Connected Vehicle CRADA Partnership

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June 21-23 2016

WSRTTI Forum, Yreka, CA

www.inl.gov

Idaho National Laboratory

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?

- **C**ooperative **R**esearch **A**nd **D**evelopment **A**greement.
- Federal Technology Transfer Act of 1986 (P.L. 99-502); Stevenson-Wydler Technology Innovation Act of 1980 (P.L. 96-480).
- 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 Bus Routes

Idaho National Laboratory

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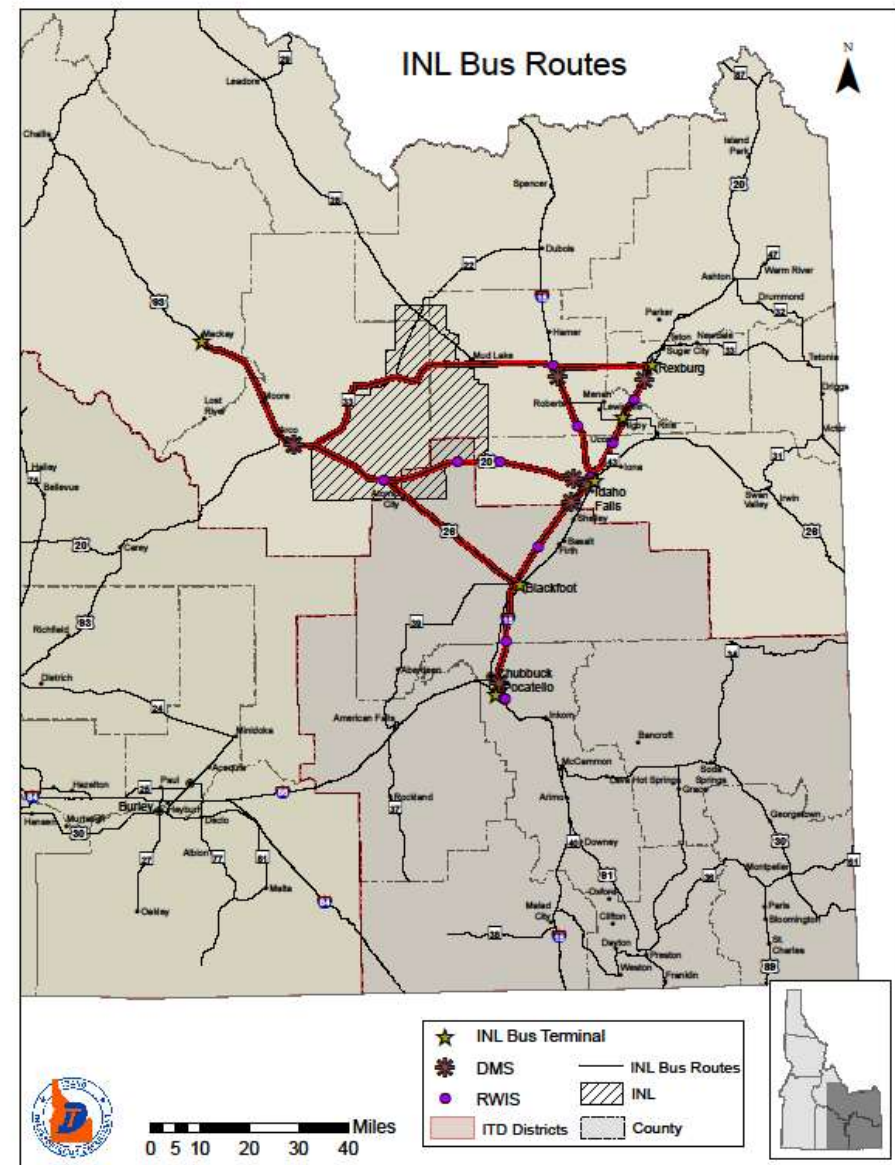
INL Approach to Transportation Research

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

RWIS Eastern Idaho

Puzzle, US-20/26, MP 272, Elev 4,954 ft, East View — Thu Dec 30 08:47:01 2010

When things Go Wrong…

Crash Data on Bus Routes, 2010-2015 Annual Average

Highway	Begin MP	End MP	Crashes	Fatalities
I-15	64	143	228	5
US-20	249	307	48	1
US-26	272	305	16	0
SH-33	0	78	34	0
US-93	82	108	17	0
Totals			**343**	**6**

