University of Idaho
National Institute for Advanced Transportation Technology

CONNECTED VEHICLE DEPLOYMENT IN ADA COUNTY, IDAHO: LESSONS LEARNED

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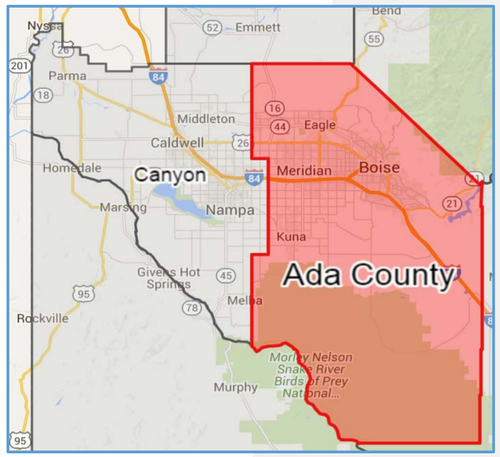
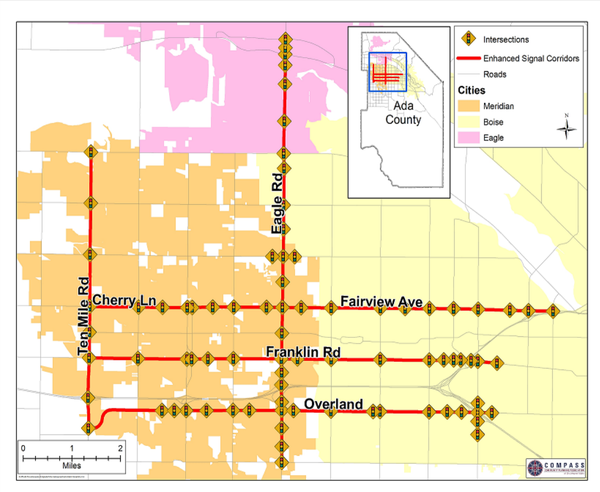
PACIFIC NW TRANSPORTATION CONSORTIUM
PACTRANS
REGION 10

PROJECT OVERVIEW

FIELD EVALUATION OF V2I CONNECTED VEHICLE DEPLOYMENT IN ADA COUNTY, IDAHO - VALIDATING COMMUNICATION ARCHITECTURE AND CONTROL TECHNOLOGY READINESS

- Traffic signal system V2I and I2V data exchange
- Connected Vehicle–based priority for vehicles at signalized intersection approaches





