INVENTORY OF CONNECTED VEHICLE APPLICATIONS AS PART OF PREPARING A POSSIBLE OREGON ROAD MAP FOR CONNECTED VEHICLE/COOPERATIVE SYSTEMS DEPLOYMENT SCENARIOS

Task 3 Report

SPR 764

Oregon Department of Transportation

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16. Abstract: The goal of this project was to lay the groundwork for Oregon to be prepared to lead in the implementation of a connected vehicle/cooperative systems transportation portfolio, and/or to avoid being caught by surprise as developments in this area evolve quickly. The project assessed ODOT's internal mechanisms for addressing connected vehicle/cooperative systems, scanned, reviewed and assessed the technical maturity of potential connected vehicle/cooperative system applications, developed preliminary goals, linked to prospective connected vehicle/cooperative systems applications, and refined/ranked/prioritized those that fit with potential ODOT role in advancing/leading these initiatives. The project identified opportunities for linking ODOT's current programs with national and international connected vehicle/cooperative system research, testing and deployment initiatives, and recommended a final shared vision and "road map" for Oregon's priority connected vehicle/cooperative system applications. This volume contains a detailed inventory and literature review of a set of 64 connected vehicle/cooperative system end user applications (with a focus on the U.S.) that are mature enough for deployment in the context of total fleet penetration. Each application was analyzed across a range of criteria including benefits, impact, maturity, interface and infrastructure requirements, vehicle component requirements, applicability to Oregon, as well as communications and data requirements. The inventory of connected vehicle/cooperative systems was performed in the context of ODOT/statewide goals, and in response to applications and initiatives being developed by U.S. DOT, AASHTO and the private sector. Comparisons to European applications are also included in this volume.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	ml
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3
NOTE: Volumes greater than 1000 L shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit	(F-32)/1.8	Celsius	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
m^2	meters squared	1.196	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
ml	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius	1.8C+32	Fahrenheit	°F

*SI is the symbol for the International System of Measurement

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DISCLAIMER

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AASHTO	American Association of State Highway and Transportation Officials
ACC	Adaptive Cruise Control
AERIS	Applications for the Environment: Real-Time Information Synthesis
AFV	Alternative Fuel Vehicles
ATIS	Advanced Traveler Information Systems
BSW/LCW	Blind Spot/Lane Change Warning
CACC	Cooperative Adaptive Cruise Control
CAD/AVL	Computer Assisted Dispatch/Automatic Vehicle Location
CCC	conventional cruise control
CSW	Curve Speed Warning
CV	Connected Vehicle
CVRIA	Connected Vehicle Reference Implementation Architecture
DII	Driver-Infrastructure Interface
DNPW	Do Not Pass Warning
D-RIDE	Dynamic Ridesharing
DR-OPT	Drayage Optimization
DSRC	Dedicated Short Range Communications
EEBL	Emergency Electronic Brake Lights
EnableATIS	Enable Advanced Traveler Information System
EVAC	Emergency Communications and Evacuation
FCW	Forward Collision Warning
FHWA	Federal Highway Administration
F-RATIS	Freight Real-time Traveler Information with Performance Monitoring
FSP	Freight Signal Priority
GHG	Green House Gases
GID	Geometric intersection description
GIS	Geographic Information System
GPS	Global Positioning System
HOT	high-occupancy toll
HOV	high-occupancy vehicle
IDTO	Integrated Dynamic Transit Operations
IMA	Intersection Movement Assist
INC-ZONE	Incident Scene Work Zone Alerts for Drivers and
INFLO	Integrated Network Flow Optimization
IRI	International Roughness Index
ITS	Intelligent transportation systems
IVBSS	Integrated Vehicle-Based Safety Systems
LIDAR	Light Detection And Ranging
LTA	Left Turn Assistant

MAPS	Mobile Accessible Pedestrian Signals
MAW	Motorist Advisories and Warnings
MDSS	Maintenance Decision Support System
MIVT	Miscellaneous and In-Vehicle Technology
MMITSS	Multimodal Intelligent Traffic Signal System
NHTSA	National Highway Traffic Safety Administration
OBE	On-Board Equipment
OBU	On-Board Unit
ODOT	Oregon Department of Transportation
PDPM	Probe-based Pavement Maintenance
PED-SIG	Mobile Accessible Pedestrian Signal System
PREEMPT	Emergency Vehicle Preemption with Proximity Warning
Q-WARN	Queue Warning
RESCUME	Response, Emergency Staging, Communications, Uniform Management, and Evaluation
RESP-STG	Incident Scene Pre-Arrival Staging Guidance for Emergency Responders
RLVW	Red Light Violation Warning
RSE	RoadSide Equipment
RSU	RoadSide Unit
RSWZ	Reduced Speed/Work Zone Warning
RWIS	Road Weather Information Systems
SOI	System-of-Interest
SPaT	Signal phase and timing
SPD-HARM	Dynamic Speed Harmonization
SSGA	Stop Sign Gap Assist
SWIW	Spot Weather Impact Warning
TB	Terabyte
T-CONNECT	Transit Connection Protection
T-DISP	Dynamic Transit Operations
T-DISP	Dynamic Transit Operations
TMC	Traffic Management Center
TRANSIT	Vehicle Turning Right In Front Of Bus Warning
TSP	Transit Signal Priority
USDOT	United States Department of Transportation
V2I	Vehicle to Infrastructure
VDT	Vehicle Data Translator
VSCC	Vehicle Safety Communication Consortium
WxTINFO	Real-Time Route Specific Weather Information for Motorized and NonMotorized Vehicles

1.0 INTRODUCTION

Through a detailed literature review the research team has identified, inventoried and document a set of connected vehicle/cooperative system end user applications (with a focus on the U.S.) that are mature enough for deployment in the context of total fleet penetration. This has included a global review of the rationale for choosing DSRC as the safety communications technology. The team has worked with ODOT staff to inventory connected vehicle/cooperative systems in the context of ODOT/statewide goals, and in response to applications and initiatives being developed by U.S. DOT, AASHTO and the private sector. This has also included a comprehensive review of connected vehicle application considered in Europe. The research team has created a list of opportunities for aligning connected vehicle/cooperative systems opportunities with the ODOT project lifecycle (from policy and planning through implementation and maintenance).

We began (Figure 1.1) with the U.S. DOT list of 55 Connected Vehicle Applications aimed at the Connected Vehicle Pilot Deployment Program (http://www.its.dot.gov/pilots/cv_pilot_apps.htm).

Figure 1.1: U.S. DOT 55 Connected Vehicle Applications

We worked with the TAC and project stakeholders to expand the list to a final total of 64 applications as shown in Figure 1.2.

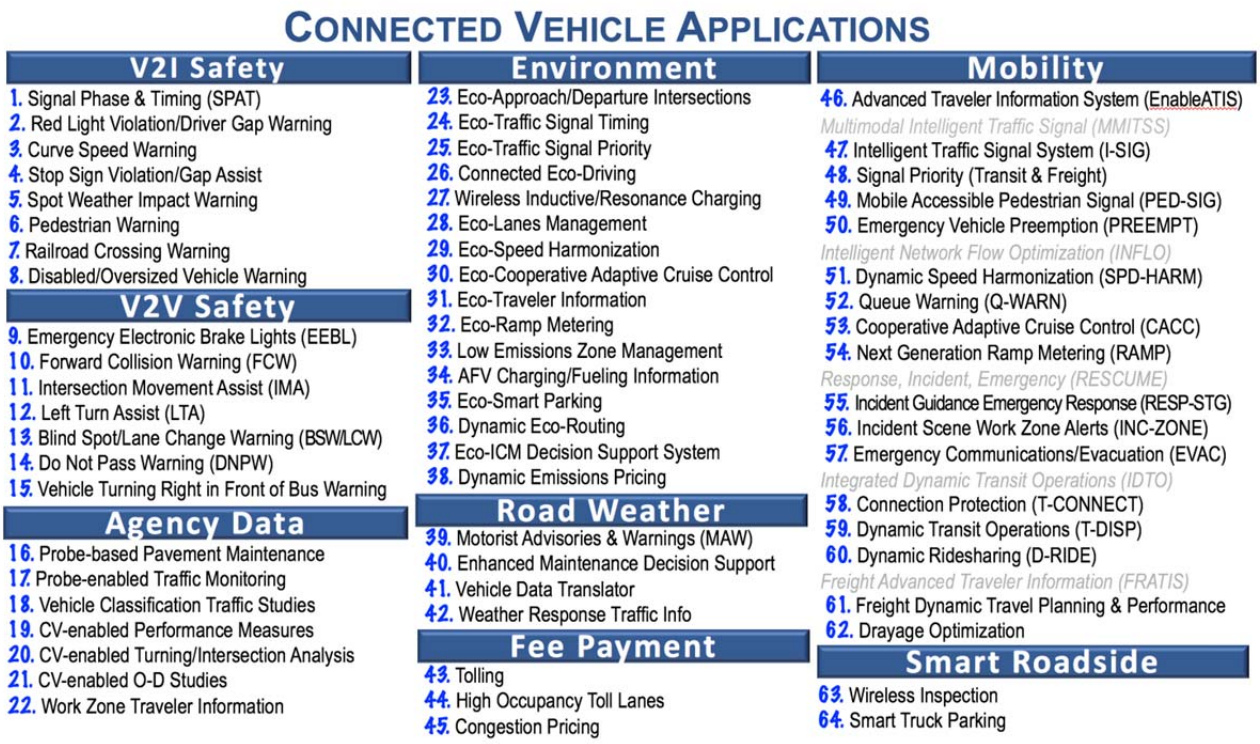


Figure 1.2: Final List of 64 Applications

Through a workshop held with key ODOT leadership, each of the applications listed above were assigned one of four possible priorities:

- **Priority 1: Near Term Focus for ODOT**
- **Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others**
- **Priority 3: Leadership by Others, ODOT Monitor**
- **Not on ODOT Priority List**

Table 1.1 contains the final list of ODOT connected vehicle applications that were analyzed. As shown, the table includes an application number, the priority color code, the source (most come from the U.S. DOT, while a few originate from the Connected Vehicle Reference Implementation Architecture and AASHTO), the application group, the application name, any applicable acronyms, a link to the relevant CVRIA application, and a reference to the ODOT Application Number selected in the final prioritization workshop (see Task 4 report).

