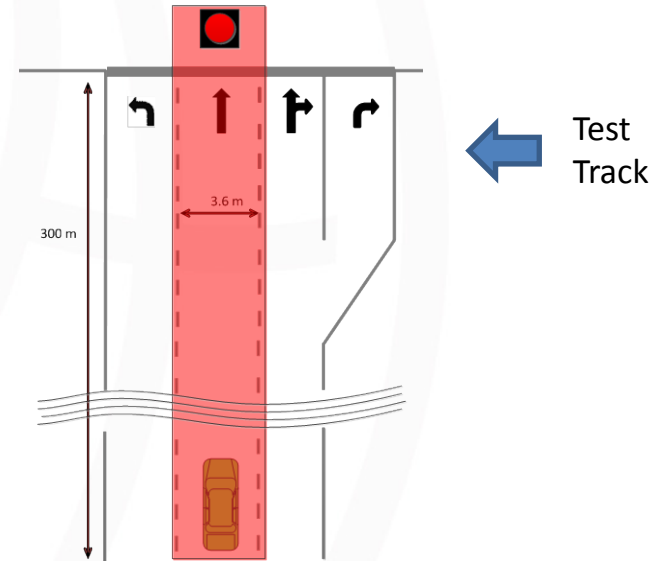
CSW Testing & Evaluation

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

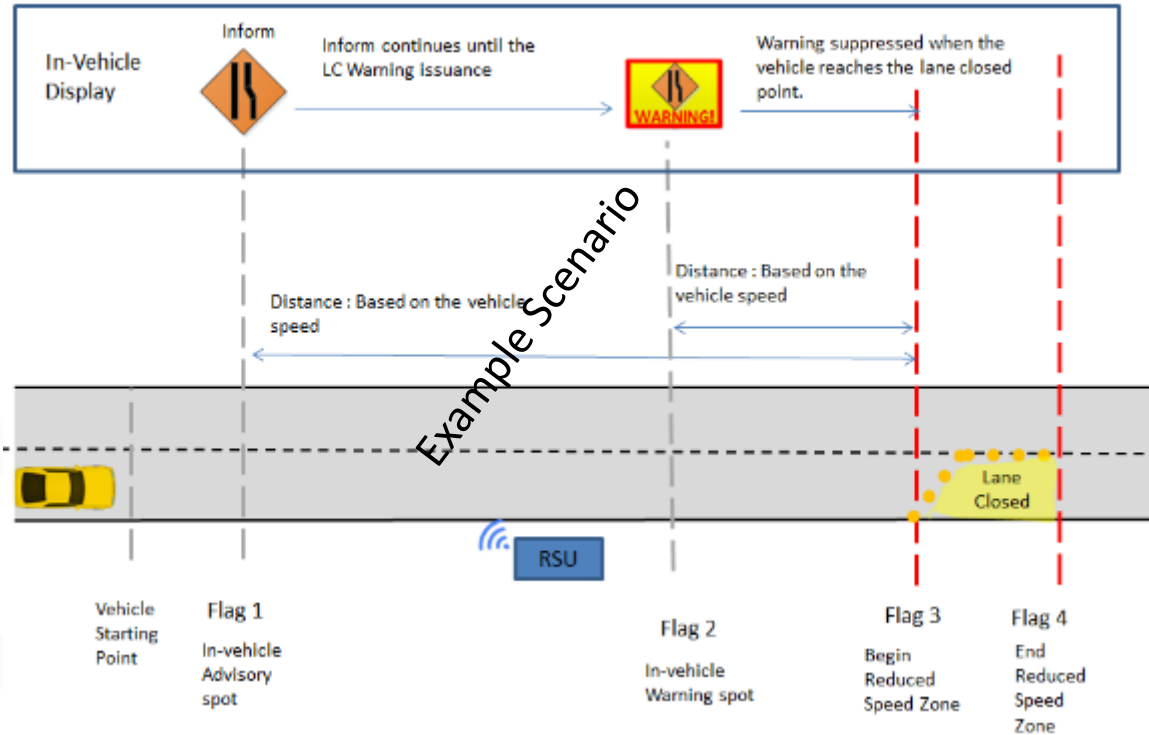Real-world interoperability evaluation
- Public road validation test

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RSZW Testing & Evaluation

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

V2I Safety Applications: Project Schedule

CAMP LLC
Vehicle to Infrastructure (V2I) Consortium
FCA · NISSAN · HONDA · Ford · SUBARU · HYUNDAI-KIA MOTORS · GM · VOLKSWAGEN · MAZDA · VOLVO

Objective: *"This project will develop and evaluate selected V2I Safety Applications"*

Task	2014 Sep	Oct	Nov	Dec	Jan	Feb	Mar	2015 Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2016 Jan	Feb	Mar	Apr	May	Deliverables	Status
1	Technical Project Management																					Quarterly progress report & risk log	Ongoing
2	Coordination with Stakeholders																					Report on meetings with stakeholders	Ongoing
3 & 4	Technical Assessment & Selection Criteria																					Report on technical assessment and selection criteria	4/21/2015
5					App Dev Plan																	Report on application development plan	4/24/2015
6						Application Development																Application system documentation	In progress
7												Vehicle Build										Vehicle system documentation	In progress
8						Infrastructure Build																Infrastructure system documentation	In progress
9												OTP Development & Testing										OTP and test plan and final test report	In progress
10	Map Generation																					Method to develop and validate intersection maps	Not started

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Connected Vehicle Pilot Deployment Program