Integrating V2X communication in an HIL set-up

Jeff Wara – Technical Specialist
dSPACE Inc · Wixom, MI

April 2015
Market introduction of V2X applications from 2017 onwards

- **Phase 1**: Basic warning functions
- **2017**: Integration in longitudinal and lateral control
- **Phase 2**: Complex warning and driving efficiency functions
- **Phase 3**: Integration in longitudinal and lateral control

Fusion with data from digital map and/or environment sensors (camera, …)
## V2X standards in Europe and US

<table>
<thead>
<tr>
<th></th>
<th>Europe</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio channel</td>
<td>Channel 180 @ 5.9 GHz</td>
<td>Channel 178 @ 5.89 GHz</td>
</tr>
<tr>
<td>Technology</td>
<td>IEEE 802.11p (ITS G5), WLAN ad hoc</td>
<td>IEEE 802.11p (DSRC), WLAN ad hoc</td>
</tr>
<tr>
<td>Protocol standard</td>
<td>ETSI TC ITS</td>
<td>IEEE 1609.x (WAVE)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SAE J2735, J2945</td>
</tr>
<tr>
<td>Message types</td>
<td>CAM (Cooperative Awareness Message, periodical 1 ... 10 Hz)</td>
<td>BSM (Basic Safety Message, periodical and event based)</td>
</tr>
<tr>
<td></td>
<td>DENM (Decentralized Environmental Notification Message, event based)</td>
<td></td>
</tr>
<tr>
<td>Security</td>
<td>Public Key Infrastructure (PKI) and Trust Assurance Levels</td>
<td>Security Credential Management System (CSMS)</td>
</tr>
<tr>
<td>Congestion Control of radio channel</td>
<td>Decentralized Congestion Control (DCC) based on Transmit Rate Control (TRC)</td>
<td>Different approaches, signal sensitivity, power or frequency adaptation</td>
</tr>
</tbody>
</table>
Exchange of data via WLAN ad-hoc network

**CAM Message**
- Transmission range: 1..10 Hz
- Destination area

**DENM Message**
- Relevance area: Traffic Jam
- Destination area: Traffic Jam

---

**CAM**
Cooperative Awareness Message

**DENM**
Decentralized Environmental Notification Message
Exchange of data via WLAN ad-hoc network

**Application Unit (AU)**

- **Application**
  - Receiver: Data processing, evaluation of relevance, …
  - Sender: Evaluation of trigger conditions, …

- **Vehicle data**
  - Vehicle position

- **CAM**
  - Cooperative Awareness Message

- **DENM**
  - Decentralized Environmental Notification Message

**Communication Unit (CU)**

- **GeoNetworking Protocol**
- **Basic Transport Protocol (BTP)**
- **ITS-G5, same radio channel for CAMs/DENMs**
- **Decentralized Congestion Ctrl. (DCC)**
Testing V2X applications by means of open-loop simulation (first set-ups planned for Q4/2015)

Manipulation of V2X messages via editor

GigE/UDP (V2X messages) → Radio adapter

Measurement and stimulus interface (e.g. XCP on Ethernet)

dSPACE real-time simulator

GPS

GPS stimulus

CAN stimulus

EGO vehicle
• CAN restbus simulation,
• GPS position
Fellow vehicles:
• CAMs/DEMs, BTP

GNSS signal generator

Vehicle CAN bus

Power and I/O signals

Data Logging

Library with test cases

Test automation

Library with test cases
Testing V2X applications by means of closed-loop simulation (first set-ups planned for Q4/2015)

„Standard“ HIL set-ups have to be extended for testing V2X applications

Automotive Simulation Models (ASM)

Sensors (radar, camera, …)

Environment

Driver

Vehicle

Hardware-in-the-Loop-Simulator

EGO vehicle

CU/AU ECU

Device under Test

Vehicle bus
Testing V2X applications by means of open-loop simulation (first set-ups planned for Q4/2015)
Simulation environment for V2X applications

Simulation example: Intersection assistant

The video will start on the next slide
Simulation environment for V2X applications

Simulation example: Intersection assistant

ControlDesk

MotionDesk

CAMs of fellow vehicles
Example: Display of V2X warnings in MotionDesk
dSPACE V2X Solution (planned for Q4/2015)

V2X blockset for Simulink®
V2X instruments for ControlDesk

Your benefits:
- Implement V2X applications easily
- Monitor status of vehicles and traffic infrastructure in ControlDesk
- Automate V2X tests

Radio adaptor
Source: Cohda Wireless

IEEE 802.11p
GNSS
Components of dSPACE V2X Solution

- Support of European standard (Q4/2015)
- Support of US standard (planned for 2016)

Documentation:
- Users guide
- Demos

Simulink blockset:
- Message encoding/decoding
- Local Dynamic Map (LDM)
- Access to network layer

Control-Desk NG Instruments:
- Local Dynamic Map (LDM) instrument
- V2X bus navigator instrument

Platform support:
- Cohda Wireless MK5 radio adapter
- dSPACE VEOS and real-time platforms

April 2015 © Copyright 2015, dSPACE GmbH
- ADAS application
- Vehicle data provider, e.g., via bus interfaces
dSPACE V2X blockset