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
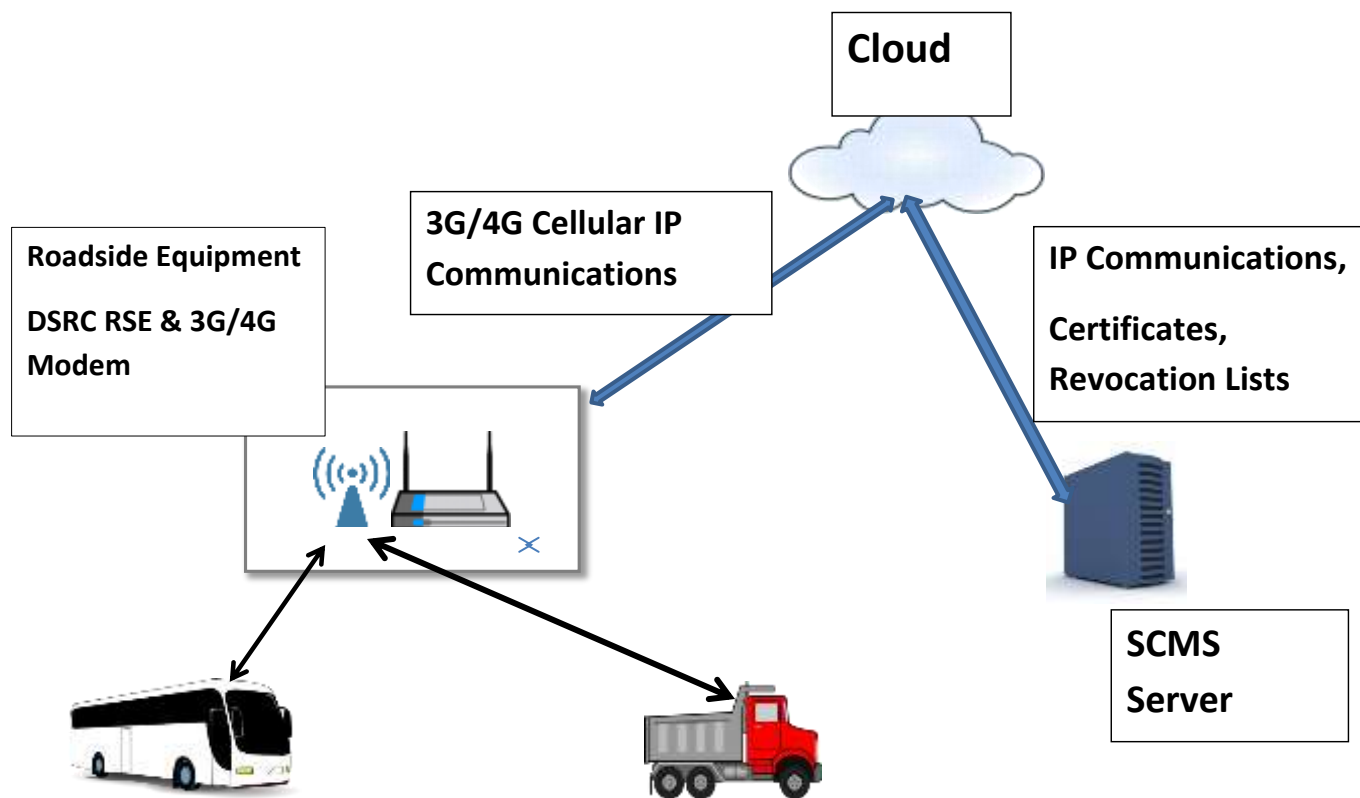- V2X – Vehicle to Device

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)
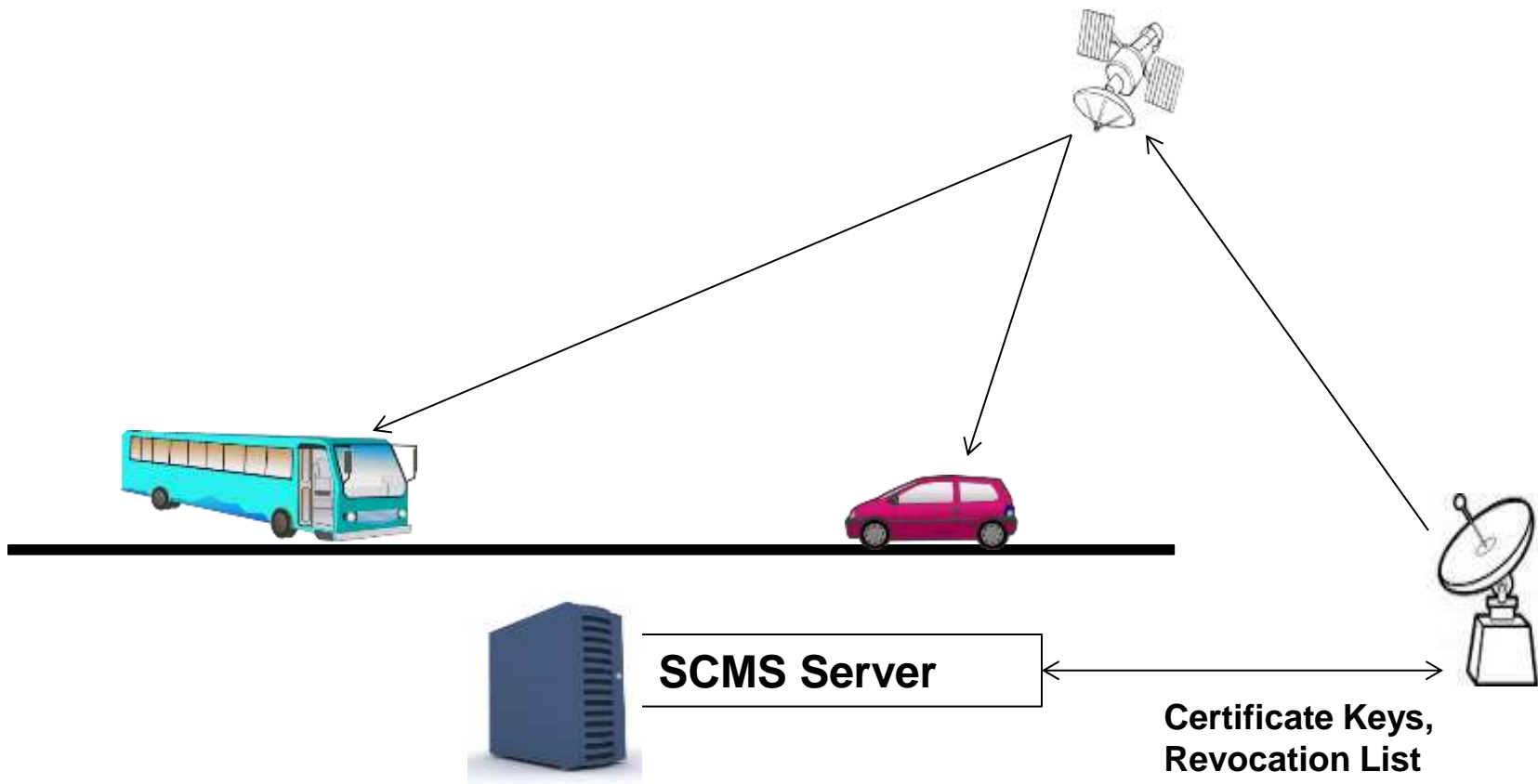 - Traveler Information Message (TIM)