Table 1.1: List of All Connected Vehicle Applications

Number/ Priority	Source	Group	Application Name	Acronym	CVRIA Application Name	ODOT Application Number
V2I SAFETY						
1.	CVRIA	**Support Signal Phase & Timing**	Signal Phase & Timing	SPaT	Signal Phase and Timing	**ODOT 11.**
2.	DOT	**V2I Safety**	Red Light Violation/ Driver Gap Warning	RLVW	Red Light Violation Warning	
3.	DOT	**V2I Safety**	Curve Speed Warning	CSW	Curve Speed Warning	**ODOT 12.**
4.	DOT	**V2I Safety**	Stop Sign Violation/Gap Assist	SSGA	Stop Sign Violation Warning Stop Sign Gap Assist	
5.	DOT	**V2I Safety**	Spot Weather Impact Warning	SWIW	Spot Weather Impact Warning	**ODOT 13.**
6.	DOT	**V2I Safety**	Pedestrian in Signalized Crosswalk Warning	TRANSIT	Pedestrian in Signalized Crosswalk Warning	
7.	AASHTO	**V2I Safety**	AASHTO: Railroad Crossing Violation Warning		Railroad Crossing Violation Warning	**ODOT 14.**

Number/ Priority	Source	Group	Application Name	Acronym	CVRIA Application Name	ODOT Application Number
8.	AASHTO	**V2I Safety**	AASHTO: Oversize Vehicle Warning		Oversize Vehicle Warning	**ODOT 15.**
V2V SAFETY						
9.		**V2V Safety**	Emergency Electronic Brake Lights	EEBL	Emergency Electronic Brake Light	
10.		**V2V Safety**	Forward Collision Warning	FCW	Forward Collision Warning	
11.		**V2V Safety**	Intersection Movement Assist	IMA	Intersection Movement Assist	
12.		**V2V Safety**	Left Turn Assist	LTA	Intersection Movement Assist	
13.		**V2V Safety**	Blind Spot/Lane Change Warning	BSW/LCW	Blind Spot Warning + Lane Change Warning	
14.		**V2V Safety**	Do Not Pass Warning	DNPW	Do Not Pass Warning	

Number/ Priority	Source	Group	Application Name	Acronym	CVRIA Application Name	ODOT Application Number
15.		**V2V Safety**	Vehicle Turning Right in Front of Bus Warning	TRANSIT	Vehicle Turning Right in Front of a Transit Vehicle	
AGENCY DATA						
16.		**Agency Data Applications**	Probe-Based Pavement Maintenance	PDPM		**ODOT 19.**
17.		**Agency Data Applications**	Probe-Enabled Traffic Monitoring		Vehicle Data for Traffic Operations	**ODOT 20.**
18.		**Agency Data Applications**	Vehicle Classification-based Traffic Studies			
19.		**Agency Data Applications**	AASHTO: CV-Enabled Performance Measures		Performance Monitoring and Planning	**ODOT 21.**
20.		**Agency Data Applications**	CV-Enabled Turning Movement & Intersection Analysis		Vehicle Data for Traffic Operations	
21.		**Agency Data Applications**	CV-Enabled Origin-Destination Studies			

Number/ Priority	Source	Group	Application Name	Acronym	CVRIA Application Name	ODOT Application Number
22.		**Agency Data Applications**	Work Zone Traveler Information		Warnings about Upcoming Work Zone Warnings about Hazards in a Work Zone	**ODOT 22.**
ENVIRONMENT						
23.		**Environment**	Eco-Approach and Departure at Signalized Intersections		Eco-Approach and Departure at Signalized Intersections	
24.		**Environment**	Eco-Traffic Signal Timing		Eco-Traffic Signal Timing	
25.		**Environment**	Eco-Traffic Signal Priority		Eco-Traffic Signal Priority	
26.		**Environment**	Connected Eco-Driving		Connected Eco-Driving	
27.		**Environment**	Wireless Inductive/Resonance Charging		Cooperative Recharge Method of Connected Electric Vehicles in Smart Grid	

Number/ Priority	Source	Group	Application Name	Acronym	CVRIA Application Name	ODOT Application Number
28.		**Environment**	Eco-Lanes Management		Eco-Lanes Management	
29.		**Environment**	Eco-Speed Harmonization		Eco-Speed Harmonization	
30.		**Environment**	Eco-Cooperative Adaptive Cruise Control		Eco-Cooperative Adaptive Cruise Control	
31.		**Environment**	Eco-Traveler Information Applications		Eco-Multimodal Real-Time Traveler Information	
32.		**Environment**	Eco-Ramp Metering		Eco-Ramp Metering	
33.		**Environment**	Low Emissions Zone Management		Low Emissions Zone Management	
34.		**Environment**	AFV Charging/Fueling Information		Electric Charging Stations Management	**ODOT 6.**

Number/ Priority	Source	Group	Application Name	Acronym	CVRIA Application Name	ODOT Application Number
35.		**Environment**	Eco-Smart Parking		Traveler Information – Smart Parking Smart Park and Ride System	
36.		**Environment**	Dynamic Eco-Routing (Light Vehicle, Transit, Freight)		Dynamic Eco-Routing	
37.		**Environment**	Eco-Integrated Corridor Management Decision Support System		Eco-Integrated Corridor Management Decision Support System	**ODOT 7.**
38.		**Environment**	AASHTO: Dynamic Emissions Pricing		Low Emissions Zone Management	See Application 33.
ROAD WEATHER						
39.		**Road Weather**	Motorist Advisories and Warnings	MAW	Road Weather Motorist Alert and Warning	**ODOT 23.**
40.		**Road Weather**	Enhanced Maintenance Decision Support System	MDSS	Enhanced Maintenance Decision Support System	**ODOT 24.**
41.		**Road Weather**	Vehicle Data Translator	VDT	Vehicle Data Translator	

Number/ Priority	Source	Group	Application Name	Acronym	CVRIA Application Name	ODOT Application Number
42.		**Road Weather**	Weather Response Traffic Information	WxTINFO	Road Weather Information and Routing Support for Emergency Responders Road Weather Information for Freight Carriers Road Weather Information for Maintenance and Fleet Management SystemsWeather Response Traffic Info (WxTINFO)	
FEE PAYMENT						
43.		**Fee Payment**	AASHTO: Tolling		Road Use Charging Electronic Toll Collection	**ODOT 8.**
44.		**Fee Payment**	AASHTO: High Occupancy Toll Lanes		High-Occupancy Toll Lanes	**ODOT 9.**
45.		**Fee Payment**	AASHTO: Congestion Pricing		Congestion Pricing	**ODOT 10.**
MOBILITY: EnableATIS • MMITSS • INFLO • RESCUME • IDTO • FRATIS						
46.		**EnableATIS**	Advanced Traveler Information System	EnableATIS	Advanced Traveler Information Systems	**ODOT 1.**

Number/ Priority	Source	Group	Application Name	Acronym	CVRIA Application Name	ODOT Application Number
47.		**MMITSS**	Intelligent Traffic Signal System	I-SIG	Intelligent Traffic Signal System	
48.		**MMITSS**	Signal Priority (Transit and Freight)	TSP FSP	Transit Signal Priority and Freight Signal Priority	
49.		**MMITSS**	Mobile Accessible Pedestrian Signal System	PED-SIG	Pedestrian Mobility	
50.		**MMITSS**	Emergency Vehicle Preemption	PREEMPT	Emergency Vehicle Preemption	
51.		**INFLO**	Dynamic Speed Harmonization	SPD-HARM	Speed Harmonization Variable Speed Limits for Weather-Responsive Traffic Management	**ODOT 2.**
52.		**INFLO**	Queue Warning	Q-WARN	Queue Warning	**ODOT 3.**
53.		**INFLO**	Cooperative Adaptive Cruise Control	CACC	Cooperative Adaptive Cruise Control	

Number/ Priority	Source	Group	Application Name	Acronym	CVRIA Application Name	ODOT Application Number
54.	AASHTO The Voice of Transportation	**INFLO**	AASHTO: Next Generation Ramp Metering System	RAMP	Eco-Ramp Metering Next Generation Ramp Metering System (RAMP)	**ODOT 4.**
55.		**RESCUME**	Incident Scene Pre-Arrival Staging Guidance for Emergency Responders	RESP-STG	Incident Scene Pre-Arrival Staging Guidance for Emergency Responders	**ODOT 16.**
56a.		**RESCUME**	Incident Scene Work Zone Alerts for Drivers and Workers	INC-ZONE	Incident Scene Work Zone Alerts for Drivers and Workers	**ODOT 17.**
56b.		**V2I Safety**	Reduced Speed/Work Zone Warning	RSWZ	Reduced Speed Zone Warning / Lane Closure Restricted Lane Warnings	**ODOT 17.**
57.		**RESCUME**	Emergency Communications and Evacuation	EVAC	Emergency Communications and Evacuation	**ODOT 18.**
58.		**IDTO**	Connection Protection	T-CONNECT	Transit Connection Protection	
59.		**IDTO**	Dynamic Transit Operations	T-DISP	Dynamic Transit Operations	

Number/ Priority	Source	Group	Application Name	Acronym	CVRIA Application Name	ODOT Application Number
60.		**IDTO**	Dynamic Ridesharing	D-RIDE	Dynamic Ridesharing	
61.		**FRATIS**	Freight Dynamic Travel Planning and Performance	DR-OPT	Freight-Specific Dynamic Travel Planning	**ODOT 5.**
62.		**FRATIS**	Drayage Optimization		Freight Drayage Optimization	
SMART ROADSIDE						
63.		**Smart Roadside**	Wireless Inspection/E-Screening Virtual Weigh Station		Smart Roadside Container Security	**ODOT 25.**
64.		**Smart Roadside**	Smart Truck Parking		Eco-Smart Parking Smart Roadside Initiative Traveler Information-Smart Parking	**ODOT 26.**

2.0 CONNECTED VEHICLE APPLICATION INVENTORY/DICTIONARY

Each of the 64 selected connected vehicle applications is tabulated according the legend shown in Table 2.1.

