Connected Vehicle CRADA Partnership

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Topics

• What Is a CRADA?
• Background
• CRADA Project Partners
• Project Needs and Objectives
• Dedicated Short Range Communications (DSRC)
• Current Status
• Project Schedule
• Mobile Road Weather Data Collection
• Communications Architecture
• Data Delivery
• Hurdles and Issues
• What’s Next
• Q & A
What Is a CRADA?

- **Cooperative Research And Development Agreement.**
- Private companies preserve their ability to file patents.
- U.S. Government gets a license to all patents filed.
- Ability to leverage assets and funds.
- INL-ITD executed CRADA in 2014.
- INL-Savari CRADA in final review.
Background

• Idaho National Laboratory (DOE)
  – Operates large nuclear research facility in eastern Idaho, 870 square miles
  – Transit fleet of over 90 motor coaches and 400 other vehicles
  – Over 6,000 employees: 4,000 at site, 2,000 in Idaho Falls

• Idaho Transportation Department (ITD)
  – Operates and maintains state highway system, including the INL bus routes that originate from six cities:
    • Idaho Falls
    • Pocatello
    • Blackfoot
    • Rigby
    • Rexburg
    • Mackey
Background cont.

- Bus route network consists of some rural interstate segments and predominately two-lane rural highway segments.
- Speed limits range from 65 mph to 80 mph.
- This region experiences environmental challenges year round:
  - Winter storms, snow, and ice
  - High winds, blowing snow/dust
  - Range fires, smoke.
- Elevations range between 4,000 and 5,000 feet.
- Bus routes are patrolled by scout vehicles in advance of bus schedules to report road conditions to dispatch and management.
Rural Two-Lane Route to INL
INL Approach to Transportation Research

Three Main Areas for INL

- Fuels – ethanol (E85), liquefied natural gas (LNG), and B20 biodiesel
- Electric vehicles – large data collection effort, visualization and analysis, battery lab, and micro grid
- Advanced and connected vehicles, including:
  - Simulation
  - Field test of prototypes
  - CRADA-supported CV research
  - Test range buildout
  - CRADA ties INL and the Idaho State Government and 511 systems and vendors
  - INL lab access to various experts – from cyber, Human Factors Engineering (HFE), electromechanical, and fleet operations
CRADA Project Partners

- Idaho National Laboratory (INL)
- Idaho Transportation Department (ITD)
- Idaho Health and Welfare (EMS Bureau)
- Vaisala
- Castle Rock Associates
- Savari
- SiriusXM
- University of Idaho
- Virginia Commonwealth University
Project Needs and Objectives

- Idaho National Laboratory (INL)
  - Improve vehicle safety
  - Improve operations
  - Executive Order 13693
    - Reduce emissions
    - Reduce fuel consumption
    - Federal agencies to take a leadership role

- Idaho Transportation Department (ITD)
  - Improve winter maintenance efficiency and effectiveness
  - Improve safety and mobility
    - Additional data for CARS 511
RWIS Eastern Idaho

Thu Dec 30 08:47:28 2018

East View

Pocatello, US-26/76, MP 272, Elev 4,354 ft,
When things Go Wrong…
## Crash Data on Bus Routes, 2010-2015
### Annual Average

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Deciphering the Acronyms

- BSM – Basic Safety Message
- C2C – Center to Center Communications
- DMS – Dynamic Message Signs
- DSRC – Dedicated Short-Range Communications (5.9 GHz, 7 channels)
- HAR – Highway Advisory Radio
- HFE – Human Factors Engineering
- OBE – On-Board Equipment, also OBU
- RSU – Roadside Unit, also RSE
- SCMS – Security Certificate Management System
- TIM – Traveler Information Message
- V2I – Vehicle to Infrastructure
- V2V – Vehicle to Vehicle
- V2X – Vehicle to Device
Dedicated Short-Range Communications (DSRC)