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.
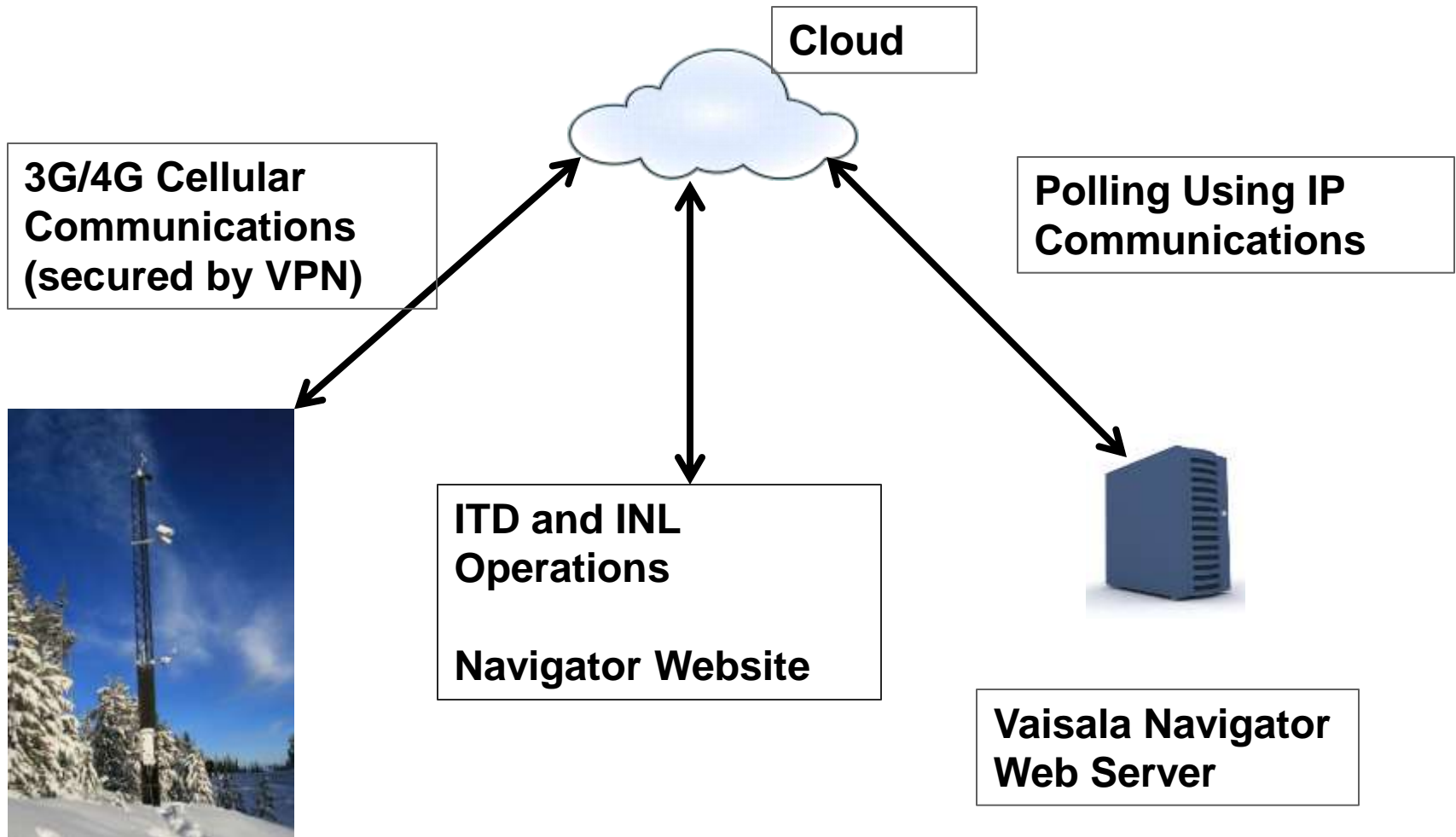
DSRC Certificate Communications Overview

