Connected Vehicle Data

The Cost Challenge

Greg Krueger, P.E.
Connected Vehicle Program Director

Logistics Services Operation

Begin at the End

- ▶ The Promise of Connected Vehicles is Appealing
- ▶ Connected Vehicle Data from the BSM is not sufficient
- ▶ Deployment is going to be expensive
- ▶ Data is the currency of the 21st Century
  - − Data drives the future of transportation
  - − Data drives IoT
  - − Data drives Smart Cities
- ▶ Be prepared to be creative

leidos

Why Connected Vehicles? (Lives & Mobility & Fuel!)

LIMIT 35

Safety
- 33,561 highway deaths in 2012
- 5.615 million crashes in 2012
- Leading cause of death for ages 4, 11-27

Mobility
- 5.5 billion hours of travel delay
- $121 billion cost of urban congestion

Environment
- 2.9 billion gallons of wasted fuel
- 56 billion lbs of additional CO_2
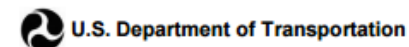
Data Sources:
- Traffic Safety Facts: 2012 Data, National Highway Traffic Safety Administration (Nov 2013)
- 2011 Annual Urban Mobility Report, Texas Transportation Institute (Feb 2013)

U.S. Department of Transportation
ITS Joint Program Office

leidos

Graphic Source: USDOT, January 2015

What is the Opportunity?

V2I Safety

Red Light Violation Warning
Curve Speed Warning
Stop Sign Gap Assist
Spot Weather Impact Warning
Reduced Speed/Work Zone Warning
Pedestrian in Signalized Crosswalk
Warning (Transit)

V2V Safety

Emergency Electronic Brake Lights (EEBL)
Forward Collision Warning (FCW)
Intersection Movement Assist (IMA)
Left Turn Assist (LTA)
Blind Spot/Lane Change Warning
(BSW/LCW)
Do Not Pass Warning (DNPW)
Vehicle Turning Right in Front of Bus
Warning (Transit)

Road Weather

Motorist Advisories and Warnings (MAW)
Enhanced MDSS
Vehicle Data Translator (VDT)
Weather Response Traffic Information
(WxTINFO)

Environment

Eco-Approach and Departure at
Signalized Intersections
Eco-Traffic Signal Timing
Eco-Traffic Signal Priority
Connected Eco-Driving
Wireless Inductive/Resonance Charging
Eco-Lanes Management
Eco-Speed Harmonization
Eco-Cooperative Adaptive Cruise Control
Eco-Traveler Information
Eco-Ramp Metering
Low Emissions Zone Management
AFV Charging / Fueling Information
Eco-Smart Parking
Dynamic Eco-Routing (light vehicle,
transit, freight)
Eco-ICM Decision Support System

Agency Data

Probe-based Pavement Maintenance
Probe-enabled Traffic Monitoring
Vehicle Classification-based Traffic
Studies
CV-enabled Turning Movement &
Intersection Analysis
CV-enabled Origin-Destination Studies
Work Zone Traveler Information

Mobility

Advanced Traveler Information System
Intelligent Traffic Signal System
(I-SIG)
Signal Priority (transit, freight)
Mobile Accessible Pedestrian Signal System
(PED-SIG)
Emergency Vehicle Preemption (PREEMPT)
Dynamic Speed Harmonization (SPD-HARM)
Queue Warning (Q-WARN)
Cooperative Adaptive Cruise Control (CACC)
Incident Scene Pre-Arrival Staging Guidance
for Emergency Responders (RESP-STG)
Incident Scene Work Zone Alerts for Drivers
and Workers (INC-ZONE)
Emergency Communications and Evacuation
(EVAC)
Connection Protection (T-CONNECT)
Dynamic Transit Operations (T-DISP)
Dynamic Ridesharing (D-RIDE)
Freight-Specific Dynamic Travel Planning and
Performance
Drayage Optimization

Smart Roadside

Wireless Inspection
Smart Truck Parking

U.S. Department of Transportation

Graphic Source: USDOT, April, 2014

leidos

The Predictions…

- Safety – reduce 80% of non-impaired crashes
  - 31,057 Fatalities (2013)
    - 10,076 impaired
  - 5,687,000 crashes (2013)
  - $242 Billion economic impact

