

Penn State Transportation Engineering and Safety Conference

Operational Considerations for Connected Vehicle Services Case Studies

John Estrada
December 4, 2018



Agenda



1. **Connected Vehicle: The Enabling Technology**

2. CV and AV, Need Both?

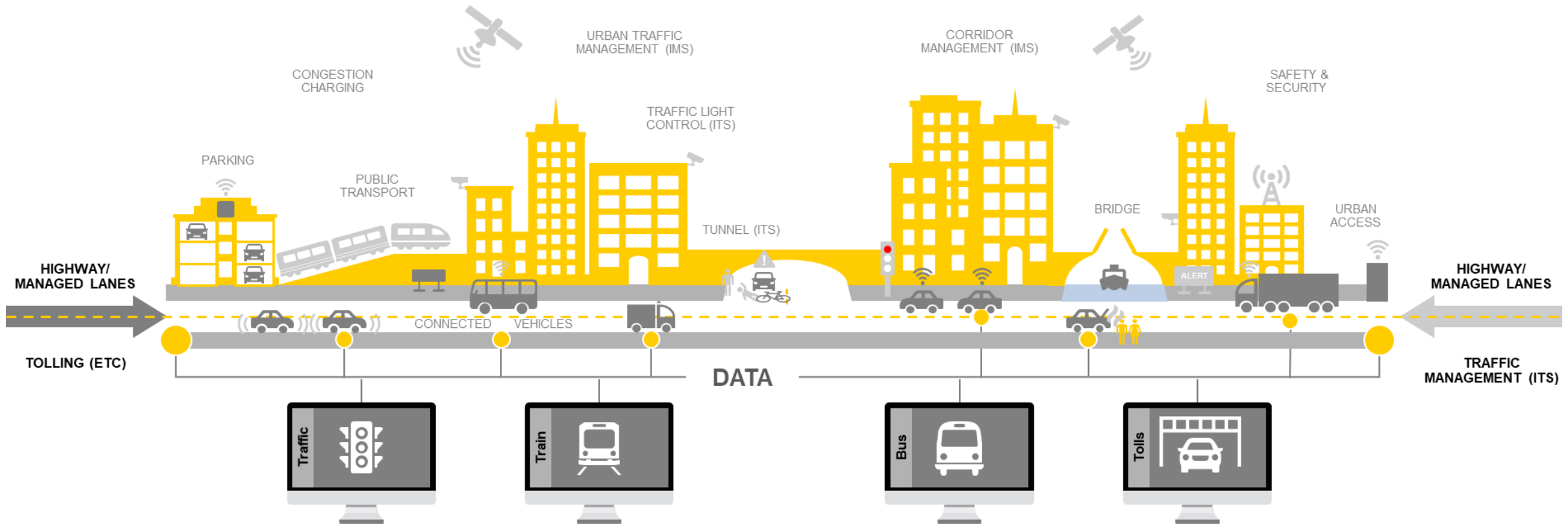
3. Validate Your Installation

4. Monitor and Manage Your Installation

5. Questions

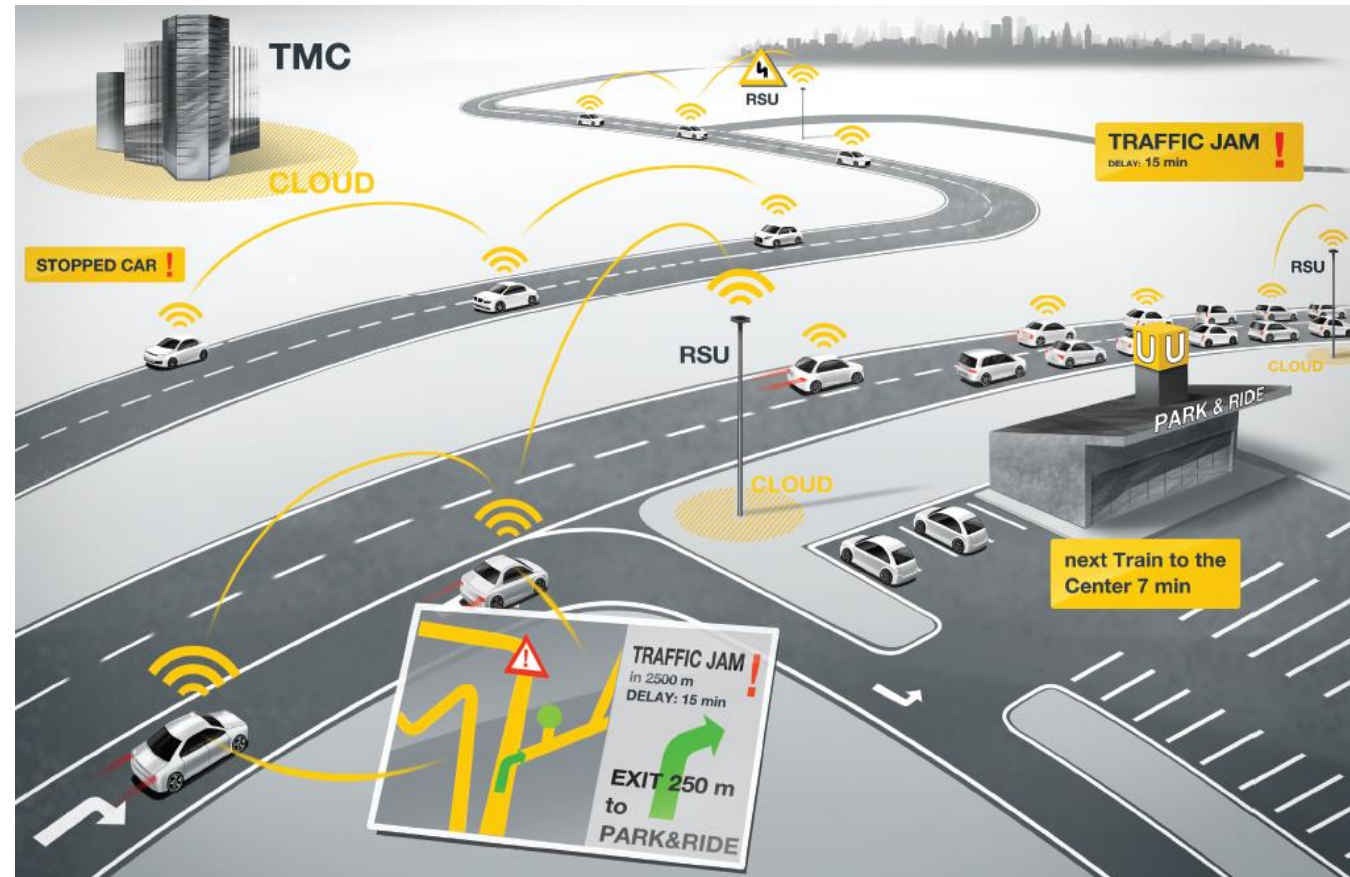
Connected Vehicle: the Enabling Technology

> From Highways to Cities.



CV Services

- > Foundational services
 - > Travel Times, Traveler Information, Work Zone Warnings
- > Operational Services
 - > Transit Signal Priority
 - > Predictive travel times
 - > Work Zone Notifications