Cloud

3G/4G Cellular IP Communications

Roadside Equipment

DSRC RSE & 3G/4G Modem

IP Communications,

Certificates,

Revocation Lists

SCMS Server

SiriusXM Security Certificate Distribution

SCMS Server

Certificate Keys, Revocation List

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

Cloud

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
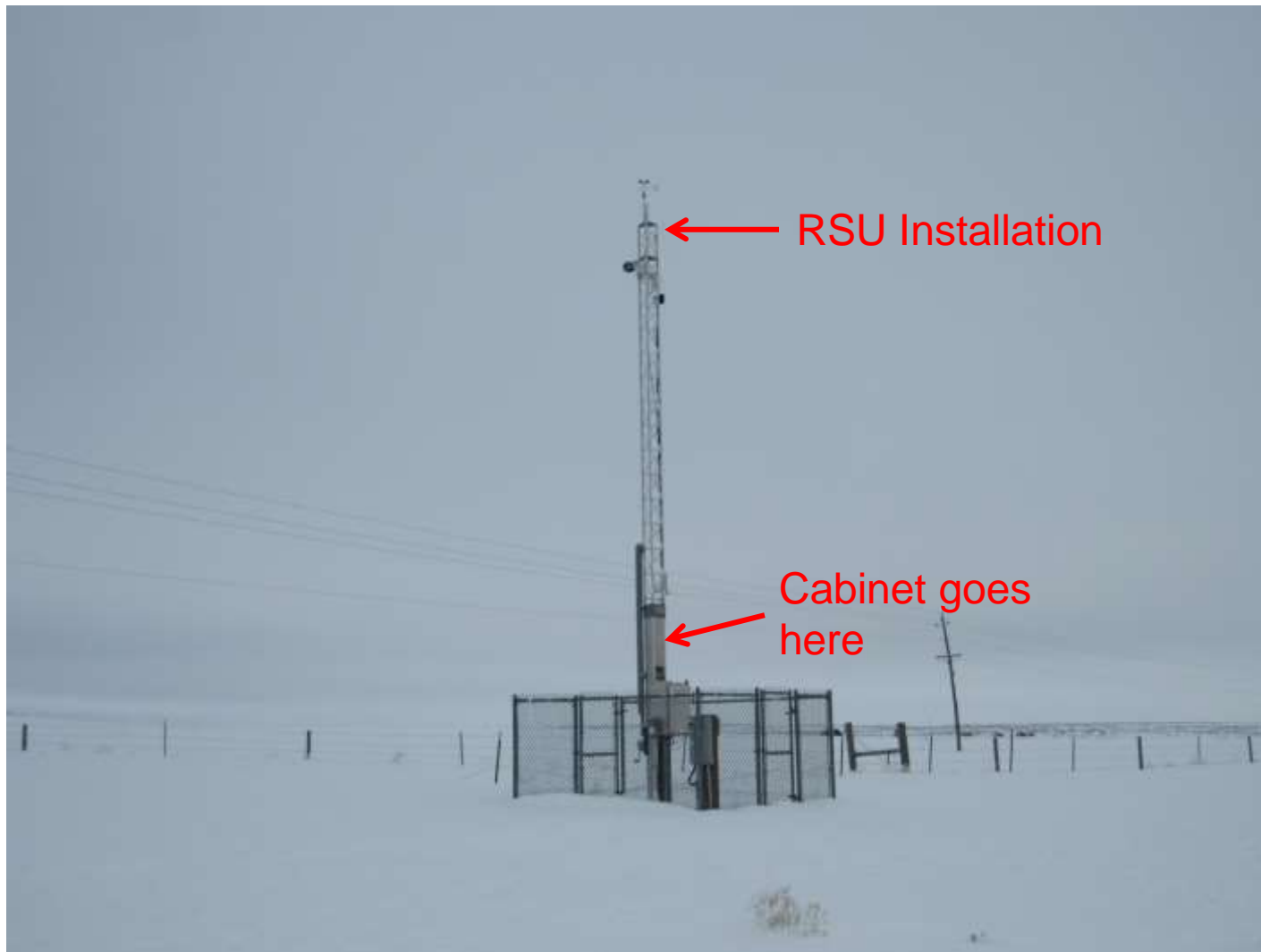
RSU

