Vehicle-to-Infrastructure Research - Track 1
Enabling Technologies

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V2I Track 1 – Enabling Technologies

Goal – Develop and integrate the infrastructure components necessary to provide the foundation for V2I deployment.

- Signal Phase and Timing (SPaT)
- Mapping
- Positioning
- Communications
- Roadside Equipment (RSE)
- Integrated Prototype
Signal Phase and Timing (SPaT)

Goal: Develop an interface between signal controllers and RSE to enable 2-way data exchange between vehicles and controllers

- **SPaT Data**
  - Signal state by movement
  - Min/max time remaining by movement
  - Exact time remaining in yellow

- **Geometric intersection description (GID)**

- **Signal request messages** (Emergency vehicle preemption, transit signal priority, etc.)

- **RTCP position correction message**

- **Standards to promote interoperability**
  - NTCIP 1202 and 1211
  - SAE J2735
SPaT Operation Overview

On Board Equipment (OBE)

No Dedicated turn signals

Left turn and through signals

Lane Centerline

Intersection Location

X

X

X

X

X

X

Stopping Location

Intersection ID: 23983

1

2

3

4

5

6

7

8

9

10

Lane ID

Traffic Control Device

DSRC radio

SPaT Processor

Positioning/GPS

Map storage/GID

Traffic Control Device
Open Interface – Concept

Traffic
Signal
Controller

- NEMA TS-X
- 2070
- ATC
- Others

SPaT Interface definition

NTCIP 1202

Mobile Equipment

SAE J2735

Two-way communication
Signal Phase and Timing (SPaT)

- Interface tested in the Connected Vehicle Highway Testbed (CVHT) at the Turner Fairbank Highway Research Center (TFHRC)
- Safety Pilot - 12 intersections equipped
  - broadcast the SPaT information
    - Transit apps plan to use data, required a new field for pedestrian detection
  - SPaT data will be logged to facilitate future application development
- Safety, mobility and environmental V2I applications will need SPaT data
Mapping

Goal: Collect relevant roadway geometry and attributes data and broadcast it for use in V2I applications.

- **Mapping Data**
  - Pavement marking
  - Roadway signs
  - Roadside furniture (poles, cabinets, other potential obstructions)
  - Roadway geometry (e.g. curvature)

- **Mapping Technology**
  - LIDAR
  - Aerial Photogrammetry
  - As-built plans/maps
  - Data Fusion
  - Probe Data/crowd sourcing
Mapping Findings

- Vehicle mounted technologies solution (LIDAR) provides the most detailed data for use as a core mapping solution.

- Vehicle mounted technologies solution is relatively costly and requires an investment in resources including skilled personnel and equipment.

- The other mapping solutions will remain useful for change detection as well as for mapping under certain specific conditions.

- Collection, preparation, and use of mapping data completed at the TFHRC Testbed May 2012.

- Three lane-level applications were demonstrated using decimeter-level positioning techniques:
  - Lane departure warning
  - Curve speed warning
  - Signal Phase and Timing, at lane-level
Positioning

Goal: Ascertain which current or near-term positioning technologies can meet requirements of V2I applications

- Which road?
- Which lane?
- Within lane?

• Two technology platforms for positioning
  • On-board vehicle equipment
  • Infrastructure-based correction messages
Positioning Findings

• Positioning and mapping are closely related
• Two approaches based on application type
  • V2I relies on absolute positioning solution
  • V2V relies on relative positioning solution
• Accurate vehicle position at intersection is critical
  • SPaT information is based on a phase to lane assignment
  • Requires lane-level accuracy
• Testing technologies at the CVHT in early fall
  – Baseline OEM grade GPS
  – Inertial Measurement Units (IMU)
  – GPS code and carrier solutions (correction messages)
Communications

Goal: To test multiple communication technologies for potential use in V2I applications

– Quantify capabilities of the technologies against requirements of key V2I applications
– Gather subject matter expert opinions to select the most promising candidates
  • Dedicated Short Range Communications (DSRC)
  • Cellular 4G/LTE
  • High definition radio
– Test the technologies in a laboratory field test at CVHT this fall
Communications Findings

• Connected vehicle program will likely utilize multiple technologies
  – Active safety applications to use DSRC
  – mobility and environmental applications to use DSRC and/or cellular (4G/LTE)

• Deployment of 4G/LTE is limited and dependent on private development

• DSRC has limited bandwidth and footprint

• Some wireless communications appear to interfere with GPS signals
Roadside Equipment (RSE)

Goal: Foster the development of RSE that meets the requirements of the connected vehicle program

- Current RSE to broadcast and receive using DSRC
- Modular in both physical and logical architectures
- Immediate forwarding (e.g. SPaT)
- Store and replay (mapping data, traffic incident management messages)
- Connected to backhaul for data logging
Roadside Equipment (RSE)

• 5 vendors participated in prototyping
• Research qualified products list (rQPL) issued 5/11/12 for use by Safety Pilot
• Development will continue to refine design based on Safety Pilot results
• Refinements will be made to incorporate multiple radio chipsets, if warranted
Integrated V2I Prototype

• Comprehensive solution to connected vehicle infrastructure needs
  – Incorporate all parts of Track 1 to work seamlessly to enable V2I applications
  – Comprehensive review of V2I system requirements
  – Integration and testing of a complete infrastructure system.
    • Data flows
    • Information exchange
    • Standards
For More Information.....

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