Table 2.1: Connected Vehicle Inventory/Dictionary Legend

Row Label	Item Description
Title	Name of the application
CVRIA Reference	Name of application in the Connected Vehicle Reference Implementation Architecture (CVRIA) Hyperlink to CVRIA Application page.
Description	Description of the application
Category	Categorical function of the application
ODOT Application Number	Number reference used in ODOT prioritization workshop
Benefits/Impact	Application effects in terms of safety, efficiency, comfort, etc.
Maturity	Age within the industry
Interface Requirements	Interfaces that application runs on or through (e.g. driver to vehicle interface, roadside interface, etc.)
Infrastructure Requirements	Required infrastructure components for application to function
Vehicle Component Requirements	Vehicle-side components that are required for application to function
Applicability	Relevance to the state DOT perspective: **Priority 1: Near Term Focus for ODOT** **Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others** **Priority 3: Leadership by Others, ODOT Monitor** **Not on ODOT Priority List**
Physical RSE Installation	Whether or not physical roadside equipment (RSE) is required, and if so, if it is fixed or portable
Roadside Interface to Local	Whether the roadside interface to local systems is required, not, or optional
Backhaul Communications	Whether the backhaul communications are not needed, required, or optional
Backhaul Restrictions	Whether the backhaul restrictions are not available,

	exclusive, on limited domains, or unrestricted
Mapping Support	Resolution of the mapping support: none, road network, lane level, localized geometric
Siting Dependency	Whether or not the siting dependency is critical
Management of Collected Data	Whether or not collected data is managed
Back Office Services/Applications	Whether or not there are back office services and applications
Latency	Amount of network latency required: low, medium, high
Vehicle Data Connection	Whether or not a vehicle data connection is required
Benefits vs. Deployment Level	Whether benefits are realizable day one, or require threshold deployment level
Other Dependency	Whether or not if there are other dependencies such as privacy or policy
Data Needs from OBU	What data is needed from onboard unit (OBU): none, position, Basic Safety Message Part 1 (BSM1), BMS Parts 1 and 2 (BSM1+2), BSM1+2+other, BSM1+other, other
Data Needs from Infrastructure	What data is needed from the infrastructure: none, Traveler Information (TI), Signal Phase and Timing (SPaT), Geometric Intersection Descriptions/Maps (GIDs/Maps), SPaT/GIDs, App-specific
Infographic	U.S. DOT Infographic for the application, if available
Other Images	Optional row for other relevant images

2.1 VEHICLE TO INFRASTRUCTURE (V2I) SAFETY APPLICATIONS

Table 2.2: V2I Safety ‣ Signal Phase & Timing

Title	Signal Phase & Timing
CVRIA Reference	Signal Phase and Timing
Description	Signal Phase and Timing Application is a support application that provides the current intersection signal light phases. The current state of all lanes at a single intersection are provided as well as any preemption or priority then follows in a structure for the whole intersection. This application is used to support a variety of V2I applications.
Category	Support Signal Phase & Timing
ODOT Application Number	**ODOT 11.**
Benefits/Impact	Signal Phase and Timing is an enabling application that will leverage existing installations at signalized intersections to facilitate a wide range of traffic signal related applications. Significant benefits and impacts are envisioned once this enabling platform is in place.

Maturity	Traffic signals are widespread and Signal Phase and Timing demonstrations are underway around the U.S. and internationally.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside Interface, Driver-Vehicle Interface, Vehicle Systems Interface, Infrastructure Communications Interface, and Vehicle Communications Interface.
Infrastructure Requirements	SPaT Application (intersection GID, count of detected vehicles, information on each detected vehicle i.e. position, speed, and heading, minor road vehicle data i.e. position and heading, infrastructure signage information).
Vehicle Component Requirements	
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Fixed
Roadside Interface to Local	Yes
Backhaul Communications	Optional
Backhaul Restrictions	Exclusive
Mapping Support	Localized Geometric
Siting Dependency	Critical
Management of Collected Data	No
Back Office Services/Applications	No
Latency	Low
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	None
Data Needs from Infrastructure	SPaT
Infographic	None

Table 2.3: V2I Safety ▸ Red Light Violation Warning

Title	Red Light Violation Warning (RLVW)
CVRIA Reference	Red Light Violation Warning
Description	The advantage of a cooperative RLVW used in infrastructure-to-vehicle communication is that it can react before, instead of after, an event occurs *(U.S. DOT 2015a)*.
Category	Vehicle to Infrastructure Safety
ODOT Application Number	--
Benefits/Impact	The application in the vehicle uses the vehicle's speed and acceleration profile, along with the signal timing and geometry information to determine if it appears the vehicle will enter the intersection in violation of a traffic signal laws for that state. If the violation seems likely to occur, a warning can be provided to the driver.
Maturity	Red light enforcement systems already are in widespread use. In-vehicle warning systems have been tested and the individual technology components are mature but the system as a package has not yet been deployed.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside Interface, Driver-Vehicle Interface, Vehicle Systems Interface, Infrastructure Communications Interface, and Vehicle Communications Interface.
Infrastructure Requirements	Infrastructure RLVW Application (intersection GID, count of detected vehicles, information on each detected vehicle i.e. position, speed, and heading, minor road vehicle data i.e. position and heading, infrastructure signage information).
Vehicle Component Requirements	Vehicle RLVW Application and In-Vehicle Warning System.
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others**
Physical RSE Installation	Fixed
Roadside Interface to Local	Yes
Backhaul Communications	Optional
Backhaul Restrictions	Exclusive
Mapping Support	Localized Geometric
Siting Dependency	Critical
Management of Collected Data	No

Back Office Services/Applications	No
Latency	Low
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	None
Data Needs from Infrastructure	SPaT
Infographic	None

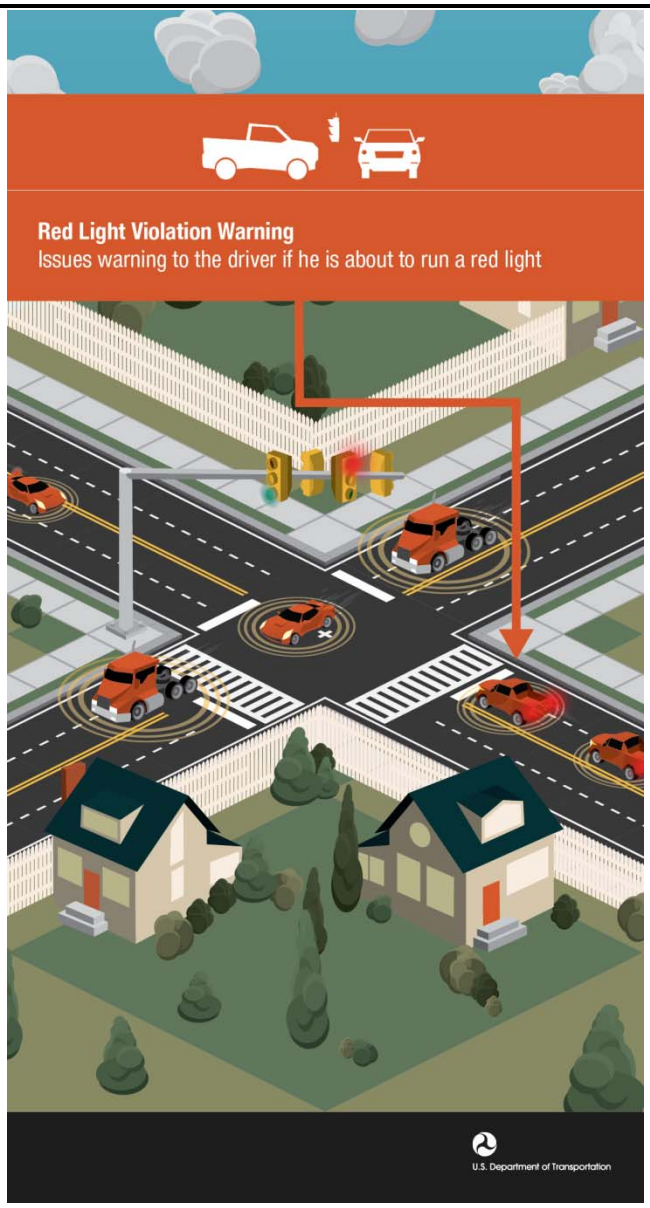
Infographic	
Other Image	 (Source: http://www.gizmag.com/volvo-car-2-car-communication-consortium/24892/)