IDAHO TRANSPORTATION DEPARTMENT

ACHD

COMPASS
COMMUNITY PLANNING ASSOCIATION

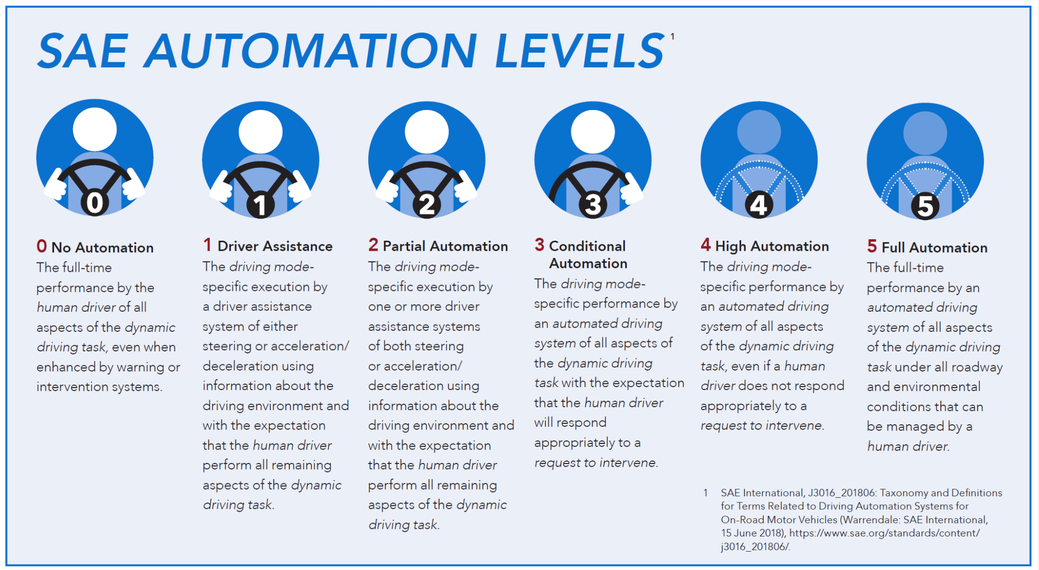
Treasure Valley

SMART Arterial Management

Advanced Transportation & Congestion Management Technologies Deployment Initiative

USDOT Funding # 693JJ317NF0001

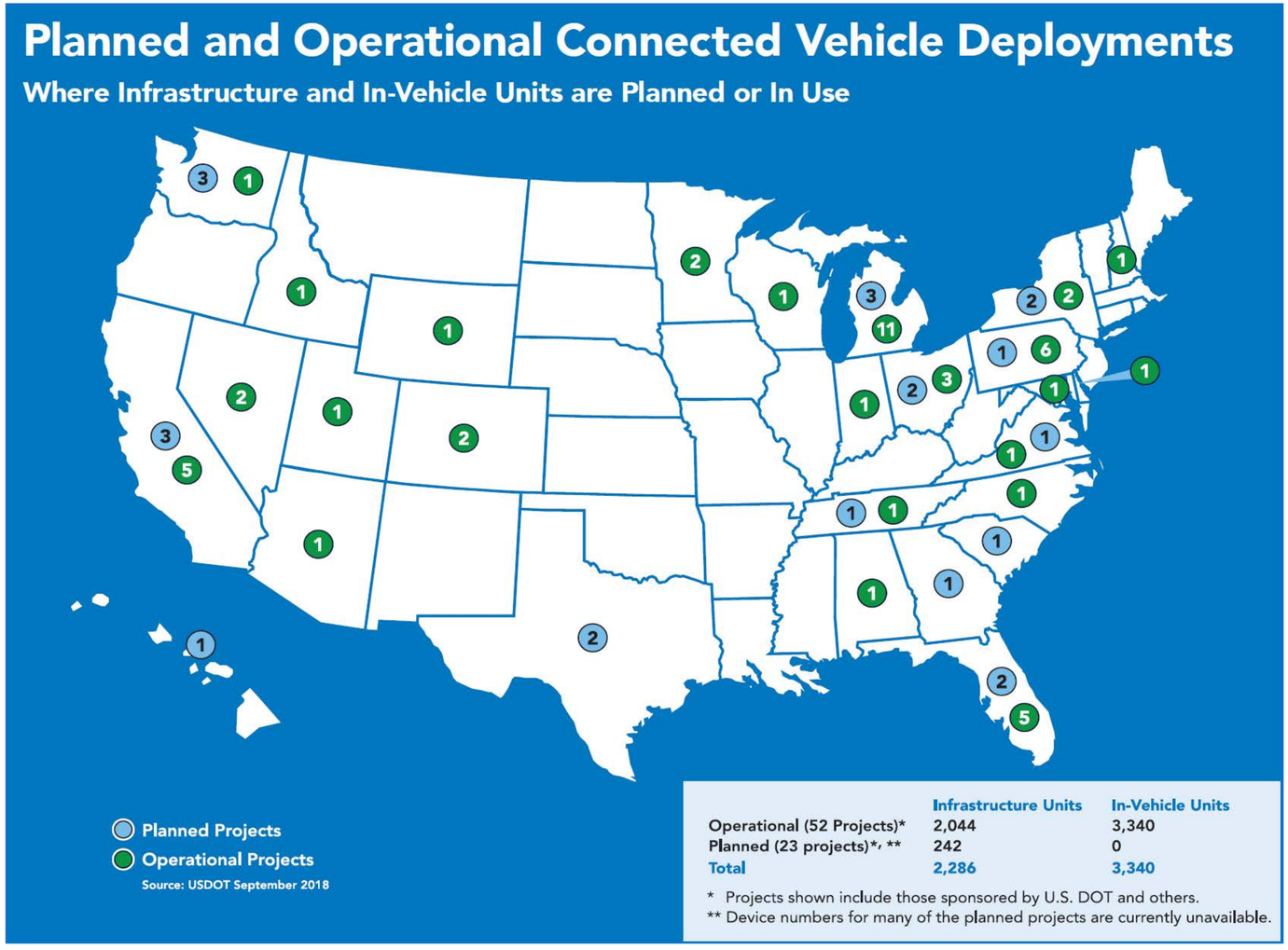
OVERVIEW: CONNECTED VEHICLE VS. AUTONOMOUS VEHICLES WHAT IS THE DIFFERENCE?