- Two-way short- to medium-range wireless communications
- Up to 1,000 meters; typical is 300 meters
- FCC allocated 75 MHz of spectrum (7 channels) in the 5.9 GHz band for use by ITS for safety and mobility applications
- Fast network acquisition
- Low latency
- High reliability, 100 millisecond transmissions
- Priority for safety messages
- Security Certificate Management System
- Interoperability, SAE J2735 standard for messages
  - Basic Safety Message (BSM)
  - Traveler Information Message (TIM)
DSRC Security Certificates

- Security certificates are used to authenticate the sender and receiver of DSRC messages.
- Certificates have short expiration times to promote privacy.
- DSRC radios need a library of certificates.
- Revocation lists of certificates are broadcast triggered by reported malicious behavior.
- SCMS delivery mechanisms for new certificates and revocation lists include:
  - Network communications to RSUs
  - V2I communications to update OBE when in proximity of RSU
  - Satellite radio communications to SiriusXM receiver equipped vehicles.
DSRC Certificate Communications Overview

Roadside Equipment
DSRC RSE & 3G/4G Modem

3G/4G Cellular IP Communications

IP Communications, Certificates, Revocation Lists

SCMS Server
SiriusXM Security Certificate Distribution
Connected Vehicle Applications

• Phase 1 2015-2016
  – Mobile road weather data collection
    • First installation: INL scout vehicle, May 2015
    • Three additional units installed 2016
    • One unit pending repair return
  – Snow plow controller data uploads to Vaisala Navigator website
  – Scout vehicle V2V safety (DSRC)
    • Forward collision warning
    • Electronic brake light warnings
    • Intersection moment assist
    • Blind spot and lane change warning

• Phase 2 2016-2017 (pending funding)
  – Signal phase and timing broadcasts along US 20, 14 intersections
  – Bus and snow plow V2I
  – Dashboard camera images
  – 511 Connected Vehicle modules
  – Two animal detection zones
RWIS Communications

3G/4G Cellular Communications (secured by VPN)

Polling Using IP Communications

ITD and INL Operations

Navigator Website

Vaisala Navigator Web Server
Cellular Communications Security

- Vaisala was tasked to provide and manage communications to all RWIS sites under a data hosting contract.
- Vaisala experienced some denial of service attacks, which inflated their cellular bills. That got their attention.
- Vaisala created a firewall at their modems to provide hacking protection. This solution has worked.
- ITD cellular modems for DMS and HAR were moved to a Verizon private network that is password protected.
- In the past there were a few hacks, but none since the network reconfiguration.
- Roadside cabinets containing the electronics are locked.
Kettle Butte RWIS

RSU Installation

Cabinet goes here
RSU
RSU Installation 1

Before installation

Tilt down lowering of the tower
RSU Installation 2

Bolting the RSU to the tower

Raising the tower
RSU Installation 3

Sierra Wireless 4G Modem
PoE Injector
AC to DC Transformer
RSI Installation 4

Yagi Antenna

Omnidirectional Antenna
Now It Is Ira’s Turn

Here is Ira Pray, Manager, Fleet Management Services
Current Status

- Mobile road and weather data collection
  - Four units installed, one pending repair
- Mobile road weather data archived on Vaisala Navigator website
- Dashboard cameras
  - iPhone versus Android being discussed
- V2V safety applications
  - Loaded into Savari DSRC OBEs
- 511 website enhancements
  - Work scope finalization underway, pending funding
511 Website
Project Schedule

• 2015-2016
  – Mobile data collection
  – Snowplow data uploads, integration with Vaisala Navigator
  – DSRC radio installation and testing
  – SiriusXM security certificate and TIM broadcast underway

• 2016-2017
  – V2V applications (scout vehicle, bus, and snowplow)
  – Signal phase and timing – US 20 in Idaho Falls
  – SiriusXM broadcasting
  – Additional V2V testing in simulator, Human Factors Engineering design optimization
  – Evaluation
INL Scout Vehicle With DSP310
DSP310 Pavement Temperature Sensor
DSP310 Controller Case
DSP310 Pavement Condition Sensor
DSP310 Pavement Condition Sensor
DSP310 Cell Phone Interface
DSP310 Data Collection Parameters