 - > Corridor Data Warehouse and Analytics Platform
 - > Performance measurements/metrics
- > Safety
 - > CV driven incident awareness
 - > End of Queue Warning
 - > Corridor condition warnings





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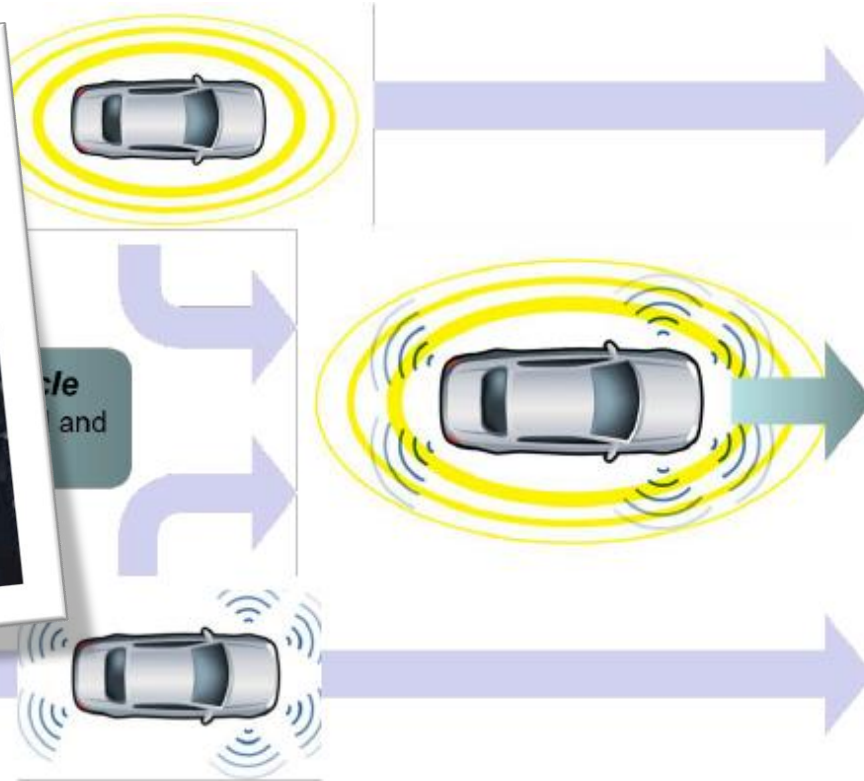
5. Questions

Plan for Technology and CAV Convergence



Autonomous Vehicle

Operates in isolation from other vehicles using internal sensors



Source: USDOT

Uber Arizona Case

March 24, 2017

“Tempe police cited a driver for making an illegal left turn and hitting one of Uber’s test Volvos while it was in self-driving mode. The **Uber SUV**, occupied by a test driver and an engineer in the passenger seat, flipped on its side and a third car was struck”.