- Facilities-Layer
  - CAM, DENM, LDM
- Network-Layer
  - BTP, Geo Networking indication & request
- Demos
dSPACE V2X blockset – LDM support

- LDM_Initialize block to initialize one LDM instance
- DataProvider and DataConsumer have a Register/Deregister block. Both blocks are connected with the LDM_Initialize block
- DataProvider is used to manipulate the LDM with Add-, Update- and Delete blocks
- DataConsumer is used to query the LDM
  - Manually with the LDM_DataConsumer_Request block
  - Or automatically with subscriptions
- All blocks are multi-instantiable
Local Dynamic Map (LDM) instrument in ControlDesk NG

Host interface

LDM-Map-Instrument
Local Dynamic Map (LDM) instrument in ControlDesk NG

- Independent map sources: OpenStreetMap or imported map tiles

- Annotations
- Objects
- Areas
- Traces

<object-type>
  <id>101</id>
  <icon>moped.png</icon>
  ...
  <annotation>%.2f km/h</annotation>
</object-type>
V2X Test Case Overview
Approaching emergency vehicle
Wireless communication is used to distribute messages about approaching emergency vehicles which claim the right of way. If a received message is relevant in the current situation the driver will be informed at an early stage. Depending on the OEM’s strategy the information is displayed on the head unit or another display device and may also be augmented by audio or haptic signals.

Motorcycle warning (Intersection collision warning)
The motorcycle continuously provides movement and position information to vehicles nearby. The surrounding vehicles receive the information and can automatically compare their own movement data with the motorcycle data. If a possible crossing with the motorcycle is detected or the relative distance between the two vehicles decreases below a given safety margin, a warning is issued to the driver.
Traffic jam ahead warning
This function enhances the safety of vehicles which approach a traffic jam or build the tail end of a traffic jam. The function aims at avoiding (fatal) rear end collisions which are often caused by traffic jams on highways. With help of C2C- or C2I-communication, vehicle systems are able to warn the driver even before the traffic jam could be noticed by the driver himself. Thus, the driver is informed in time and can react smoothly and safe.

Road works warning
Roadside units mounted on road works send messages to approaching vehicles, making drivers aware of potentially dangerous conditions at road works.

Car breakdown warning
This function enhances the safety of vehicles by detecting an upcoming disabled vehicle or by warning other/following cars that the own car is about to break down or disabled. Cars receiving this information will relay it to other following traffic-participants.
**Weather warning**
The objective of this function is to increase traffic safety by informing drivers about critical weather conditions ahead. The system particularly applies to scenarios where the danger can hardly be visually perceived by the driver or in which the weather conditions change unforeseeably. These may include strong wind gusts, black ice, heavy rain or other events.

**Emergency electronic brake lights**
This function enhances the safety of vehicles in a dense driving environment. It aims to avoid (fatal) rear end collisions which can occur if a vehicle driving ahead suddenly brakes on highways, especially in dense driving situations or in situations with decreased visibility. The driver will be warned before he is able to realize that the vehicle ahead is braking hard, especially if he/she does not see the vehicle directly (vehicles in between).

**Slow vehicle warning**
The slow vehicle warning system is designed to aid the driver in avoiding or mitigating rear-end collisions with vehicles in front of the own car. The driver will be alarmed through driver notification or warning of the impending collision on slow vehicles. The system does not attempt to control the vehicle in order to avoid an impending collision; instead it warns the following vehicles on the potential danger of the slow vehicle.
Post crash warning
The objective of this function is to provide information about one or more crashed vehicles on the driver's route. The most relevant factor is to provide the information about the location of the crashed vehicle as soon as possible after the event. It must be taken into account that the crashed vehicles might not be able to send out any messages. Therefore, the challenge consists in the capacity to detect the crashed vehicle(s) by recognizing its/their situation from the outside.

Obstacle warning
The driver will receive a warning to be prepared for an upcoming danger. For example the driver receives a warning about an obstacle blocking the driver’s route, such as lost cargo on the road. This allows the driver to slow down the vehicle early.

In-vehicle signage
Roadside units mounted on traffic signs and key points along the roadway send messages to approaching vehicles, increasing the likelihood of drivers being aware of potentially dangerous conditions in case a roadside traffic sign is not noticed.
Green light optimized speed advisory (GLOSA)
This function reduces stop times and unnecessary acceleration in urban traffic situations to save fuel and reduce emissions. The provided speed advice helps to find the optimal speed to pass the next traffic lights during a green phase. In case it is not possible to provide a speed advice, the remaining time to green is displayed.

Traffic information and recommended itinerary
In this function the overall traffic flow in monitored areas is improved by suggesting an optimized route for the driver maneuvering through areas with dense traffic.
Thank you for your attention

Are there any questions?
Important Notice

© Copyright 2014, dSPACE GmbH

All rights reserved. Written permission is required for reproduction of all or parts of this publication.
The source must be stated in any such reproduction.

This publication and the contents hereof are subject to change without notice.
Brand names or product names are trademarks or registered trademarks of their respective companies or organizations.