RSU Installation 1

Before installation

Tilt down lowering of the tower

RSU Installation 2

Bolting the RSU to the tower
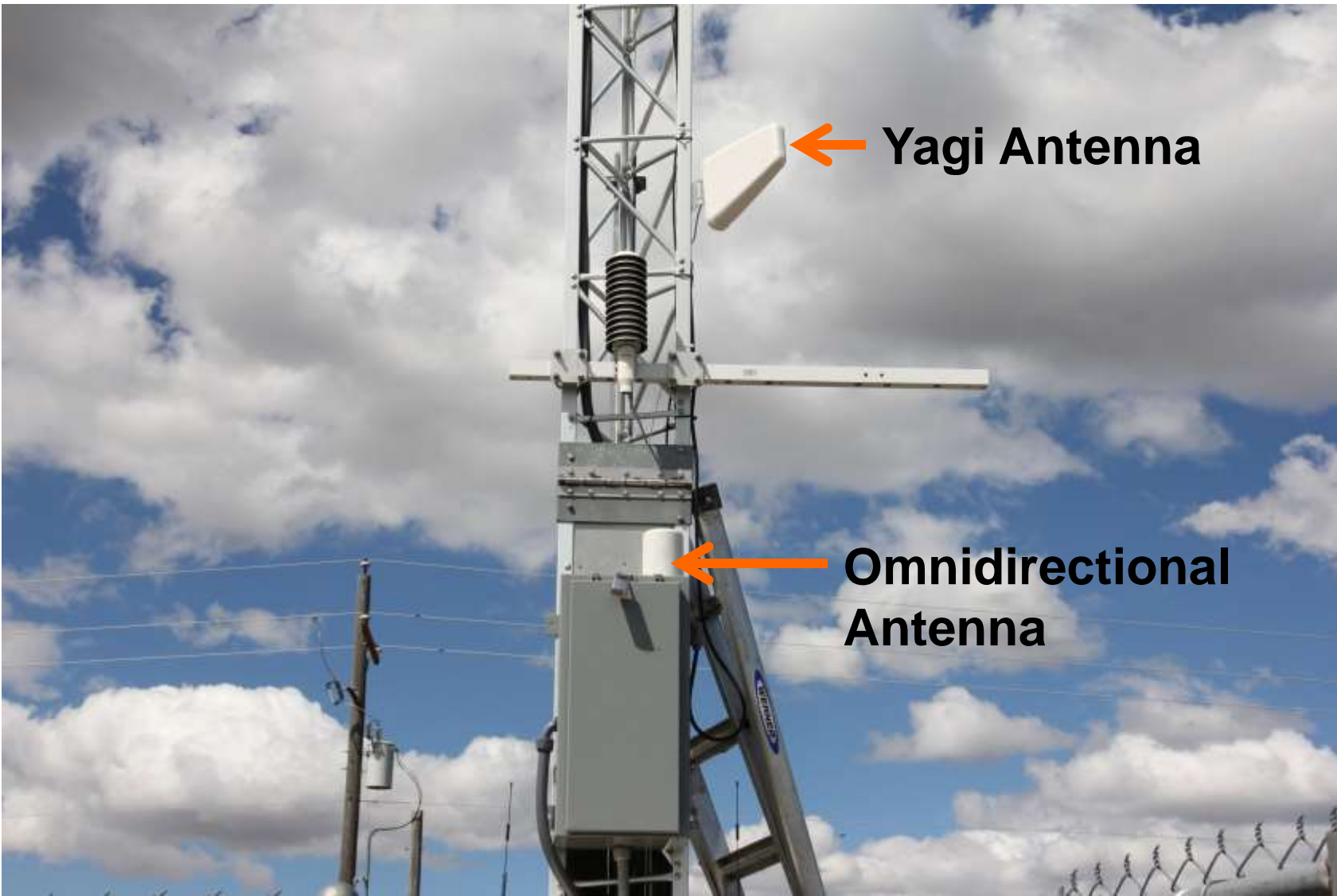
Raising the tower