Table 2.4: V2I Safety ‣ Curve Speed Warning

Title	Curve Speed Warning
CVRIA Reference	Curve Speed Warning
Description	Curve Speed Warning (CSW) application is intended to help drivers approaching a curve to travel through it at a safe speed based on the current road and weather conditions. In particular, the application warns drivers if they are exceeding the safe speed threshold which may result in a loss of vehicle stability and control, leading to a roadway departure and/or rollover crash. This can be particularly important for trucks and other large vehicles *(U.S. DOT 2012)*.
Category	Vehicle to Infrastructure Safety
ODOT Application Number	**ODOT 12.**
Benefits/Impact	• Reductions in the number of roadway fatalities • Reductions in the number and severity of roadway injuries • Reductions in property damage associated with roadway incidents • Reductions in the number of near-miss intersection conflict and run-off-road (ROR) incident scenarios
Maturity	Still within the technological development stages. The extension to a connected/cooperative environment has been demonstrated but not yet deployed.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside Interface, Driver-Infrastructure Interface, Driver-Vehicle Interface, Vehicle Systems Interface, Infrastructure Communications Interface, and Vehicle Communications Interface.
Infrastructure Requirements	Infrastructure CSW Application (curve location i.e. Latitude/Longitude and divergent path or part of roadway, curve geometry i.e. curve radius, roadway super-elevation, and slope, road way material, posted speed limit, and advisory speed).
Vehicle Component Requirements	Vehicle CSW Application and In-Vehicle Warning System.
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Fixed: the Dedicated Short-Range Communication (DSRC) Roadside Unit (RSU) is deployed to a particular location and fixed to a permanent structure
Roadside Interface to Local	No: no connections are needed.
Backhaul Communications	None: no backhaul communications are needed.
Backhaul Restrictions	N/A: backhaul restrictions are not applicable since there are no backhaul

	communications needed for CSW.
Mapping Support	Optional-Road Network: CSW needs to be able to place the mobile unit within the context of a particular road. This class of map can support applications like Curve Speed Warning and be broadcasted to a vehicle at a remote location and used by the vehicle some time later when it reaches the curve.
Siting Dependency	Critical: consistency and reliability of roadside to mobile unit communications is critical to application effectiveness.
Management of Collected Data	No: no data management services are needed.
Back Office Services/Applications	No: no back office applications/services are needed.
Latency	Low: prompt information exchange is essential to the effectiveness of the application; response times on the order of one second or less are needed.
Vehicle Data Connection	Required: CSW requires data from the vehicle.
Benefits vs. Deployment Level	Benefits are realizable from day one: users can begin to see benefits from CSW as soon as it is deployed.
Other Dependency	None
Data Needs from OBU	None: no data are needed from the OBU
Data Needs from Infrastructure	App-specific: information specific to CSW beyond the other data groups.

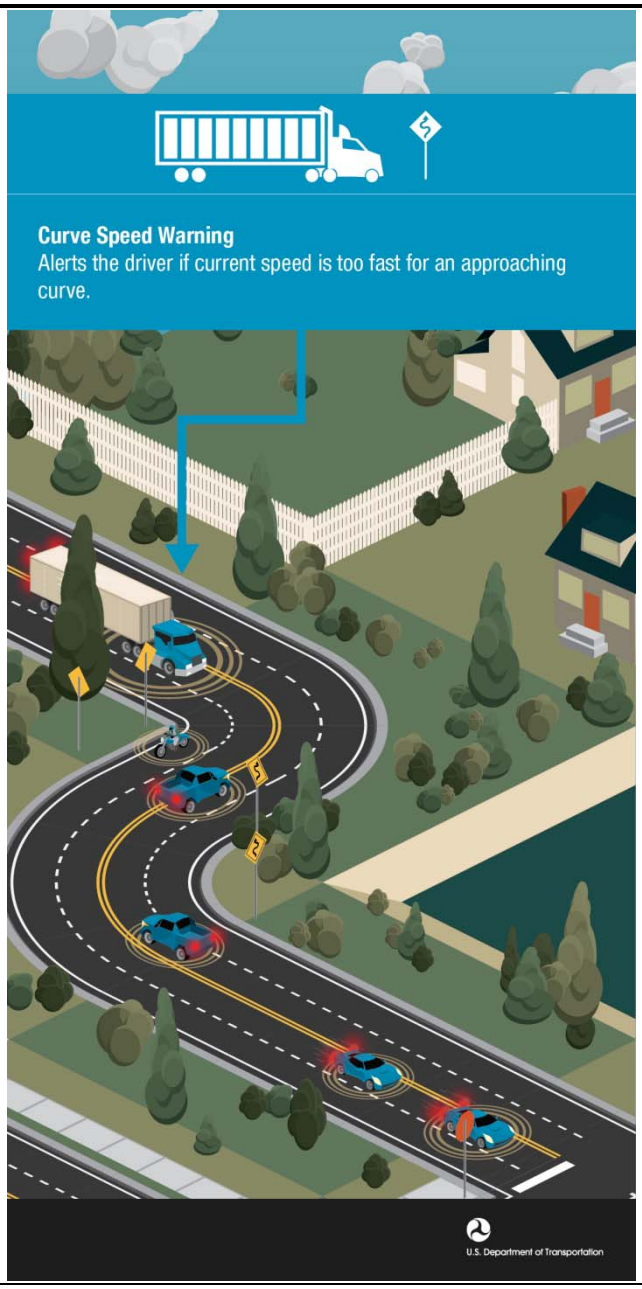
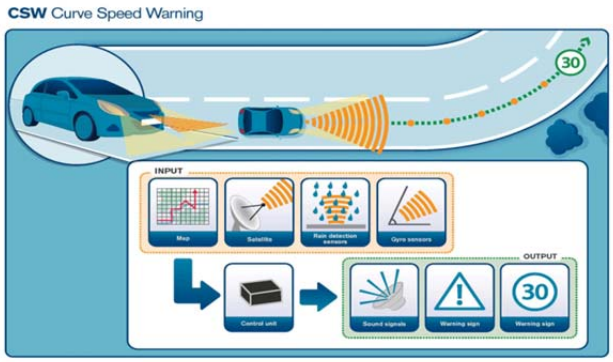
Infographic	
Other Image	 (Source: http://www.eurofot-ip.eu/en/intelligent_vehicle_systems/csw/)

Table 2.5: V2I Safety ‣ Stop Sign Gap Assist

Title	Stop Sign Gap Assist (SSGA)
CVRIA Reference	Stop Sign Gap Assist Stop Sign Violation Warning
Description	"The SSGA application is intended to improve safety at un-signalized intersections where only the minor road has posted stop signs" *(U.S. DOT 2015b)*. To have this technology work there will need to be the integration of both vehicle based and infrastructure-based technologies. This can be accomplished by having both onboard and roadside signage warning systems integrated. The SSGA application collects all available sensor information (major road, minor road, and median sensors) data and computes the dynamic state of the intersection in order to issue appropriate warnings and alerts. The SSGA application is configured for both equipped and unequipped scenarios, and thus the vehicle components of the application can be optional *(U.S. DOT 2012)*
Category	Vehicle to Infrastructure Safety
ODOT Application Number	--
Benefits/Impact	The application will help drivers on a minor road remain stopped at an intersection by providing a warning of unsafe gaps on the major road. In this way, the SSGA safety application will help drivers maneuver through cross traffic. This will reduce the number of conflicts and crashes that occur at intersections.
Maturity	Elements in the application have been developed and individual components are relatively mature, but this does not exist as a stand-alone package at this stage.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside Interface, Driver-Infrastructure Interface, Driver-Vehicle Interface, Vehicle Systems Interface.
Infrastructure Requirements	Infrastructure Communications Interface, and Vehicle Communications Interface, Infrastructure SSGA Application.
Vehicle Component Requirements	Vehicle SSGA Application, and In-Vehicle Warning System.
Applicability	**Priority 3: Leadership by Others, ODOT Monitor.**
Physical RSE Installation	Fixed
Roadside Interface to Local	Yes
Backhaul Communications	None

Backhaul Restrictions	N/A
Mapping Support	Localized Geometric
Siting Dependency	Critical
Management of Collected Data	No
Back Office Services/Applications	No
Latency	Low
Vehicle Data Connection	Not Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	None
Data Needs from Infrastructure	App-specific