- DMA Applications – eliminate 1/3 of travel time delay from congestion
- 20% reduction in freight travel times
- Reduction in the 30% of urban congestion cruising looking for parking

leidos

Data ultimately makes it all possible

Graphic Source: www.isymmetry.com

leidos

The Basic Safety Message

BSM Part 1	BSM Part 2
Position (local 3D): • Latitude • Longitude • Elevation • Positional accuracy	Road coefficient of friction
Motion: • Transmission state • Speed • Heading • Steering wheel angle • Acceleration Set (4-way): this includes 3 axes of acceleration plus yaw rate	Rain sensor (called a Rain sensor in J2735, but it is a precipitation sensor. J2735 states "The "Rain Sensor" Probe Data Element is intended to inform Probe Data Users as to how hard it was raining/snowing…")
Vehicle size	Traction Control System active over 100 msec
	Antilock Brake System active over 100 msec
	Lights changed and Exterior lights (status)
	Wipers changed and wiper status
	Ambient air temperature
	Ambient air pressure
	Vehicle type (BSM currently only includes this for fleet vehicles)

leidos

What is the Challenge?

▶ NHTSA Rulemaking for V2V – Implement BSM Part 1 for safety

▶ USDOT BSM Analysis:
  - "…is useful for a limited subset …, but is not solely sufficient for any of the envisioned mobility applications, especially since complete roadway coverage using DSRC has never been envisioned as a feasible option."
  - "A subset of the BSM Part 1 and Part 2 data, if cached, bundled and sent in another manner (e.g. over cellular networks), adequately provides the vehicle-based information needed for most mobility applications."

leidos

The Deployment Cost is Significant!

leidos

Infrastructure

Element	Cost (2013$) at Signalized Intersection with Controller Upgrade	Cost (2013$) at Signalized Intersection without Controller Upgrade	Cost (2013$) at Other (Non-signalized) Location
(DSRC) Equipment and Site Deployment	$17,600	$17,600	$17,600
Backhaul Upgrades and Deployment (Weighted Average)	$30,800	$30,800	$30,800
Traffic Signal Controller Upgrades	$3,200	-	-
Total Potential Site/Unit Cost	$51,600	$48,400	$48,400

Level of Deployment	20% Signalized + Unsignalized/ITS-Equipped Sites	50% Signalized + Unsignalized/ITS-Equipped Sites	80% Signalized + Unsignalized/ITS-Equipped Sites
Signalized Locations	62,200	155,500	248,800
Unsignalized/ITS-Equipped Locations	25,000	25,000	25,000
Total	87,200	180,500	273,800