Fully Autonomous Intersections

V2V, V2I, I2V, I2X, X2V, V2X

CONNECTED VEHICLES – CURRENT IMPLEMENTATION STATUS



CONNECTED VEHICLE TERMINOLOGIES

- V2I/V2V/V2X
  - Vehicle-to-Infrastructure, Vehicle-to-Vehicle, Vehicle-to-Everything
- DSRC – Dedicated Short Range Communications
  - Standards document: IEEE 802.11p (lower layer)
  - Defines the data link and physical layer of V2X communications
  - Operates on 75 MHz spectrum of 5.9GHz band (5.850-5.925GHz, 7 channels)
- WAVE – Wireless Access in Vehicle Environments
  - Standards document: IEEE 1609 (upper layer)
  - Defines the architecture, communications model, management structure, and security access

CONNECTED VEHICLE TERMINOLOGIES

- RSU/RSE – Road Side Unit / Road Side Equipment
  - RSU – Infrastructure DSRC radio module
  - RSE – RSU plus supporting equipment
  - Specified by WAVE and USDOT RSU Specifications 4.1
  - Messages defined by SAE J2735
  - Installed at intersection
  - Connected to traffic controller via Ethernet
- OBU/OBE – On Board Unit / On Board Equipment
  - OBU – Vehicle DSRC radio module
  - OBE – OBU plus supporting equipment
  - Specified by WAVE; Messages defined by SAE J2735
  - Installed in vehicle
  - Connected to vehicle ECU via CAN, mobile device via Wi-Fi, infotainment via Ethernet