RSU Installation 3

Sierra Wireless 4G Modem

PoE Injector

AC to DC Transformer

RSI Installation 4
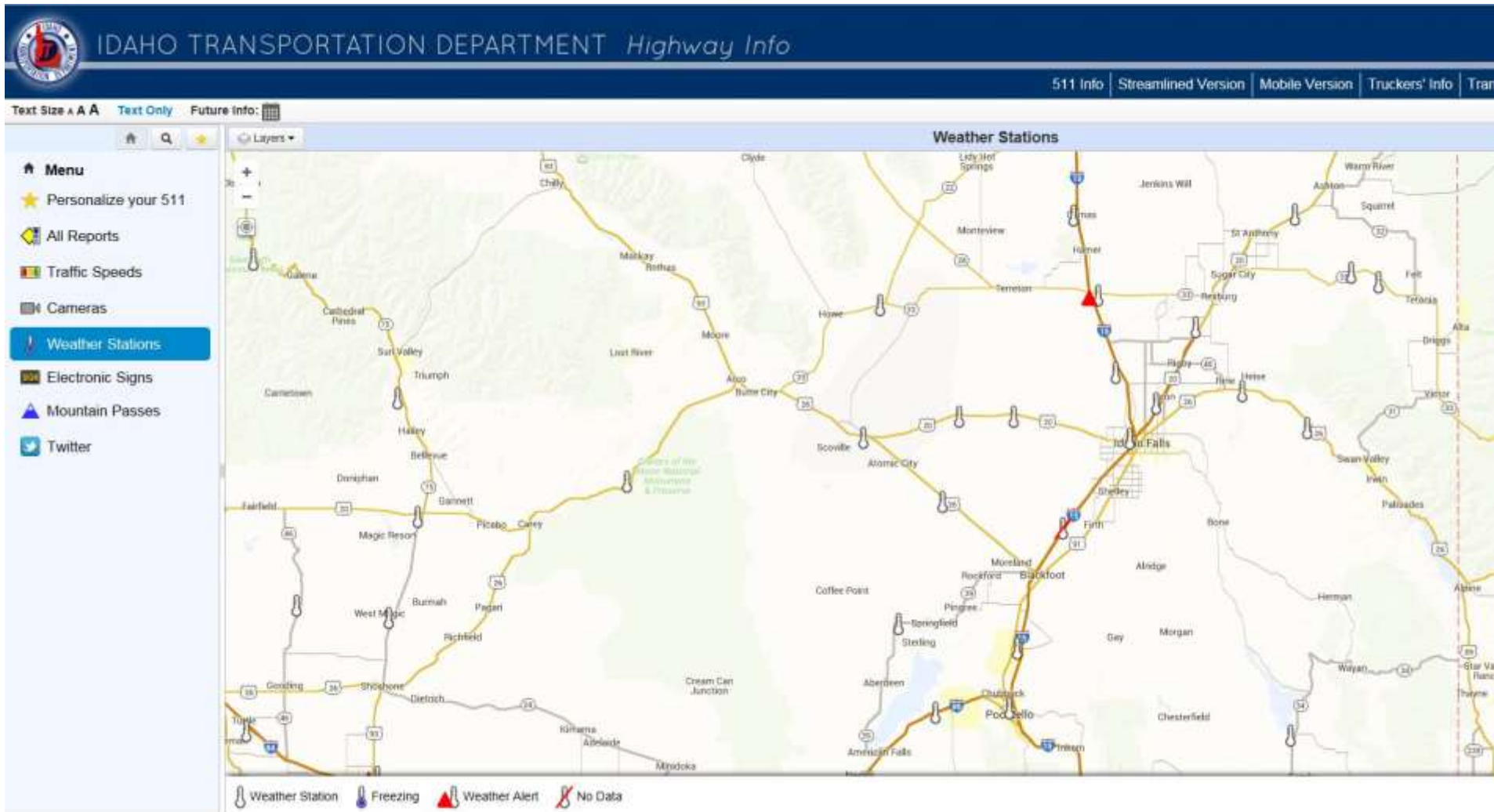

Yagi Antenna

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
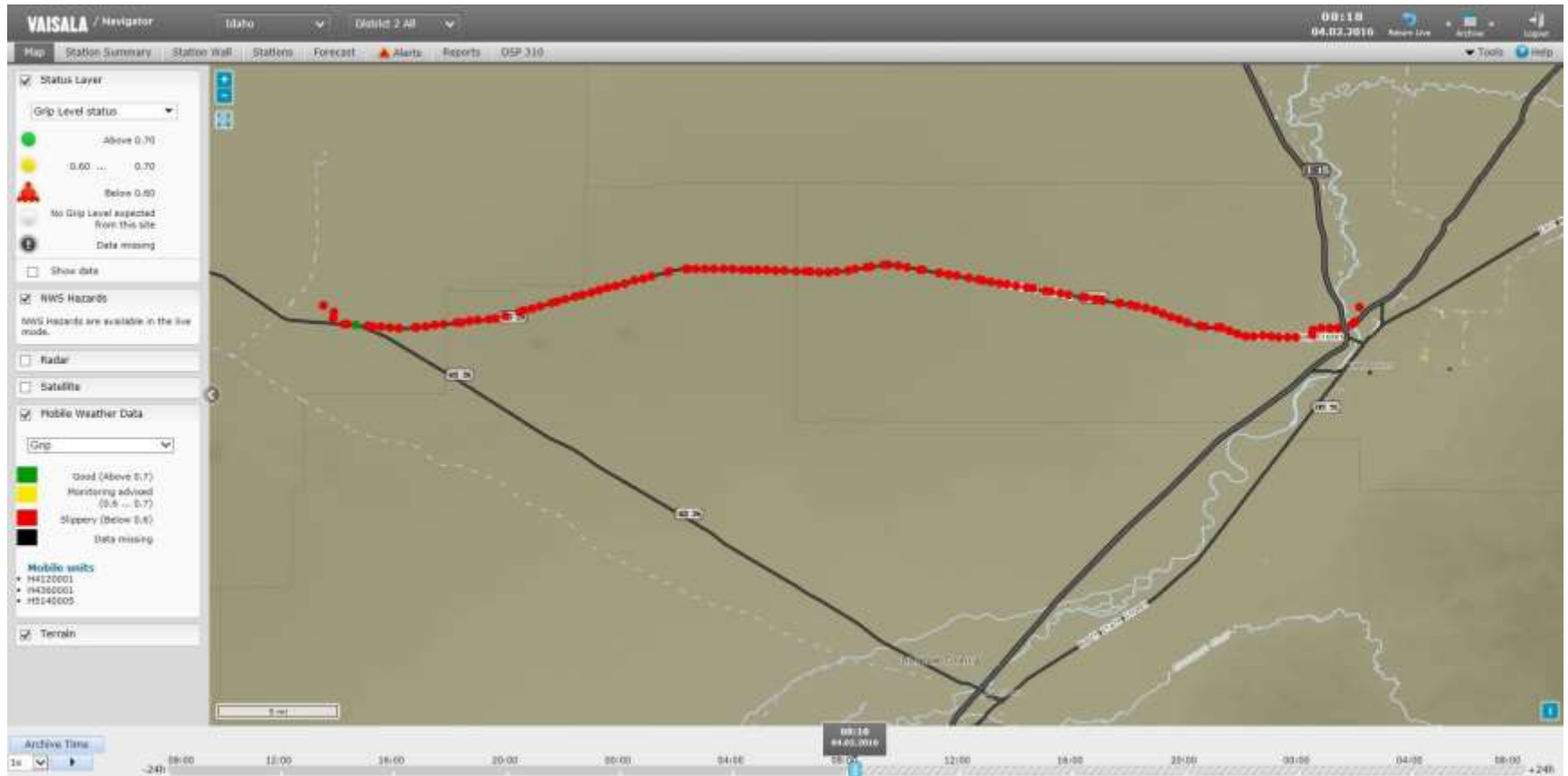
DSP310 Cell Phone Interface