The **Honda** was turning left and did not see the oncoming **Uber** vehicle due to traffic in the other direction

The vehicles in the left most lanes were stopped but not blocking traffic so the **Honda** proceeded with its left turn.



The **Uber** was going 38 miles per hour, didn’t see the **Honda**, and proceeded through the intersection.

The **Honda** hit the **Uber**, which proceed forward into a pole, flipped over and ran into two other cars.

Uber Arizona Case – with CV Technology

DSRC allows vehicles to communicate information, such as speed, bearing, and direction to nearby vehicles, even if not in the line of site.



The **Honda** would have still wanted to turn left

However, with V2V it would have been notified that the **Uber** was coming even though it couldn't see it.

Also, the Uber would have been notified about the Honda and would have known to slow down, giving the Honda more time

The accident could have been avoided, other cars would have been safe and the Uber could proceed on its way

Let's Do The Math

(Don't worry there's no Quiz at the end)

- > The V2V application Intersection Movement Assist would have provided enough information to each of the vehicles to warn the driver or software of the other vehicle
- > DSRC will provide information for at least 150 meters (longer in many intersections)
- > The Uber Vehicle was traveling 38 miles per hour and the Honda was going about 10 mph, so they would have begun to get warnings 6.7 seconds before hitting each other
 - Uber 38 mph = 63.3 kph = 17.5 m/s
 - Honda 10 mph = 16.7 kph = 4.7 m/s
 - Total is 22.2 m/s (total speed heading toward each other)
 - It takes 6.7 seconds to traverse 150m at 22.2 m/s
- > 6.7 Seconds would be more than enough time for both vehicles to react, slow down and avoid each other.

Emergency Braking

Without V2V technology if the front car slams on its brakes, the last car will not know that this has happened if the middle car isn't paying attention. This can cause a multi-car pile up. Traditional ADAS/AV Sensors (Camera, Lidar, Radar) can't see through cars.

Emergency braking is best handled through V2V technology. As the front car quickly slows down this is announced via DSRC communication and then the last car can easily stop in time.

An option for trucks is to have video in the truck provide information to the car behind. A camera on the front of the truck streams video to the car behind so that that driver/AV system can "see through" the truck to see what is happening in front. When that front car brakes, the rear car will be notified. This has the advantage of not requiring DSRC in the front car.



V2V Platooning

Without V2X even autonomous vehicles will have to keep greater distance between vehicles. This takes up more road space and limits the speed at which the vehicles can travel

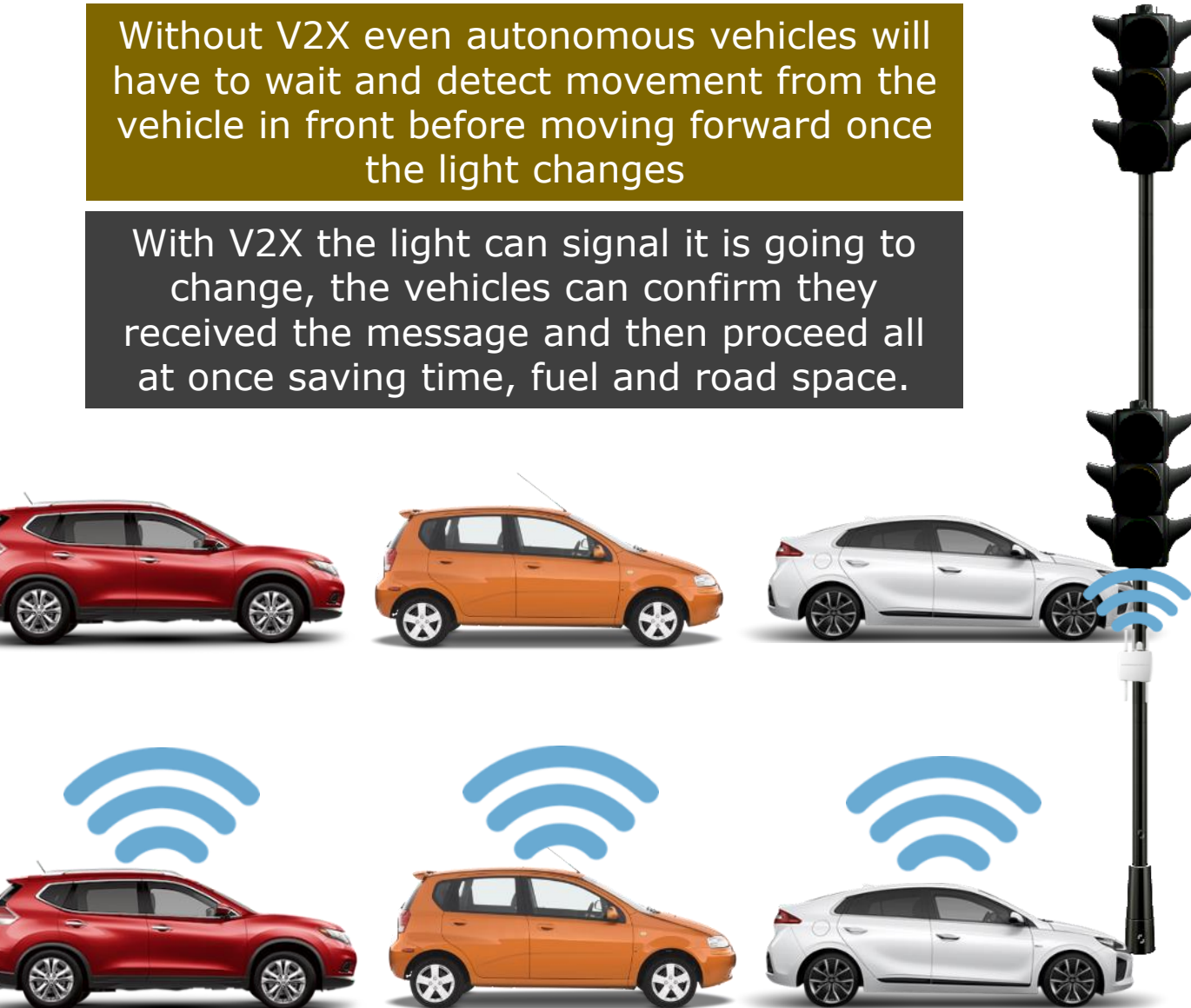
With V2X the vehicles can stay closer together thus saving fuel and allowing more vehicles on an individual stretch of road which is increasingly important as the number vehicles increases.