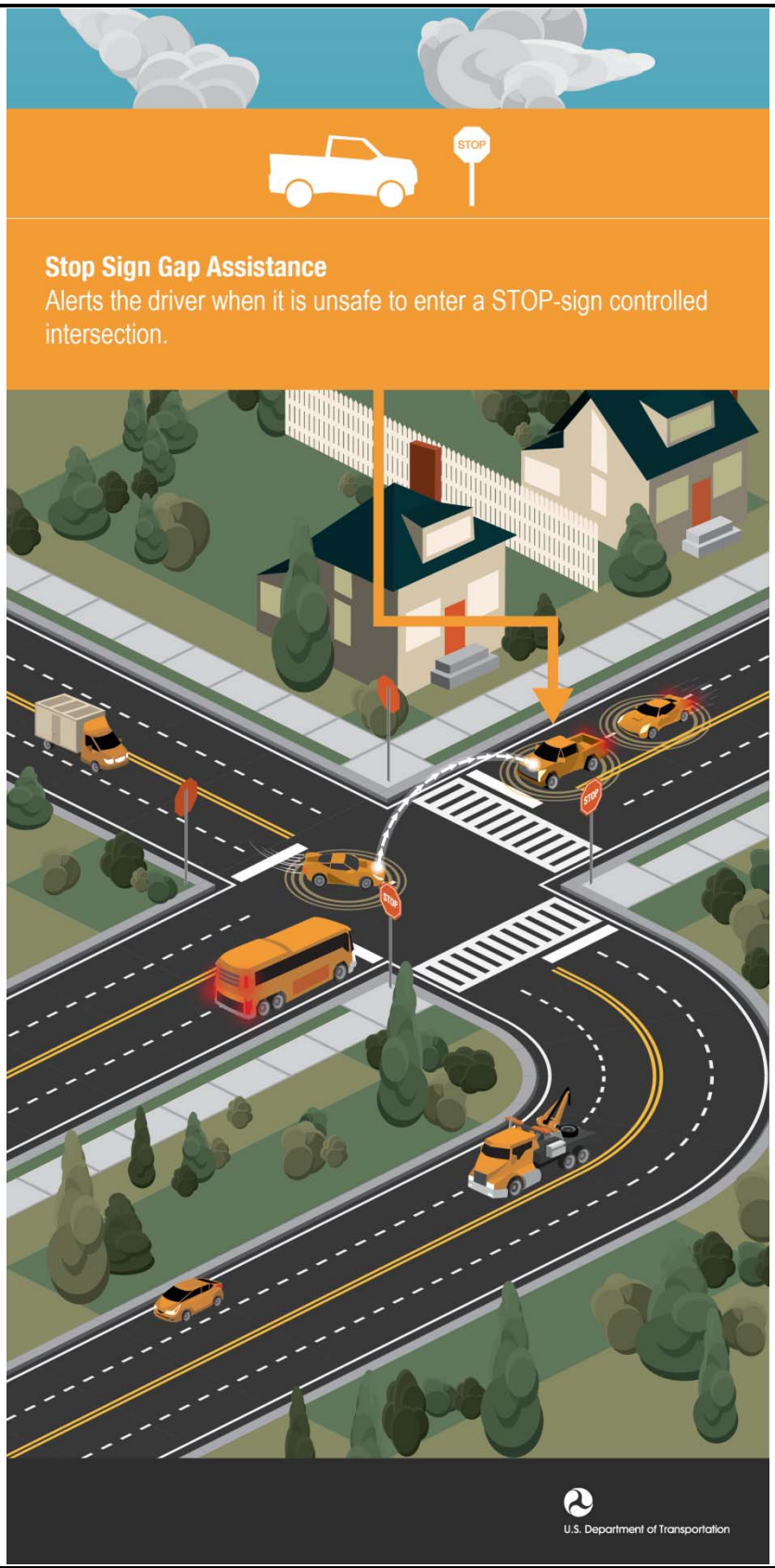
Infographic	

Table 2.6: V2I Safety ‣ Spot Weather Impact Warning

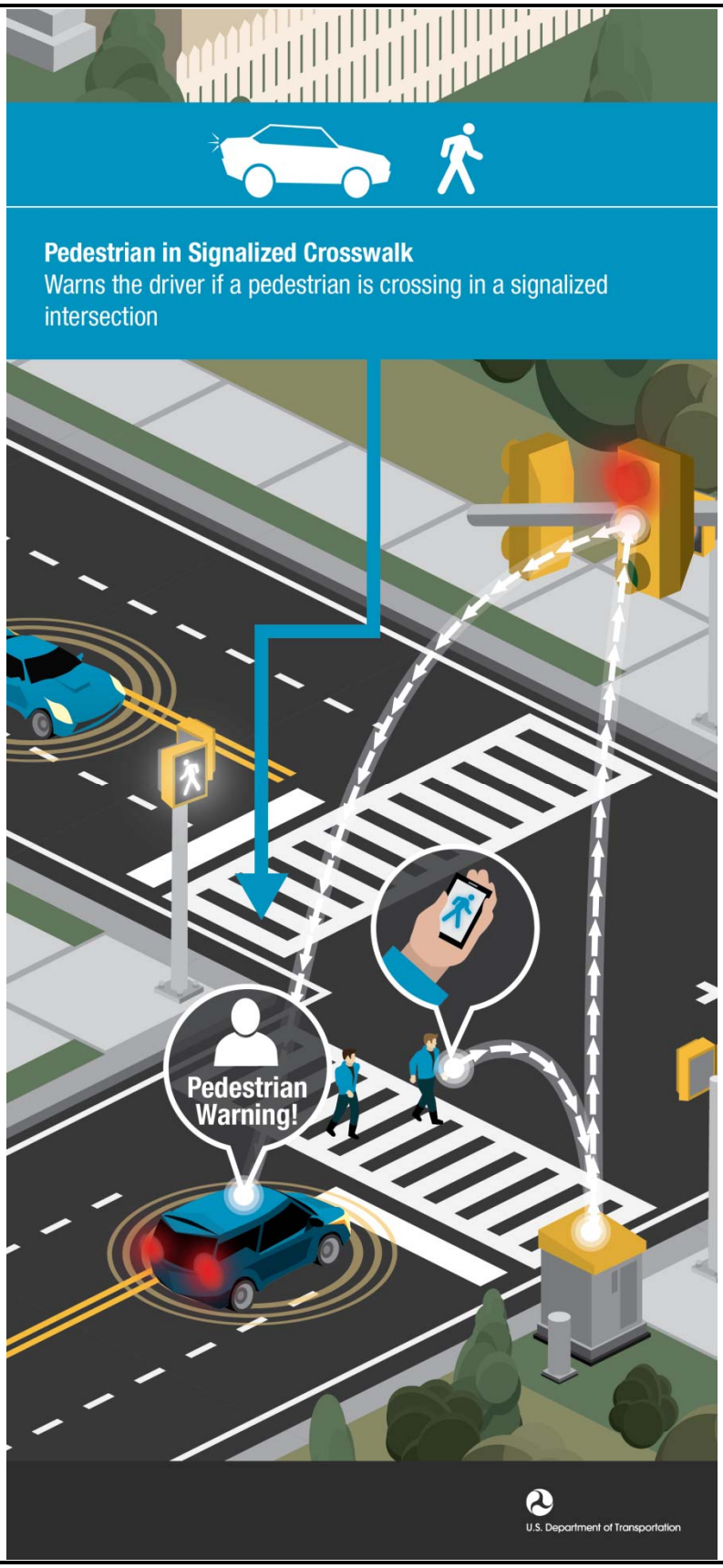
Title	Spot Weather Impact Warning
CVRIA Reference	Spot Weather Impact Warning
Description	The SWIW application alerts drivers regarding unsafe conditions at specific points on the roadway as a result of weather (high winds, flood conditions, ice, or fog). Real time weather information is collected via Road Weather Information Systems (RWIS) or via vehicle based probe data. The information is processed to determine priority of the alert or warning to be delivered. Then this warning is communicated to the driver, other connected vehicles in the vicinity, and to on roadway signage *(U.S. DOT 2015c).*
Category	Vehicle to Infrastructure Safety
ODOT Application Number	**ODOT 13.**
Benefits/Impact	The application is designed to use standalone weather systems to warn drivers about inclement weather conditions that may impact travel conditions.
Maturity	Road weather warning systems are mature and are used in Oregon and around the U.S. The connected/cooperative version has been demonstrated but is not yet implemented.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside Interface, Driver-Infrastructure Interface, Driver-Vehicle Interface, Vehicle Systems Interface, Infrastructure Communications Interface, and Vehicle Communications Interface.
Infrastructure Requirements	Infrastructure SWIW Application: Road-weather data (including raw, processed, and quality check data), Current DII Message, Duration and/or distance of applicability weather impact zone, Location of weather impact zone, Infrastructure application recommended advisory speed (Optional), Infrastructure application recommendation to divert to alternate route (Optional).
Vehicle Component Requirements	Vehicle SWIW Application and In-Vehicle Warning System *(U.S. DOT 2012, Stephens et al. 2012).*
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Fixed
Roadside Interface to Local	Yes
Backhaul Communications	None
Backhaul Restrictions	N/A
Mapping Support	Optional

Siting Dependency	Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	Medium
Vehicle Data Connection	Not required
Benefits vs. Deployment Level	Day one
Other Dependency	Privacy
Data Needs from OBU	BSM1
Data Needs from Infrastructure	Wireless Communication to Connected Vehicle
Infographic	 (Source: http://www.its.dot.gov/infographs/stop_sign_gap.htm)

Table 2.7: V2I Safety ‣ Pedestrian in Signalized Crosswalk Warning

Title	Pedestrian in Signalized Crosswalk Warning (Transit)
CVRIA Reference	Pedestrian in Signalized Crosswalk Warning
Description	This technology provides connected vehicle information from the infrastructure that indicates the presence of pedestrians in a crosswalk at a signalized intersection. This infrastructure-based indication can either include the outputs of pedestrian sensors or an indication that the pedestrian has placed a call to a signals control cabinet. This application has been applied to public transit vehicles in test applications, but can be applicable to any vehicle *(U.S. DOT 2015e)*.
Category	Vehicle to Infrastructure Safety
ODOT Application Number	--
Benefits/Impact	This technology provides connectivity between and among vehicles, infrastructure, and wireless devices to enable crash warnings, enable safety, mobility, and environmental benefits, and provide continuous real-time connectivity to all system users.
Maturity	Flashing crosswalk systems have been deployed *(Huang et al. 1999)* but the connected/cooperative elements are still on the horizon.
Interface Requirements	Back Office Interface, Infrastructure Communications Interface, and Vehicle Communications Interface.
Infrastructure Requirements	ITS Roadside Equipment
Vehicle Component Requirements	Vehicle OBE
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others**
Physical RSE Installation	Fixed
Roadside Interface to Local	Yes
Backhaul Communications	Optional
Backhaul Restrictions	Exclusive
Mapping Support	Localized Geometric
Siting Dependency	Non-Critical
Management of Collected Data	No

Back Office Services/Applications	No
Latency	Low
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	None
Data Needs from Infrastructure	App-specific