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
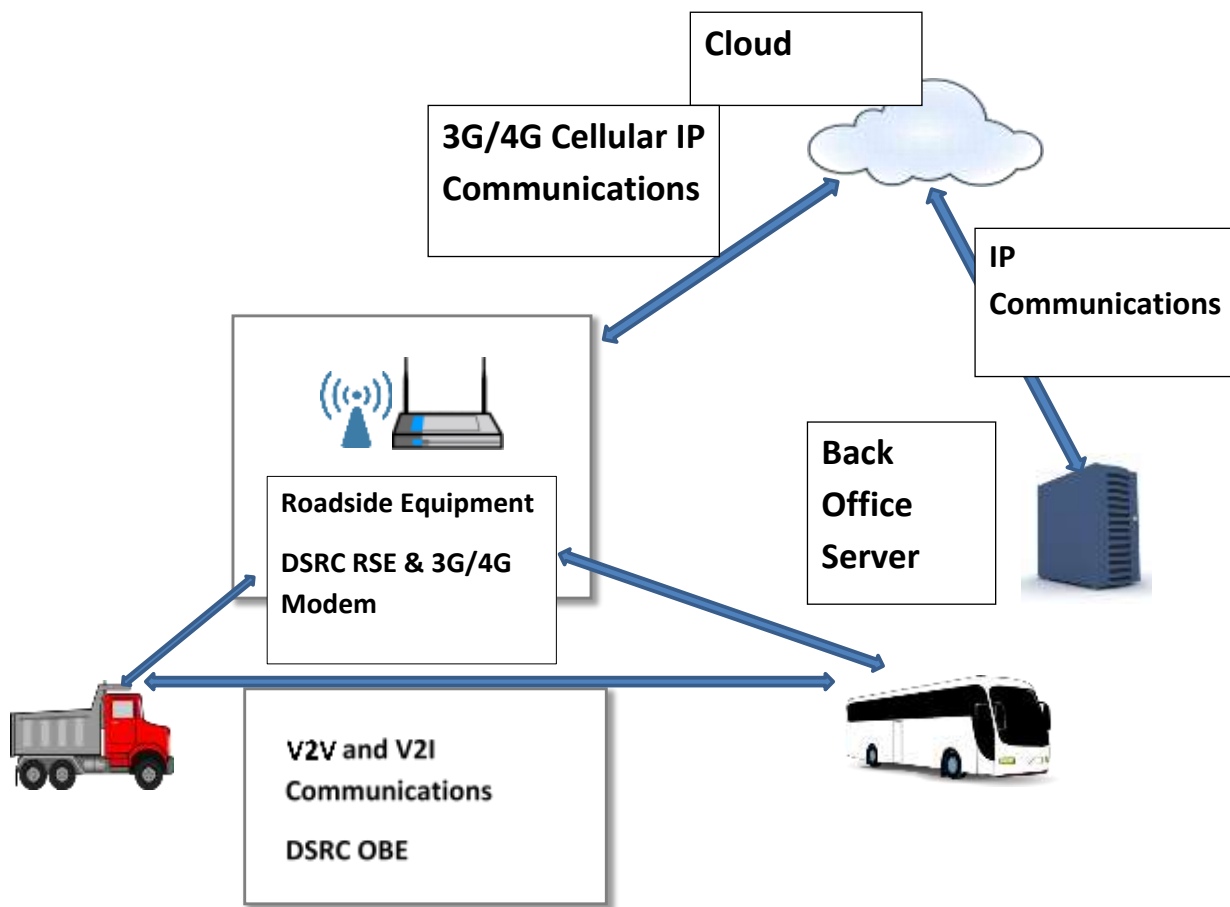
Scout Vehicle DSRC Installation One

DSRC
Antenna

OBE

DSRC Communications Overview

Wide Area TIM Distribution

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)

Broadcast Satellite

Ice Warning

Ice Patch

#1

#2   #3

RSU

RSU Coverage

Satellite Uplink

| Other Situational Sources | → | Situation Data Warehouse | Ice Warning | Satellite Uplink |