Platooning Advantages

Without V2X even autonomous vehicles will have to wait and detect movement from the vehicle in front before moving forward once the light changes

With V2X the light can signal it is going to change, the vehicles can confirm they received the message and then proceed all at once saving time, fuel and road space.





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Panasonic V2X Program

Connected Vehicles



- > B2B V2X RSU Development Program supporting Panasonic Smart City Initiatives
 - > Panasonic under MSA with Colorado DOT to provide a statewide V2X ecosystem
 - > State plans expanding to 1000 miles of V2X Corridor and 10,000 equipped vehicles beyond initial program
- > Multi-Phase 12 mo Program
 - Base RSU Development Program
 - 100 unit I-70 90 mile V2X corridor deployment
 - C-V2X Pilot initiative in cooperation with Panasonic and Qualcomm completed by end of 2018



\$1.6M Budget



Establishes industry partnership



2018-2019



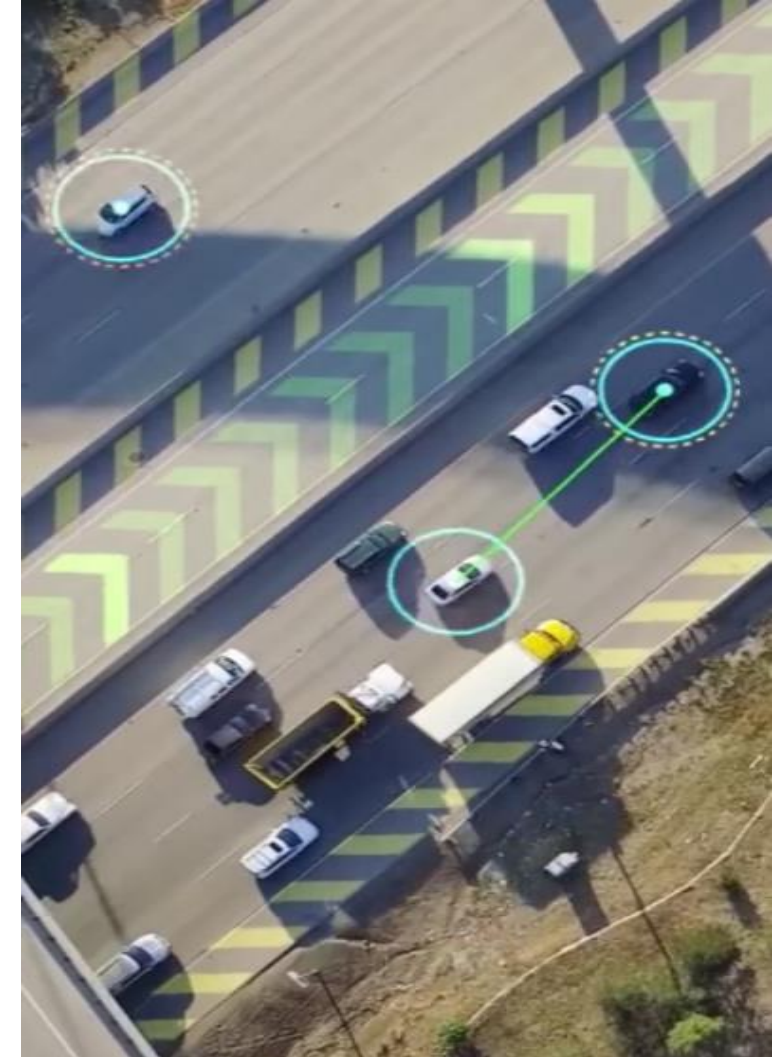
100+ unit deployment



I-70 90 mile V2X corridor



Participation in automotive industry



Modeling and Coverage Testing



- > Software virtualization models signal coverage for new construction such as tunnels and overpasses
- > Coverage Testing
 - > Identifies optimal RSU placement
 - > C470 project average distance has been 500m-700m, greatest distance was 900m