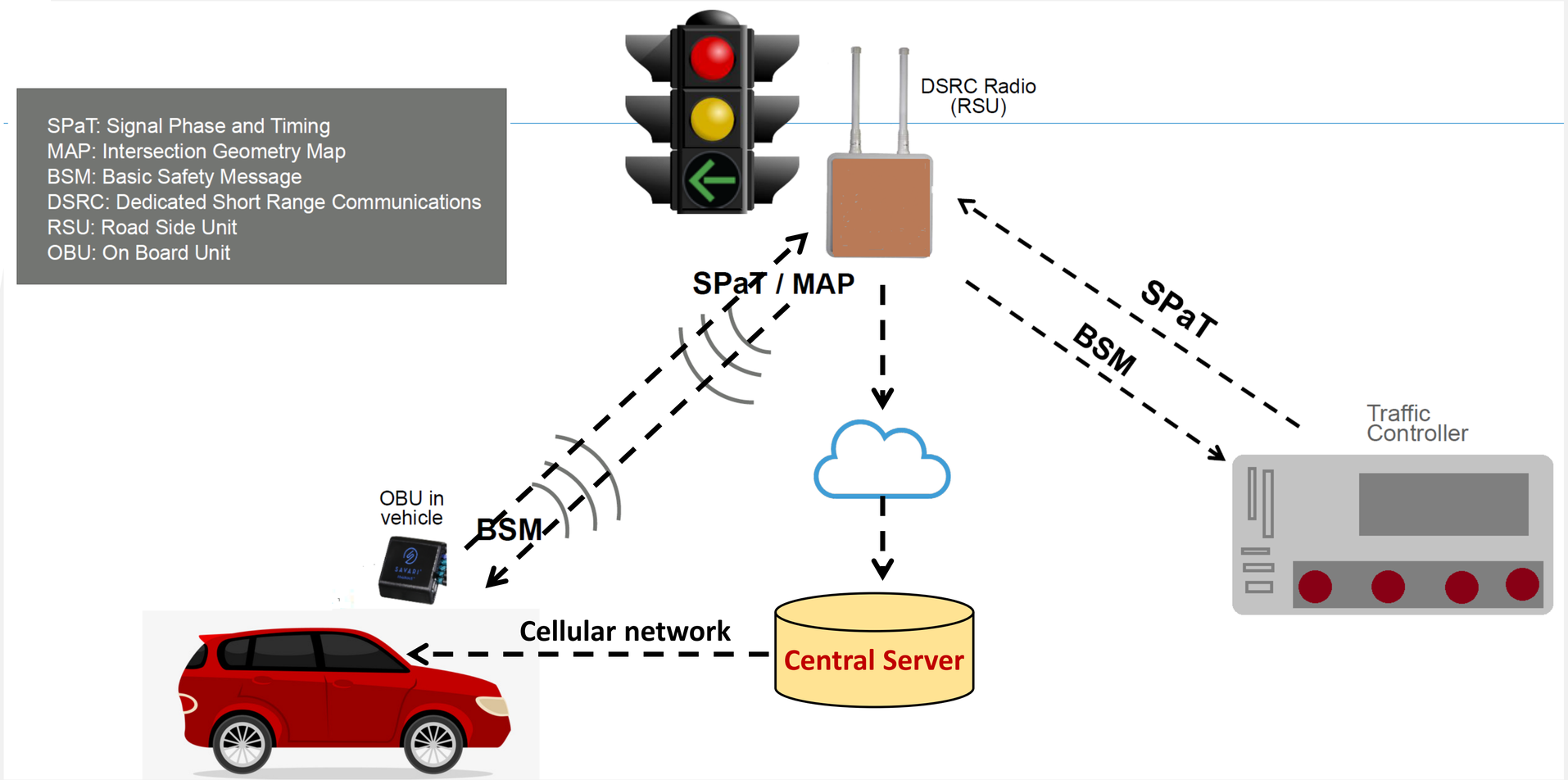
CONNECTED VEHICLE J2735 MESSAGE TYPES

- SPAT – Signal Phase and Timing
  - Current phase status of intersection,
  - Includes intersection status, i.e. MCE, stop time, flash, PMT active, TSP active
  - Used in conjunction with MAP
  - RSU transmits ten SPAT messages per second to OBU
- MAP – Map Data
  - Geographic road information based on GPS coordinates
  - Includes lane geometry and descriptions/attributes (including phase assignments)
  - RSU transmits one MAP message per second to OBU
- BSM – Basic Safety Message
  - Positional info, speed, heading, transmission state, steering wheel angle, acceleration, brake status, and size of vehicle
  - OBU transmits ten BSMs every second

CONNECTED VEHICLE J2735 MESSAGE TYPES

- TIM – Traveler Information Message
  - Sends traveler advisories (incl. traffic information, traffic incidents, major events, evacuations, etc.) and (static) road signs to OBU from RSU
- RTCM – Radio Technical Commission For Maritime Services
  - Provides differential corrections for GPS to increase absolute and relative accuracy
- SRM – Signal Request Message
  - Sent by OBU to RSU to view current status of signals
  - Can be used for preemption or priority signal requests
- SSM – Signal Status Message
  - Sent by RSU in response to SRM
  - Current status of signals and pending/active/denied preemption or priority requests
  - Both SRM and SSM function similar to SPAT with the addition of acknowledgement