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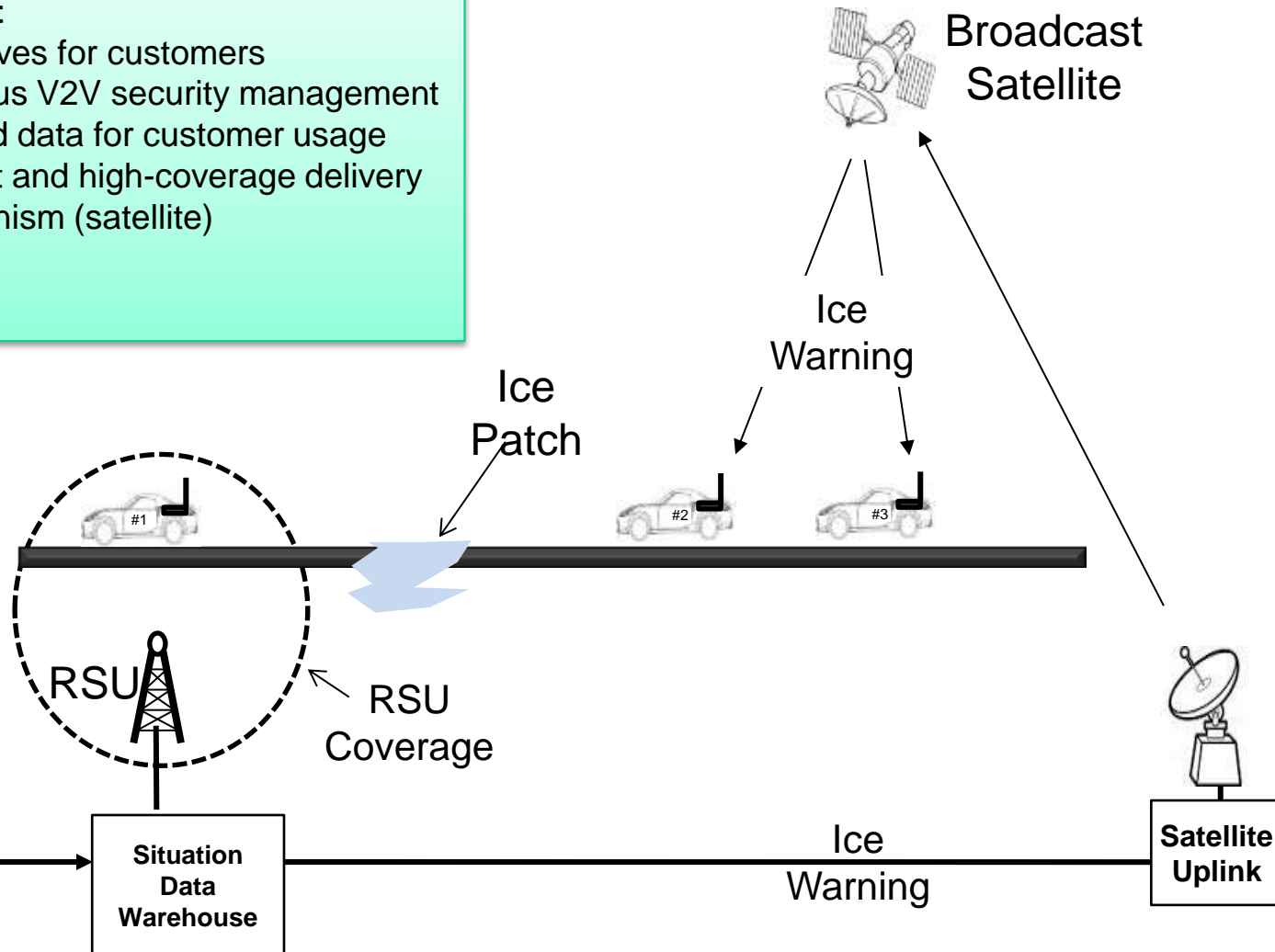
Communications Software Required

- 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

Contact Information

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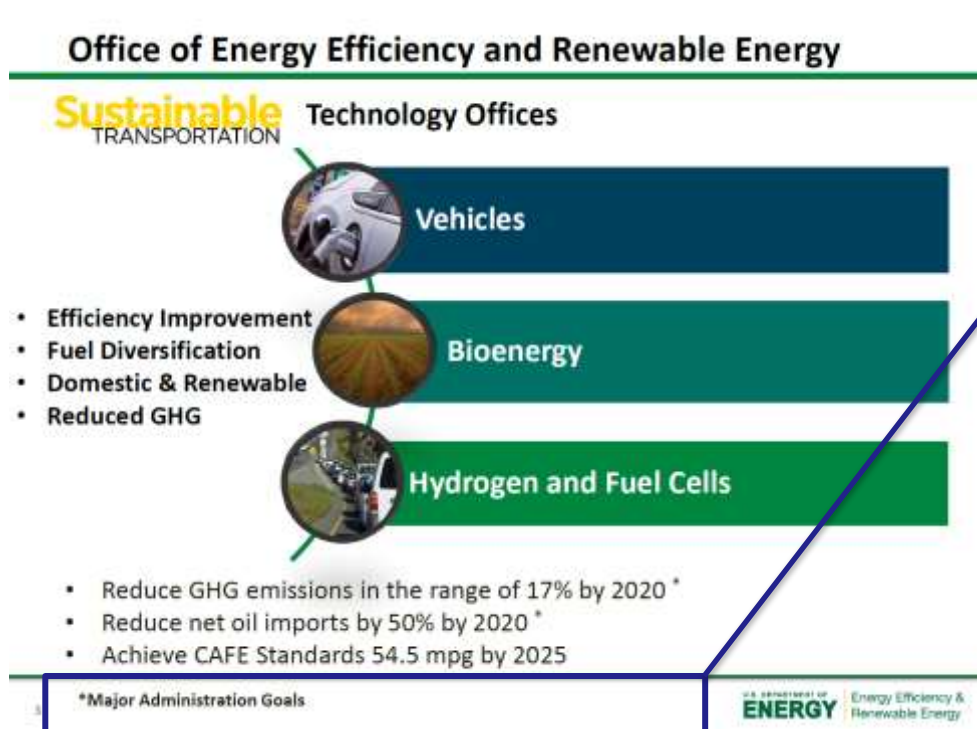
Questions??

Thanks for your attention.

What is DOE Interest?
Office of Energy Efficiency & Renewable Energy (EERE)

- **Renewable Energy: $370M**
- **Energy Efficiency: $664M**
- **Sustainable Transportation: $558M**

Office of Energy Efficiency and Renewable Energy

Sustainable TRANSPORTATION **Technology Offices**

Vehicles

- Efficiency Improvement
- Fuel Diversification
- Domestic & Renewable
- Reduced GHG

Bioenergy

Hydrogen and Fuel Cells

- Reduce GHG emissions in the range of 17% by 2020 *
- Reduce net oil imports by 50% by 2020 *
- Achieve CAFE Standards 54.5 mpg by 2025

*Major Administration Goals

ENERGY | Energy Efficiency & Renewable Energy

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