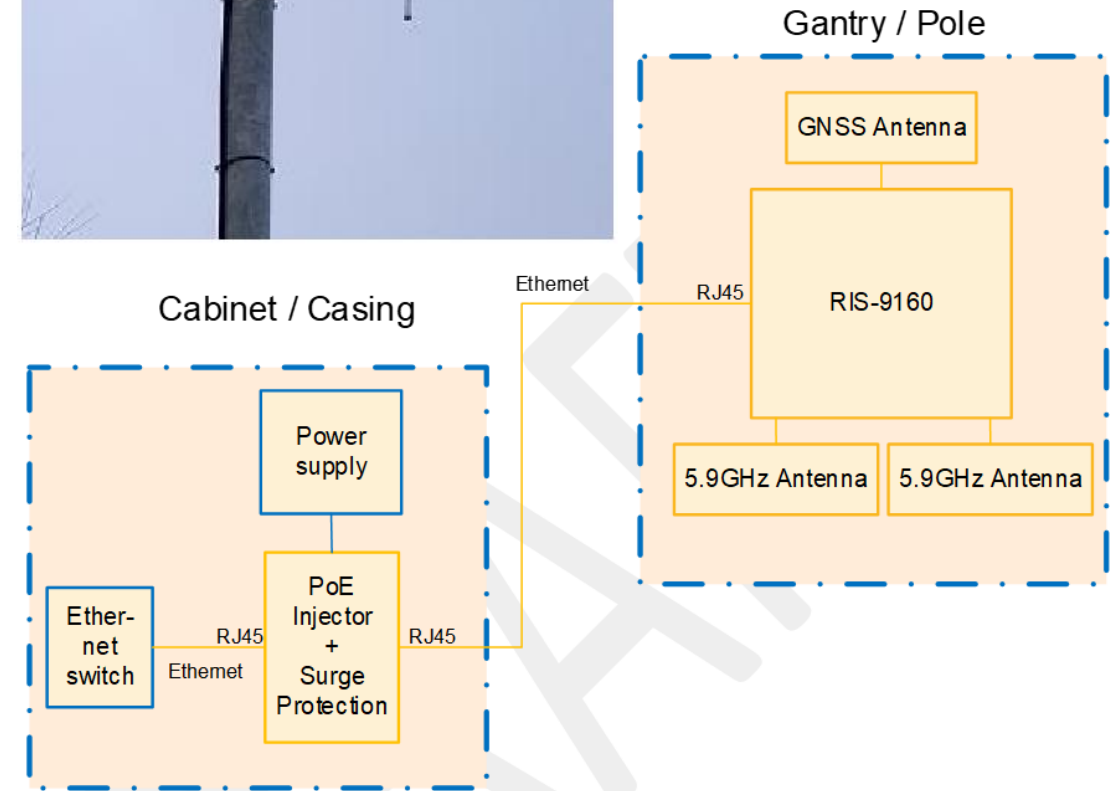
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2	0.989793	Kapsch_00:bb:54	Broadcast	CAM	176	1010084	-378367204	1449547784	2300
3	1.998868	Kapsch_00:bb:54	Broadcast	CAM	193	1010084	-378369456	1449544239	2310
4	2.998893	Kapsch_00:bb:54	Broadcast	CAM	211	1010084	-378371171	1449541608	2290
5	4.001481	Kapsch_00:bb:54	Broadcast	CAM	219	1010084	-378371759	1449540748	2290
6	5.000193	Kapsch_00:bb:54	Broadcast	CAM	237	1010084	-378373478	1449538120	2300
7	6.000023	Kapsch_00:bb:54	Broadcast	CAM	254	1010084	-378375075	1449535372	2330
8	7.000087	Kapsch_00:bb:54	Broadcast	CAM	262	1010084	-378375581	1449534432	2350
9	8.000612	Kapsch_00:bb:54	Broadcast	CAM	280	1010084	-378377098	1449531612	2350
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11	10.000892	Kapsch_00:bb:54	Broadcast	CAM	306	1010084	-378378531	1449526263	2580
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13	12.000604	Kapsch_00:bb:54	Broadcast	CAM	340	1010084	-378377996	1449519544	2870
14	13.000666	Kapsch_00:bb:54	Broadcast	CAM	349	1010084	-378377721	1449518461	2870
15	14.000824	Kapsch_00:bb:54	Broadcast	CAM	366	1010084	-378377022	1449515188	2760
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20	17.000715	Kapsch_00:bb:54	Broadcast	CAM	366	1010084	-378377614	1449506272	2490
21	17.921495	Kapsch_00:9b:38	Broadcast	CAM	188	88880010	-378223470	1449476480	
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No	Time	Source	Destination	Protocol	Length	stationID	latitude	longitude	heading	KML
1	0.000	Kapsch_00:bb:54	Broadcast	CAM	168	1010084	-378266632	1449548661	2300	144.9548661,-37.8266632,0
2	1.000	Kapsch_00:bb:54	Broadcast	CAM	176	1010084	-378267204	1449547784	2300	144.9547784,-37.8267204,0
3	2.000	Kapsch_00:bb:54	Broadcast	CAM	193	1010084	-378269456	1449544239	2310	144.9544239,-37.8269456,0
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9	8.001	Kapsch_00:bb:54	Broadcast	CAM	280	1010084	-378277098	1449531612	2350	144.9531612,-37.8277098,0
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12	11.001	Kapsch_00:bb:54	Broadcast	CAM	323	1010084	-378278588	1449522859	2720	144.9522859,-37.8278588,0
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20	17.001	Kapsch_00:bb:54	Broadcast	CAM	366	1010084	-378277614	1449506272	2490	144.9506272,-37.8277614,0
21	17.921	Kapsch_00:9b:38	Broadcast	CAM	188	88880010	-378223470	1449476480		144.9476480,-37.8223470,0
22	18.003	Kapsch_00:bb:54	Broadcast	CAM	366	1010084	-378278444	1449504254	2420	144.9504254,-37.8278444,0
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25	19.922	Kapsch_00:9b:38	Broadcast	CAM	188	88880010	-378223470	1449476480		144.9476480,-37.8223470,0