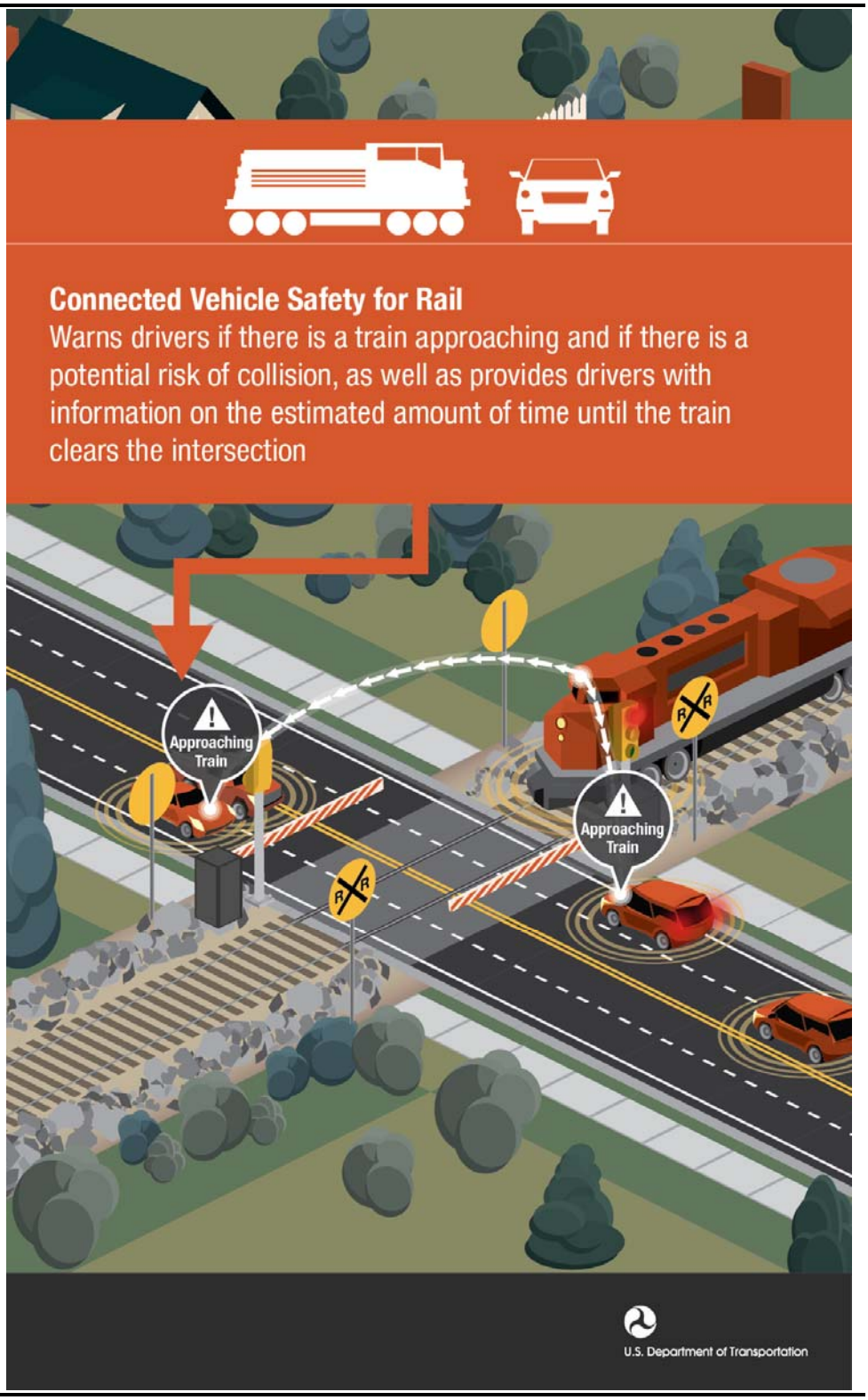
Infographic	


Pedestrian in Signalized Crosswalk
Warns the bus driver when a pedestrian is crossing the street as the bus is making a right or left turn.
Pedestrian Warning!
Pedestrian Warning!
U.S. Department of Transportation

Table 2.8: V2I Safety ‣ Railroad Crossing Violation Warning

Title	AASHTO: Railroad Crossing Violation Warning
CVRIA Reference	Railroad Crossing Violation Warning
Description	RSU in vicinity of intersection and connected to RR crossing guard controller sends out Signal Phase and Timing Messages (or RRX equivalent). Vehicle OBU receives SPAT/RRX info and determines if a warning is appropriate. Alerts and warn drivers if they are about to collide with a crossing/approaching train. Goal: to reduce, mitigate, or prevent additional accidents from occurring beyond the standard safety countermeasures, such as flashing lights, warning bells, and cross gates, that are typically installed.
Category	Vehicle to Infrastructure Safety
ODOT Application Number	**ODOT 14.**
Benefits/Impact	Safety – To prevent vehicle accidents, to discourage drivers from violating railroad crossing traffic controls
Maturity	RCVW is currently being researched and tested. Today, Rail Crossing Warning systems have been widely deployed and include flashing light signals, automatic gates, and warning bells. There are different types of train detection systems that are in use today, such as an AC-DC track circuit, audio frequency overlay track circuit, and motion-sensitive track circuits. However, these systems do not meet the requirement of the RCVW. (See requirements section below).
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside interface, Driver-Vehicle Interface, Vehicle Systems Interface, Infrastructure Communications Interface, and Vehicle Communications Interface.
Infrastructure Requirements	ITS Roadside Equipment
Vehicle Component Requirements	Vehicle OBE
Applicability	**Priority 1: Near Term Focus for ODOT** The railroad, transit agency, ODOT and local agencies are responsible for all infrastructure-related actions (repair, maintenance, communication network).
Physical RSE Installation	Fixed
Roadside Interface to Local	Yes
Backhaul Communications	Optional
Backhaul Restrictions	Exclusive

Mapping Support	Localized Geometric
Siting Dependency	Critical
Management of Collected Data	No
Back Office Services/Applications	No
Latency	Medium
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	None
Data Needs from Infrastructure	SPaT

Infographic	

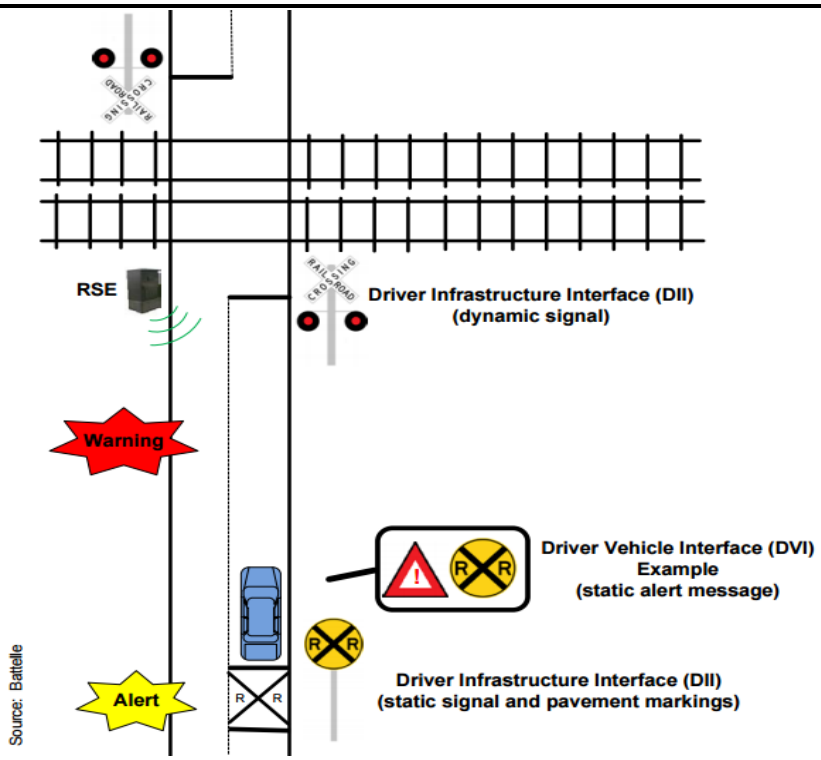
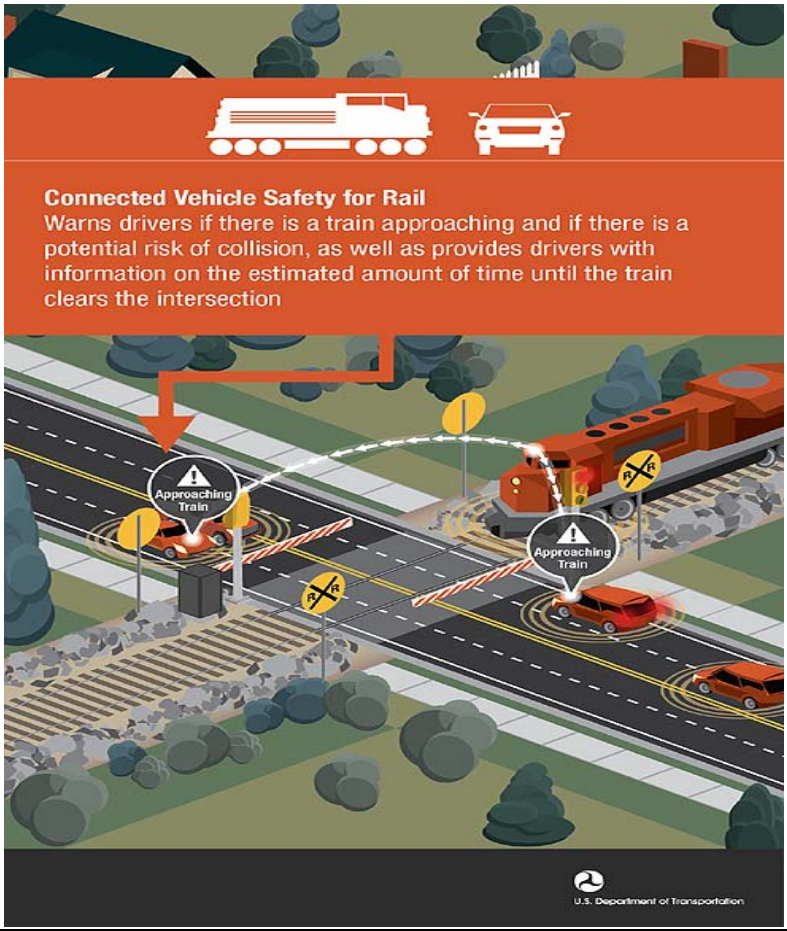
Other Image	 