- Surface temperature
- Surface state
  - Dry
  - Moist
  - Wet
  - Snow
  - Ice
  - Slush
- Grip (friction coefficient)
- Dew point temperature
- Air temperature
- Relative humidity
Mobile Data on Vaisala Navigator Website
INL Bus
ZONAR Android Tablet
OBE to Be Installed on INL Scout Vehicles
Scout Vehicle DSRC Installation One

DSRC Antenna

OBE
DSRC Communications Overview

- Cloud
- 3G/4G Cellular IP Communications
- Back Office Server
- IP Communications
- Roadside Equipment
  - DSRC RSE & 3G/4G Modem
- V2V and V2I Communications
- DSRC OBE

3G/4G Cellular IP Communications
Example: A V2V system leveraging satellite distribution may warn vehicles approaching icy conditions before passing through a RSU coverage area.

**OEM Benefit**
- Safer drives for customers
- Ubiquitous V2V security management
- Improved data for customer usage
- Low-cost and high-coverage delivery mechanism (satellite)
Communications Software Required

• Existing
  – RWIS polling (Vaisala)
  – DMS & HAR central control (iNET)
  – iNET to CARS-511 (C2C)
  – Situation Data Warehouse (SiriusXM)

• To be developed
  – DSRC units to/from back office archive
  – CARS-511 hub to Situation Data Warehouse
Hurdles and Challenges

- Traveler Information Message (TIM) development (FEU to SAE J2735)
- Configuration of DSRC radio sets (first cellular backhaul)
- Human-machine interface on vehicles
- Integration of SiriusXM data on INL Android Zonar tablet
- Funding for expansion of project (ATCMTD proposal has been submitted)
Data Delivery Summary

• Mobile road weather data delivered to Vaisala; displayed on Navigator website; accessed by INL & ITD

• DSRC message traffic just starting
  – V2V scout vehicles
  – V2I Kettle Butte RWIS
Are We Meeting Our Goals?

• Mobile data via Navigator website will provide valuable data to winter operations at ITD and INL.

• Expected results are improved and more efficient winter operations for both INL and ITD, including:
  – INL dispatch decision making
  – INL site closure decisions
  – ITD Winter Performance Measure scoring
  – Lower winter maintenance costs for ITD.

• Safety improvement results will await data collection starting in late 2016.

• Too early to evaluate DSRC and satellite communications enabled applications.
What’s Next (Pending Funding)

• Add dash cameras on snowplows, buses, and scout vehicles
• Add thermal and grip mapping to 511 website
• Add mobile road weather data and dashboard camera images to 511 website, apps, and subscription service
• Interface 511 with SiriusXM
• SiriusXM broadcasting of critical events with geofencing
• Expand DSRC deployment, OBEs, and RSUs.
• Upgrade signalized intersections on US 20 with new controllers, detectors, and DSRC radios
• Deploy two large animal warning systems on bus routes
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Questions??

Thanks for your attention.
What is DOE Interest?
Office of Energy Efficiency & Renewable Energy (EERE)

• Renewable Energy: $370M
• Energy Efficiency: $664M
• Sustainable Transportation: $558M

Drivers of Technology:
➢ Reduce GHG emissions by 15% by 2020
➢ Reduce net oil imports by 50% by 2020
➢ Achieve CAFE Standards 54.5 mpg by 2025
Advanced Transportation: Drivers & Gaps

<Drivers>:

- **High-Level Goals at the Federal Level – DOE-EERE:**
  - Reduce GHG emissions by 15% by 2020
  - Reduce net oil imports by 50% by 2020
  - Achieve CAFE Standards 54.5 mpg by 2025

- **State Level Mandates Driving Sales – CARB:**
  - Reduce smog/reduce greenhouse gas
  - Promote cleanest cars/provide fuels for cleanest cars (electricity & hydrogen)
  - 7500 ZEVs between 2012 - 2014; 25,000 ZEVs between 2015 - 2017

<Gaps>:

1. Cost of vehicle is prohibitive to consumer
2. Vehicle does not meet the perceived needs of the consumer (range, fill-time, infrastructure accessibility/cost/convenience)
3. Infrastructure/fuel is cost-prohibitive or does not exist