Mounting and Installation

- > Simplistic mounting approach / Custom or Proprietary
- > PoE per USDOT RSU 4.1 Spec standards
- > O&M packages should be considered such as data storage

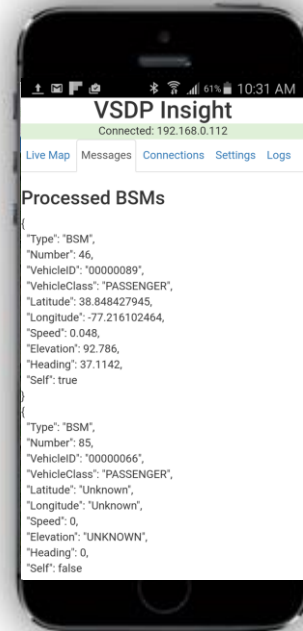


CV Validation Tools

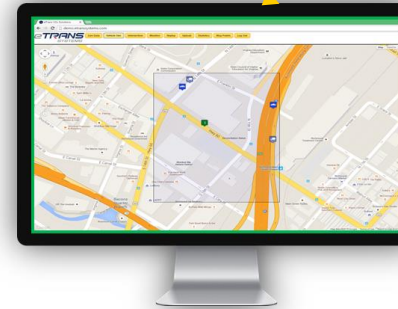


Kapsch OBU plus Bluetooth or Wi-Fi/Cell Modem.

RSU attached to a light transmitting SPaT, MAP, RSM and TIM Messages. This is the unit that is being validated.



Insight on a tablet or smartphone. Connects to OBU over Wi-Fi or Bluetooth.



Omnisight in the cloud records and plays back recorded data. Verifies SPaT and MAP data.

Time Run: 2018-08-21 12:00:05
 Replay Id: w20180722-001022.log
 Owner: etrans

Italicized items are optional for J2735.

Intersection Id: 2017

Automatic Verification		Manual Verification	
SPaT Verification			
Errors:	3	SPaT Message	
SPaT Frequency (50 to 150 ms over 10 sec) is valid	No	RSU system clock is within 10 ms of UTC	
Message Timestamp is filled in	No	MinEndTime is within 100 ms of earliest phase change	
Intersection State construction time stamp filled in	No	MaxEndTime is within 100 ms of earliest phase change	
Signal Group Id non-zero	Yes	MAP Message	
Min End Time filled in	Yes	MAP is accurate within 0.5 meters	
Max End Time filled in	Yes	Node points are centered within each lane	
Likely Time filled in	No	Node points are at least 300 meters from stop bar	
MAP Verification		There are at least 2 Node points per lane	
Errors:	4	Node points are less than 0.5 meters perpendicularly from center of lane	
Map Frequency (950 to 1050 ms over 10 sec) is valid	No		
Map Message Issue Revision	3		
Map Intersection Revision	3		
Latitude	38.1342421		
Longitude	-115.163243		
Lane Width	3.66		
Number of Ingress Lanes	7		
Number of Egress Lanes	7		
Lanes use delta offsets	No		
Allowed Maneuvers are filled in	No		
Connections are filled in	Yes		
Signal Groups are filled in	Yes		
Connection Maneuvers are filled in	No		