Table 2.9: V2I Safety ‣ Disabled/Oversize Vehicle Warning

Title	AASHTO: Disabled/Oversize Vehicle Warning
CVRIA Reference	Oversize Vehicle Warning
Description	RSU in vicinity of (i.e. on approach to) overhead restriction sends out overhead limit locations and directions. Vehicle OBU receives overhead limit info and determines if a warning is appropriate. Ideally, an alert would be given so that the oversize vehicle can be rerouted before a warning to stop is required.
Category	Vehicle to Infrastructure Safety
ODOT Application Number	**ODOT 15.**
Benefits/Impact	Uses external measurements taken by the roadside infrastructure, and transmitted to the vehicle, to support in-vehicle determination of whether an alert/warning is necessary
Maturity	In the general category of motorist warnings, many of the issues have been tested in field deployments, but this is not at the stage of actual implementation yet.
Interface Requirements	ITS Roadway Equipment, Maintenance and Construction Vehicle Platform, Weather Service
Infrastructure Requirements	Maintenance and Construction Management Center "Roadside Equipment" (RSE)
Vehicle Component Requirements	Maintenance and Construction Vehicle OBE, Dedicated Short Range Communications (DSRC)
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Portable or Fixed
Roadside Interface to Local	No
Backhaul Communications	None
Backhaul Restrictions	N/A
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	No
Back Office Services/Applications	No
Latency	Medium
Vehicle Data Connection	Not Required

Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	None
Data Needs from Infrastructure	GIDs/Maps
Infographic	None

2.2 VEHICLE TO VEHICLE (V2V) SAFETY APPLICATIONS

Table 2.10: V2V Safety ‣ Emergency Electronic Brake Light

Title	Emergency Electronic Brake Light (EEBL)
CVRIA Reference	Emergency Electronic Brake Light
Description	Broadcasts “hard braking” messages to surrounding vehicles. EEBL issues a warning to the driver when the lead vehicle is decelerating by a minimum of 0.4 g. This application addresses the "Lead Vehicle Decelerating" scenario and shares some overlap in functionality with the Forward Collision Warning (FCW) application *(U.S. DOT 2015f)*.
Category	Vehicle to Vehicle Safety
ODOT Application Number	--
Benefits/Impact	Warns drivers of hard-braking/stopped vehicles despite obstacles and visibility constraints. Will decrease and could potentially eliminate rear-end collisions. Impacts: Safety 5, Efficiency 2, Comfort 4
Maturity	New fleets will be equipped with such devices in the near future.
Interface Requirements	V2V Safety applications need to broadcast the performance of their vehicle in the transportation environment.
Infrastructure Requirements	Map Update System
Vehicle Component Requirements	Vehicle Platform Vehicle On-Board Equipment (OBE)
Applicability	**Priority 3: Leadership by Others, ODOT Monitor**
Physical RSE Installation	None
Roadside Interface to Local	No
Backhaul Communications	None

Backhaul Restrictions	N/A
Mapping Support	None
Siting Dependency	Not critical
Management of Collected Data	Algorithm determining whether a braking event requires a driver warning
Back Office Services/Applications	No
Latency	Low: DSRC=10Hz
Vehicle Data Connection	Requires DSRC
Benefits vs. Deployment Level	As more vehicles become EEBL-equipped, the number of rear-end collisions is expected to decrease.
Other Dependency	For the EEBL system to work properly, all vehicles need to be equipped.
Data Needs from OBU	Position, speed, brake monitoring
Data Needs from Infrastructure	None

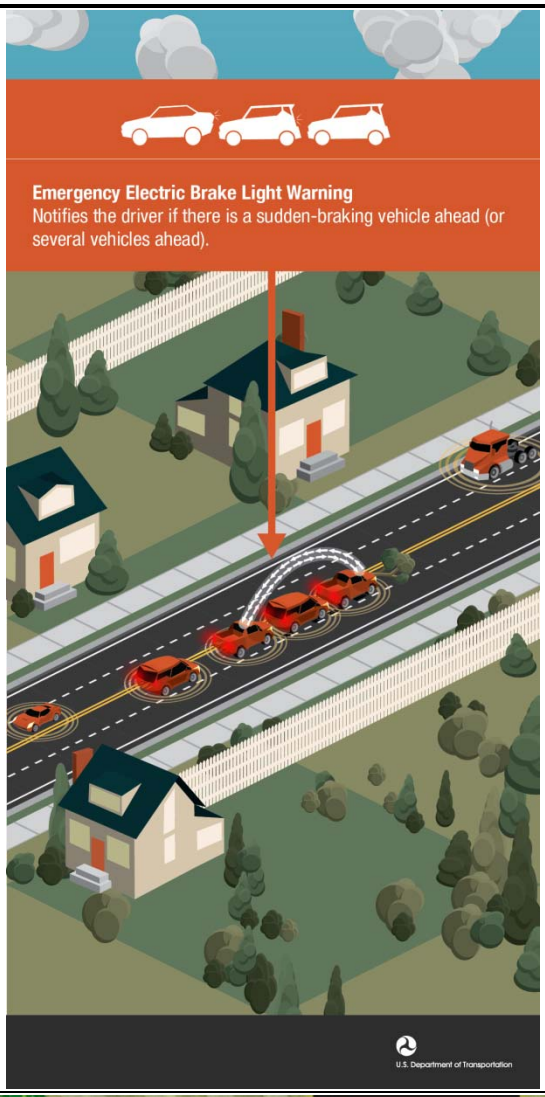
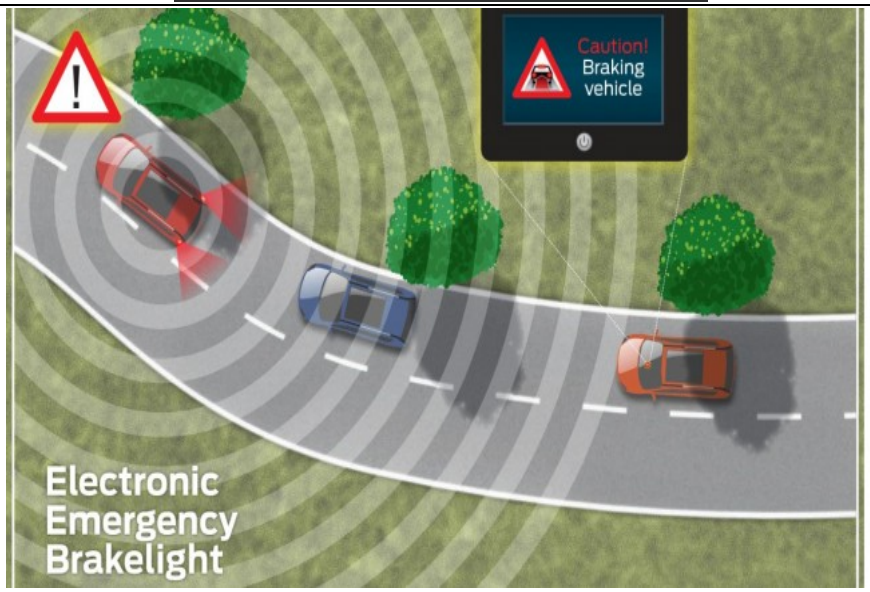
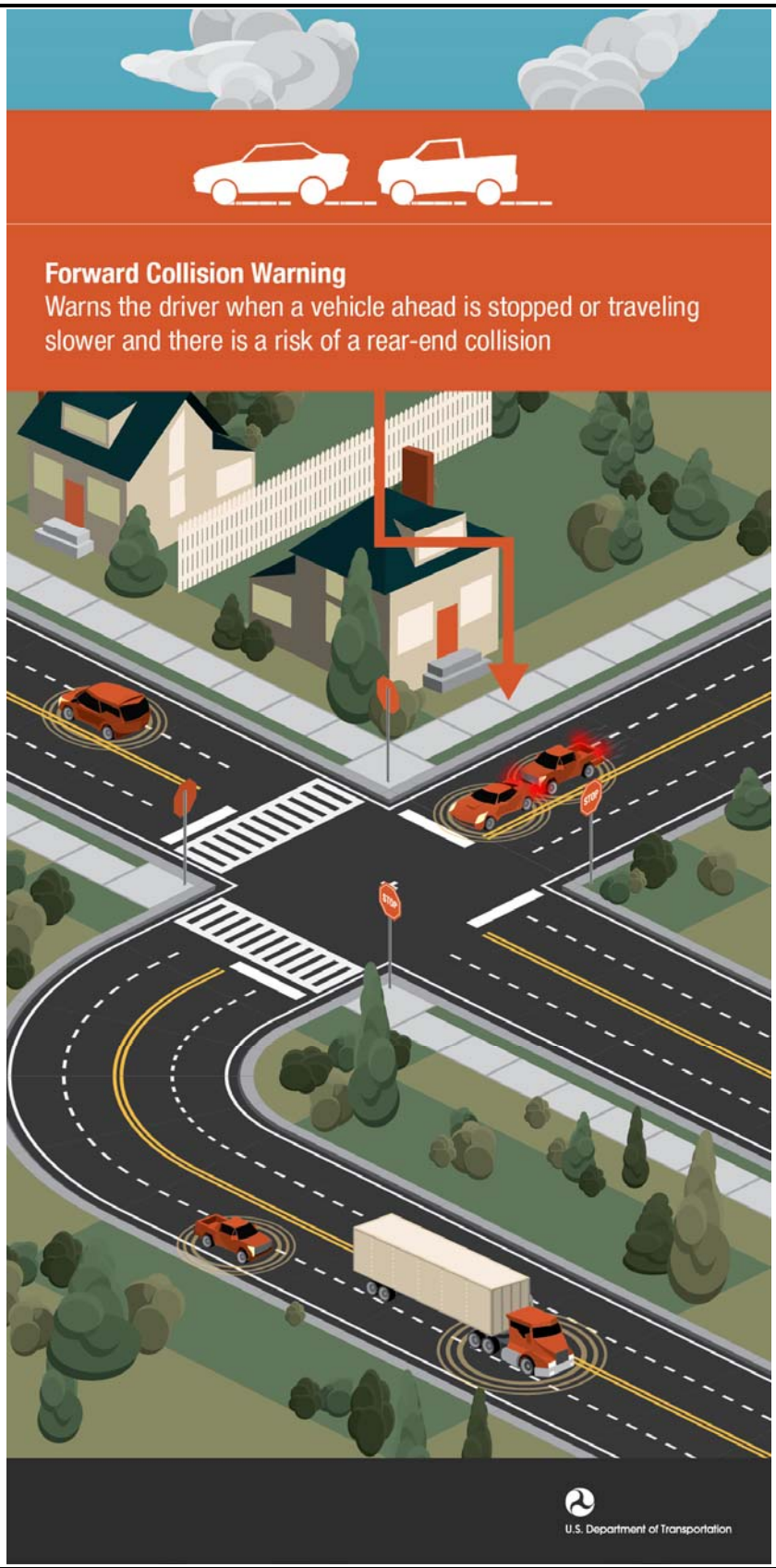
Infographic	
Other Image	 (Source : http://goo.gl/102Kh)