275,000 sites at $48,000 per site equals $13.2BN to deploy

Graphic Source: AASHTO National Connected Vehicle Field Footprint Analysis, 2014

leidos

Oakland County (Michigan) Example

	Design (per site)	Install Cost (per site)	Operations (per site)	Maintenance (per site)	Replacement Budget	Enterprise Operations	Replacement Cost	Linear Distribution of Devices being planned, designed or installed	Cumulative number of devices Deployed	Leased Backhaul Costs per Site			Total Annual Cost (in 2013 dollars)	Cumulative Cost (in 2013 Dollars)	Ann Plar Des
14						$3,704.02	Enterprise Operations / Overhead Costs (10% of install costs per site)								
16			$500.00	$1,852.01	$2,778.01	$3,704.02		360					$2,333,242.27	$2,333,242.27	$
17	$6,746.12		$500.00	$1,852.01	$2,778.01	$3,704.02		360					$4,761,846.01	$7,095,088.28	$3,
18	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02		360	360	1200	0	0	$20,375,126.48	$27,470,214.76	$3,
19	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02	$0.00	360	720	1200	0	0	$23,987,382.58	$51,457,597.34	$3,
20	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02	$0.00	360	1080	1200	0	0	$27,599,638.67	$79,057,236.01	$3,
21	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02	$0.00	360	1440	1200	0	0	$31,211,894.77	$110,269,130.78	$3,
22	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02	$0.00	360	1800	1200	0	0	$34,824,150.86	$145,093,281.64	$3,
23	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02	$0.00	0	1800	1200	0	0	$18,061,280.47	$163,154,562.11	
24	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02	$0.00	0	1800	1200	0	0	$18,061,280.47	$181,215,842.59	
25	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02	$0.00	0	1800	1200	0	0	$18,061,280.47	$199,277,123.06	
26	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02	$0.00	0	1800	1200	0	0	$18,061,280.47	$217,338,403.53	
27	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02	$28,730.61	0	1800	1200	0	0	$18,061,280.47	$235,399,684.01	
28	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02	$28,730.61	0	1800	1200	0	0	$18,061,280.47	$253,460,964.48	
29	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02	$28,730.61	0	1800	1200	0	0	$18,061,280.47	$271,522,244.95	
30	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02	$28,730.61	0	1800	1200	0	0	$18,061,280.47	$289,583,525.43	
31	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02	$28,730.61	0	1800	1200	0	0	$18,061,280.47	$307,644,805.90	
32	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02	$0.00	0	1800	1200	0	0	$18,061,280.47	$325,706,086.37	
33	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02	$0.00	0	1800	1200	0	0	$18,061,280.47	$343,767,366.85	
34	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02	$0.00	0	1800	1200	0	0	$18,061,280.47	$361,828,647.32	
35	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02	$0.00	0	1800	1200	0	0	$18,061,280.47	$379,889,927.79	
36	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02	$0.00	0	1800	1200	0	0	$18,061,280.47	$397,951,208.27	
37	$6,746.12	$37,040.20	$500.00	$1,852.01	$2,778.01	$3,704.02	$0.00	0	1800	1200	0	0	$18,061,280.47	$416,012,488.74	
38					$28,730.61			0	1800						

Deploy, Operate and maintain 1,800 sites for 20 years - $416m

Graphic Source: Oakland County Connected Vehicle Test Bed

leidos

Security Credential Management System

Cost Category	YR 1	Std Dev	YR 2	Std Dev	YR 3	Std Dev	YR 4	Std Dev	YR 5	Std Dev	YR 6	Std Dev	Total	Std Dev
Software	$ 1.7	$ 0.3	$ --	$ --	$ --	$ --	$ 0.5	$ 0.1	$ --	$ --	$ --	$ --	$ 2.2	$ 0.4
Software, O&M	$ 0.2	$ --	$ 0.3	$ 0.1	$ 0.3	$ 0.1	$ 0.3	$ 0.1	$ 0.3	$ 0.1	$ 0.3	$ 0.1	$ 1.7	$ 0.3
Hardware	$ 474.8	$ 79.5	$ --	$ --	$ --	$ --	$ 474.8	$ 79.5	$ --	$ --	$ --	$ --	$ 949.7	$ 159
Hardware, O&M	$ 66.5	$ 11.1	$ 95	$ 15.9	$ 95	$ 15.9	$ 95	$ 15.9	$ 95	$ 15.9	$ 95	$ 15.9	$ 541.3	$ 90.6
FTEs: Initial Cost	$ 0.2	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ 0.2	$ --
FTEs: Annual	$ 23.5	$ --	$ 33.6	$ --	$ 33.6	$ --	$ 33.6	$ --	$ 33.6	$ --	$ 33.6	$ --	$ 191.3	$ --
Facilities: Initial Costs	$ 117.7	$ 29.2	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ 117.7	$ 29.2
Facilities: Annual	$ 2.9	$ 0.6	$ 4.2	$ 0.9	$ 4.2	$ 0.9	$ 4.2	$ 0.9	$ 4.2	$ 0.9	$ 4.2	$ 0.9	$ 23.7	$ 4.9
Total	$ 687.5	$ 120.9	$ 133	$ 16.8	$ 133	$ 16.8	$ 608.3	$ 96.4	$ 133	$ 16.8	$ 133	$ 16.8	$ 1,827.8	$ 284.6

Graphic Source: USDOT Draft Report FHWA-JPO-12-078

leidos

What other costs are there?

Video Source: Back to School, 1986, Orion Pictures

leidos

Short List of Other Costs

- ▶ Contingency
- ▶ Operations
  - – Power
  - – Maintenance
  - – Replacement & Upgrades
- ▶ Testing
- ▶ Integration
- ▶ Data Management
- ▶ Data Analytics
- ▶ Data Storage
- ▶ Security
- ▶ Etc.

leidos

What is the value of data?

leidos

Data has Value!