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5. Questions

Cary, NC SPaT Demonstration

- > Cary and NC DOT Collaborative Corridor
- > Supports FHWA SPaT Challenge Initiative
- > Multi-vendor RSU and OBU Interoperability
- > Intersection Safety Focus
 - Red Light Warning
 - eWalk Pedestrian Safety
 - Curve Speed Warning
 - Speed Zone Warning



Fiscally Sound



Establishes industry partnership



2018-2019



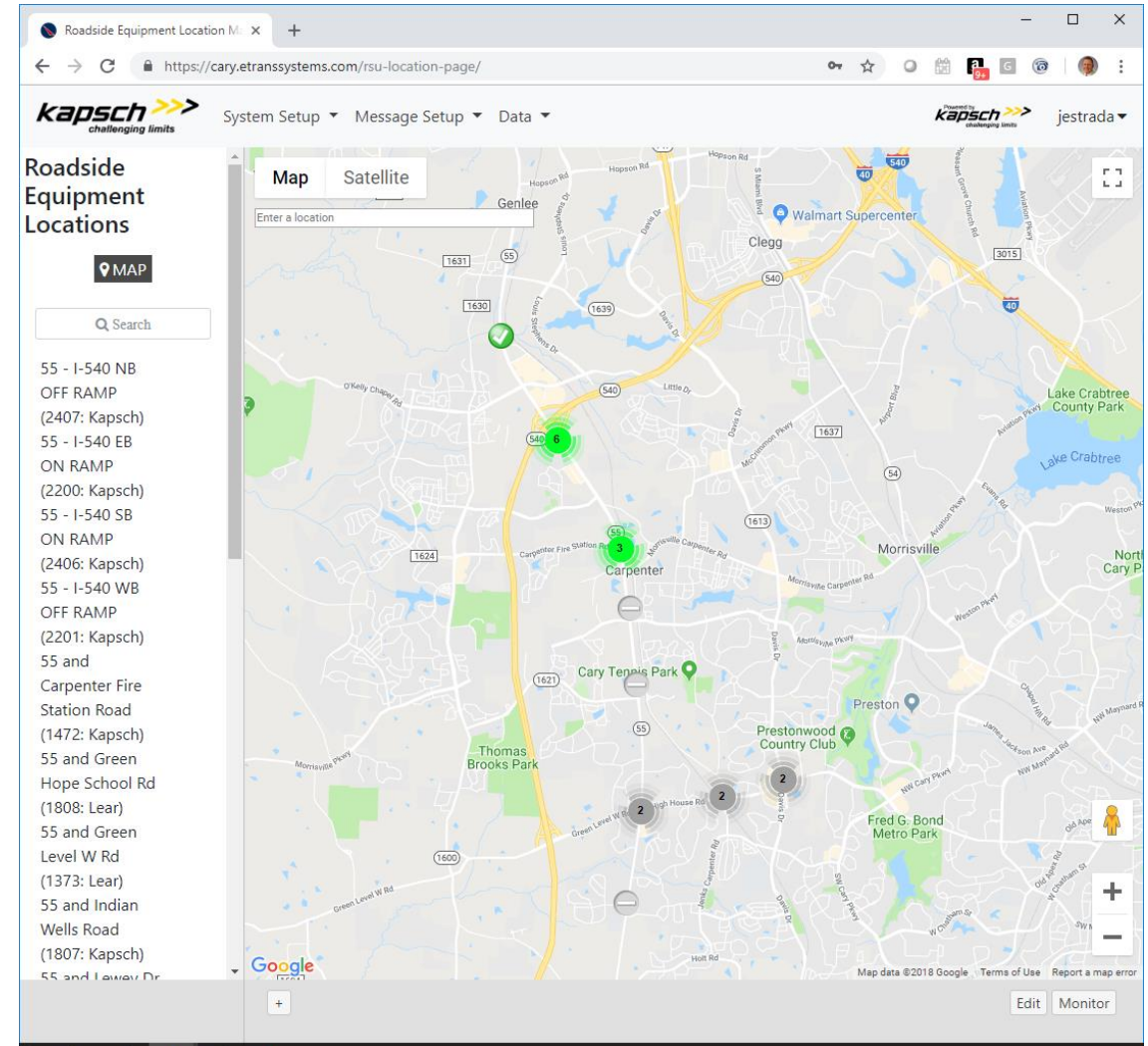
Revealing user and agency benefits



20 intersection V2X corridor



Collaboration with multiple vendors and Transportation agencies



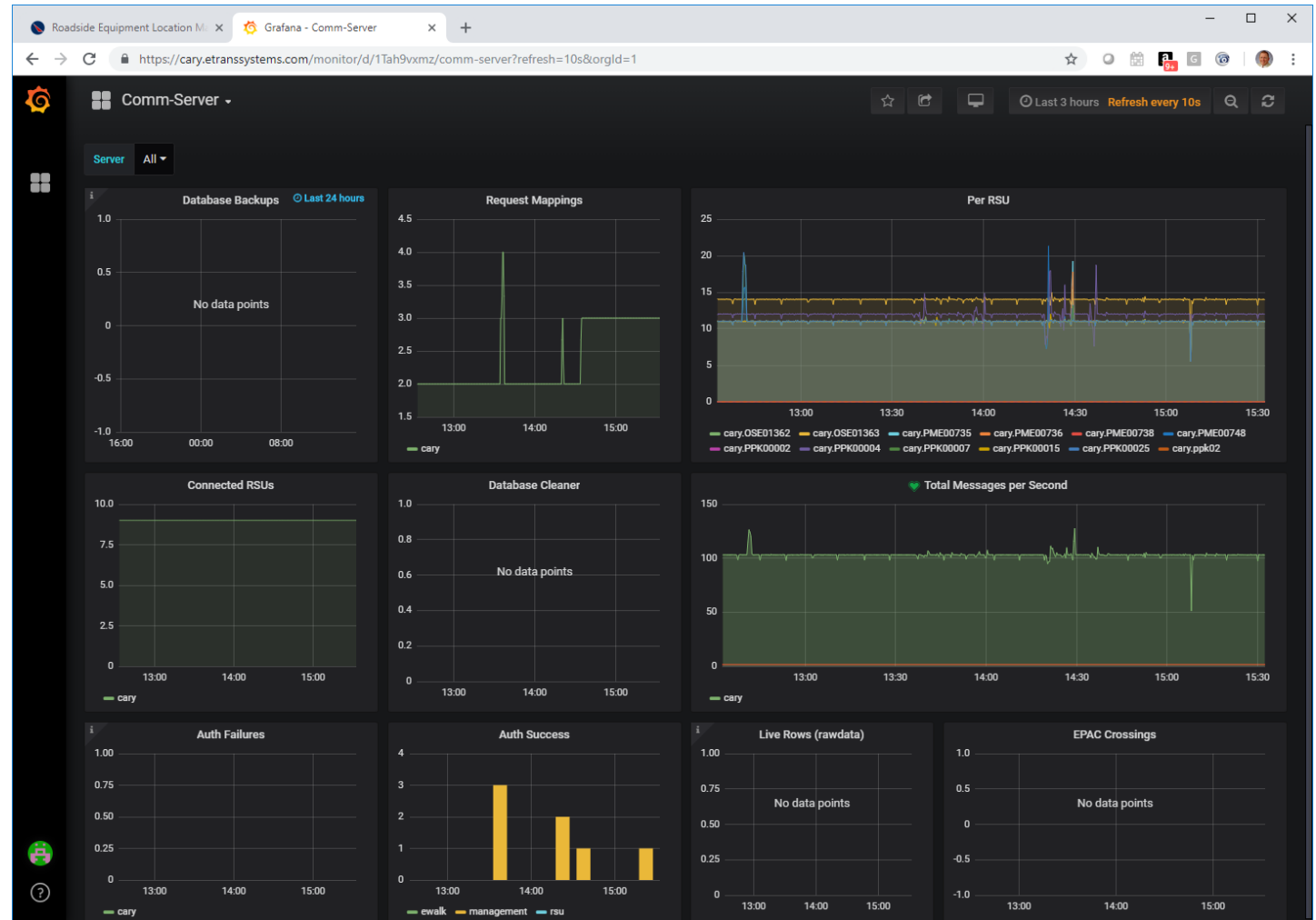
Corridor Management

- > Manage and Configure
 - > Locations
 - > RSUs
 - > MAP Messages
- > Receive and Process Real Time Alerts
- > Monitor Real-Time Message Traffic
 - > MAP Information (Blue & Green Lines)
 - > Traffic Lights
 - > Vehicles
 - > Pedestrians

The screenshot shows a web browser window displaying the 'Roadside Equipment Location Management' interface. The browser address bar shows the URL 'https://cary.etranssystems.com'. The page header includes the Kapsch logo and navigation menus for 'System Setup', 'Message Setup', and 'Data'. The user 'jestrada' is logged in. The main content area is titled 'Roadside Equipment Locations' and features a search bar with the text '55 and McCrimmon Pkwy (2255: Kapsch)'. Below the search bar is a map showing a road intersection with blue and green lines indicating message traffic. The map is overlaid on a satellite view of the area. At the bottom of the interface, there is a 'Message Count: 2208' and buttons for 'Edit', 'Monitor', 'Filter Data', and 'Stop Data'.

Data Management

- > Monitor Data Being Processed
 - > From RSUs
 - > From OBUs
 - > Other Sources
- > Receive and Process Real Time Alerts
- > Analytics for Gaining Future Value



Questions?

John Estrada

Vice President, CV Sales & Business Development

john.estrada@Kapsch.net

Kapsch TrafficCom

Kapsch TrafficCom North America

8201 Greensboro Drive, Suite 1002

McLean, VA 22102

USA

Phone: +1.571.230.5265

www.kapsch.net

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