CONNECTED VEHICLE TRAFFIC SIGNAL SYSTEM ARCHITECTURE



ADA COUNTY CONNECTED VEHICLE TEST

FOUR INTERSECTIONS – FOUR RSU VENDORS

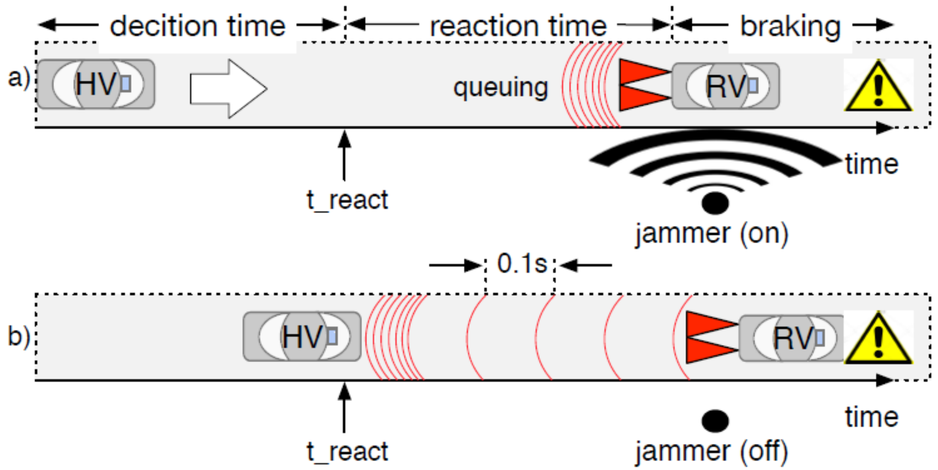
Major Issues -- Lessons

- Traffic Controllers/RSUs Compatibility
- Initial Installation/Setup process
- GPS accuracy and availability
- Connected vehicle control logic (what to do with all these data) -- RSU role?
- RSU/OBS Data Exchange “stability”
- Cyber Security (jamming)

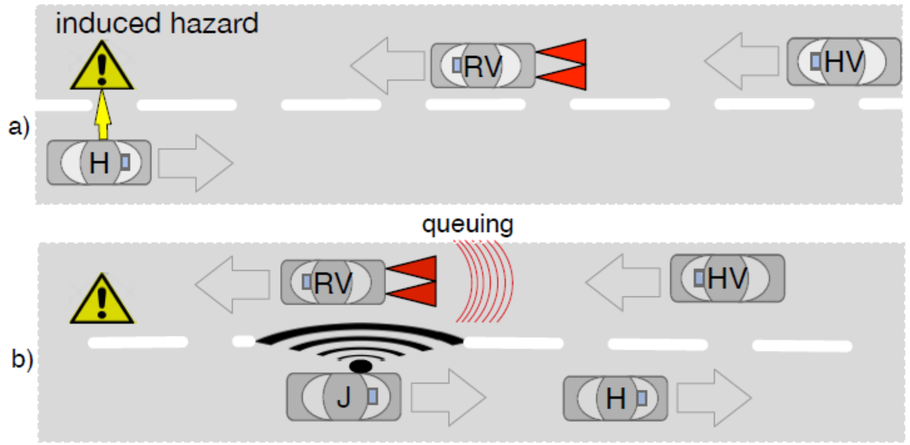
RSU/OBU DATA EXCHANGE - EXAMPLE

Time Data			Packets TX/RX in-between intervals				Packets dropped in-between intervals	
Time	Total Elapsed	Δelapsed (Interval)	ΔTx RSU	ΔRx OBU	ΔTx OBU	ΔRx RSU	ΔRx OBU Dropped	ΔRx RSU Dropped
10:06 AM								
10:10 AM	4 mins	4 mins	51	51	2556	2556	0	0
10:13 AM	7 mins	3 mins	22	22	1104	1104	0	0
10:16 AM	10 mins	3 mins	41	41	2081	2081	0	0
10:18 AM	12 mins	2 mins	17	17	839	839	0	0
11:05 AM	59 mins	47 mins	585	398	29550	28974	187 (32%)	576 (2%)
11:08 AM	1 hr 2 mins	3 mins	30	0	1520	441	30 (100%)	1079 (71%)
11:11 AM	1 hr 5 mins	3 mins	37	0	1901	160	37 (100%)	1741 (92%)
11:14 AM	1 hr 8 mins	3 mins	28	0	1423	114	28 (100%)	1309 (92%)
12:37 PM	2 hr 31 mins	1 hr 23 mins	998	0	50420	3887	998 (100%)	46533 (92%)

SECURITY OF BSM DATA EXCHANGE



Stationary jammer



Mobile jammer

THANK YOU