Big Data: A $1 Billion Bet At Caesar's

Jul 12, 2015 | 27,705 views   👍 362 Likes   💬 40 Comments   in f 🐦

Caesar's Entertainment, formerly known as Harrah's – the company which runs the famous Caesar's Palace Las Vegas and more than 50 other casinos worldwide – established itself as an early leader in Big Data customer service.

It has hit more than a spot of bother recently – amidst a messy bankruptcy of its casino operating unit, it is also now reportedly facing fines of up to $20 million over money laundering allegations.

The most valuable of the individual assets being fought over by creditors is the data which has been collected over the last 17 years through the company's Total Rewards scheme. This program gained Caesar's a reputation as a pioneer in Big

leidos

Value to Google

What are you worth?

$565

Share

Google makes about this much per year from ads at your level of activity. Per-search revenue estimates from Trefis.com

Google collects data on
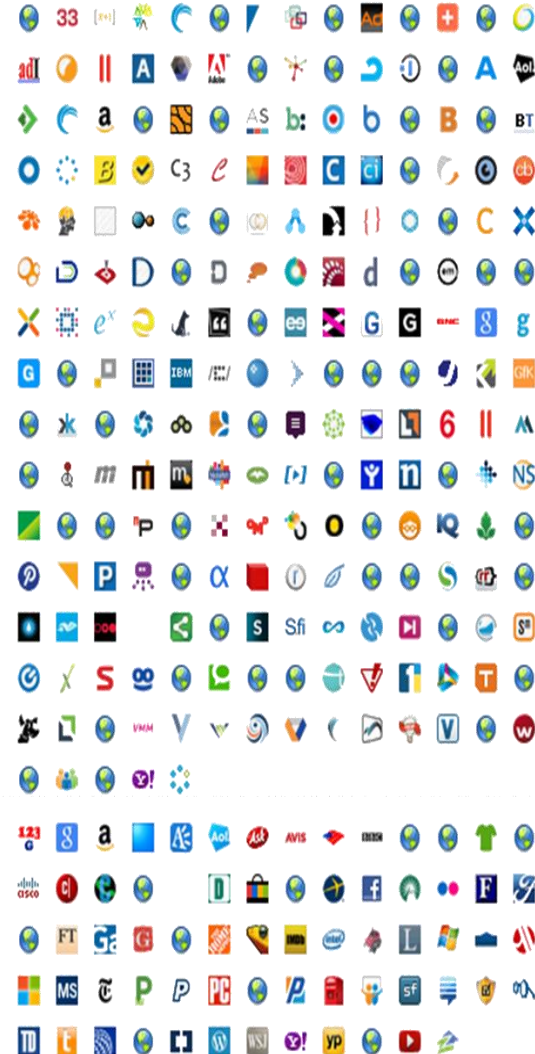
25%
of pages that you visited

Facebook tracks on

94%
of sites that you visited

Note – single desktop, does not include work issued laptop, home laptop, mobile phones, iPad_1, iPad_2.

leidos

EnLighten

BMW announces EnLighten® integration

BMW today announced that owners of recent-model BMWs equipped with BMW Apps can now experience enhanced EnLighten features in their center console. The service is available in Portland, Eugene, and Salt Lake City. Other cities are coming.

To experience EnLighten on your BMW, get EnLighten for your iPhone and connect it to your car.

What does this all mean?

- ▶ Basic Safety Message Data is not sufficient
    - − Ubiquitous Coverage
    - − Additional Data Points
- ▶ Deployment of CV Infrastructure will be expensive
    - − Field Infrastructure
    - − Back End systems (data analytics)
    - − Security
- ▶ There is value in the data in the right hands and with right other ingredient

leidos

Partnerships are the Key to Deployment

▶ DOTs need to identify what they have of value AND assess it's value appropriately

- − Right of Way
- − ITS components
- − Communications Networks

▶ Nothing should be considered off the table

- − Right of Way access
- − Data ownership

▶ Seek unconventional partnerships

▶ The objective is the goal!

- − Save lives
- − Reduce congestion and delay

leidos

Thank You!

Contact:

Greg Krueger, Connected Vehicle Program Manager
Leidos
E-Mail: gregory.d.krueger@leidos.com

leidos