Table 2.11: V2V Safety ‣ Forward Collision Warning

Title	Forward Collision Warning
CVRIA Reference	Forward Collision Warning
Description	FCW is an application that currently has well-developed research-level performance and test metrics. Current FCW applications based on visual and radar detection systems can be hindered by certain lighting and weather conditions, and are limited with respect to distance. FCW applications using V2V technology can function in environments and under conditions beyond the current visual and radar detection systems (e.g., sunrise, sunset, rain, snow, >300m range), allowing for a more robust warning system *(Harding et al. 2014)*.
Category	Vehicle to Vehicle Safety
ODOT Application Number	--
Benefits/Impact	The benefit of this technology can definitely outweigh cost of installation. It does not change levels of efficiency or comfort but it will undoubtedly increase levels of safety for everyone in the vehicle. : The main type of crash prevented by this technology is a rear end warning situation.
Maturity	Not the most mature and perfected technology, but implementations of such or similar have been available on the market.
Interface Requirements	None
Infrastructure Requirements	Inexpensive installation of hardware, e.g. sonars and radars and simple software installation
Vehicle Component Requirements	None
Applicability	**Priority 3: Leadership by Others, ODOT Monitor.**
Physical RSE Installation	None
Roadside Interface to Local	None
Backhaul Communications	None
Backhaul Restrictions	None
Mapping Support	None
Siting Dependency	None
Management of Collected Data	No

Back Office Services/Applications	No
Latency	Low
Vehicle Data Connection	Not required
Benefits vs. Deployment Level	Benefits will increase with greater penetration rates.
Other Dependency	None
Data Needs from OBU	None
Data Needs from Infrastructure	None

Infographic	

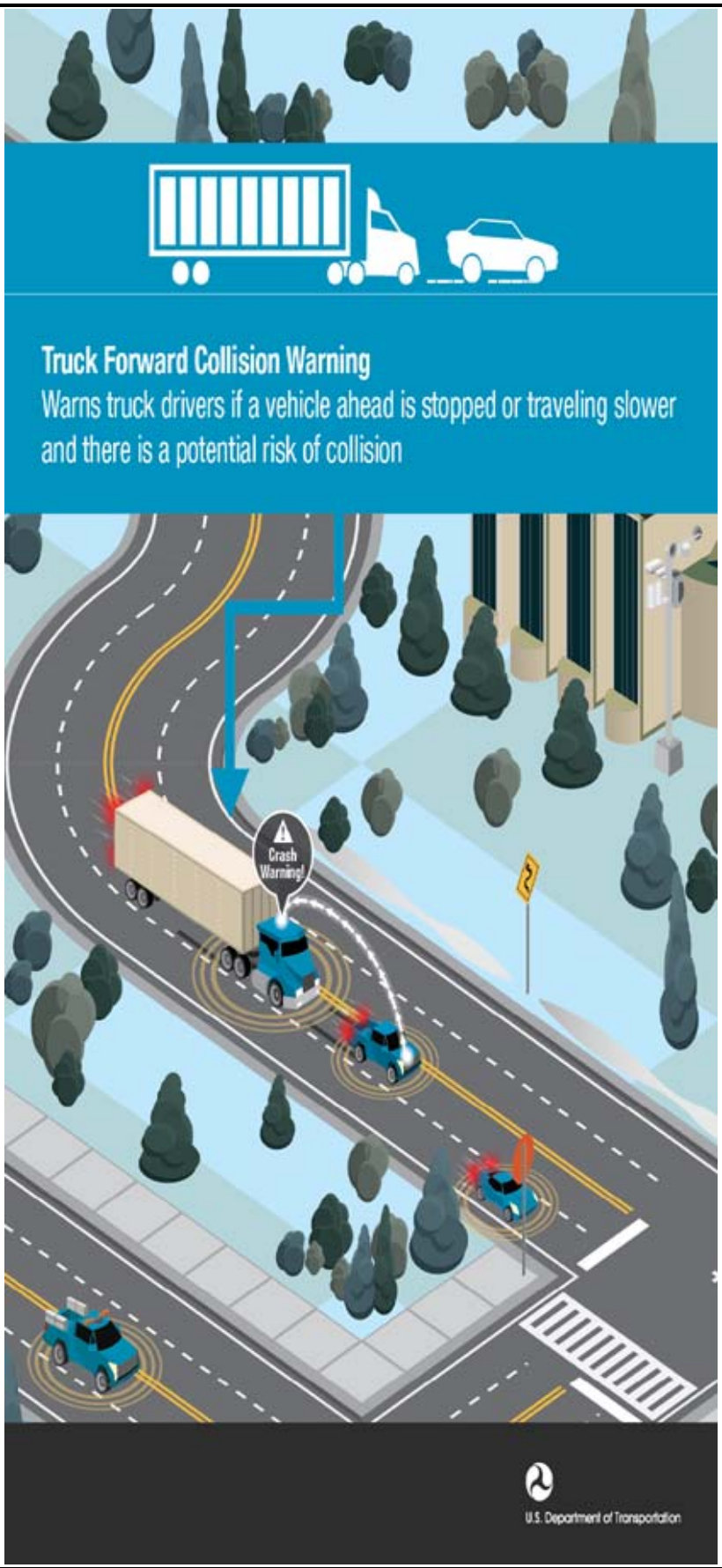
Infographic	

Table 2.12: V2V Safety ‣ Intersection Movement Assist

Title	Intersection Movement Assist (IMA)
CVRIA Reference	Intersection Movement Assist
Description	The IMA application warns the driver when it is not safe to enter an intersection due to high collision probability with other vehicles. IMA has the potential for significant safety benefits and cost savings (26 percent of all crashes occurring in the crash population and 23 percent of comprehensive costs)
Category	Vehicle to Vehicle Safety
ODOT Application Number	--
Benefits/Impact	The main type of crash type addressed by this application is an intersection crossing crash.
Maturity	As currently implemented in research/demonstration situations, the application does not issue a warning under certain circumstances, such as when a vehicle entering an intersection is moving at low speeds. A wider range of testing, especially at higher speeds (representing real-world crash speeds), requires the development of safer protocols that reduce or eliminate the consequences of a crash during testing, such as using remote guided targets as opposed to real vehicles. Various roadway geometries (e.g., cloverleaf, on-ramp, exit ramp) that do not represent a crash-imminent situation can be incorrectly classified as conflict situations by the system.
Interface Requirements	V2V Safety applications need to broadcast the performance of their vehicle in the transportation environment.
Infrastructure Requirements	Map Update System
Vehicle Component Requirements	Vehicle Platform Vehicle On-Board Equipment (OBE)
Applicability	**Priority 3: Leadership by Others, ODOT Monitor**
Physical RSE Installation	None
Roadside Interface to Local	None
Backhaul Communications	None
Backhaul Restrictions	None
Mapping Support	None
Siting Dependency	None
Management of	No

Collected Data	
Back Office Services/Applications	No
Latency	Low
Vehicle Data Connection	Not required
Benefits vs. Deployment Level	Benefits will increase with greater penetration rates.
Other Dependency	None
Data Needs from OBU	None
Data Needs from Infrastructure	None

Infographic	
Other Image	 (Source: http://blog.beachford.com/tag/ford-focus/)

Table 2.13: V2V Safety ‣ Left Turn Assist

Title	Left Turn Assist (LTA)
CVRIA Reference	Intersection Movement Assist
Description	The LTA application will provide information to drivers performing unprotected left turns to judge the gaps in oncoming traffic as well as inform them when other users, such as pedestrians or bicyclists, pose hazards to completing a safe left turn *(Harding et al. 2014)*.
Category	Vehicle to Vehicle Safety
ODOT Application Number	--
Benefits/Impact	LTA is an application that addresses left turn across path/opposite direction crashes that constitutes approximately 7.4 percent of all light vehicle crashes. Recent research suggests that while executing a turn, drivers activate the turn signal about 75 percent of the time. Current performance and test metrics for LTA require turn signal activation to activate the safety application.
Maturity	NHTSA has estimated that LTA would prevent 36 to 62 percent of left turn crashes. LTA is considered to have no impact on mitigating the severity of the left turn crashes that cannot be avoided
Interface Requirements	V2V Safety applications need to broadcast the performance of their vehicle in the transportation environment.
Infrastructure Requirements	Map Update System
Vehicle Component Requirements	Vehicle Platform Vehicle On-Board Equipment (OBE)
Applicability	**Priority 3: Leadership by Others, ODOT Monitor.**
Physical RSE Installation	None
Roadside Interface to Local	None
Backhaul Communications	None
Backhaul Restrictions	None
Mapping Support	None
Siting Dependency	None
Management of Collected Data	No
Back Office Services/Applications	No
Latency	Low

Vehicle Data Connection	Not required
Benefits vs. Deployment Level	Benefits will increase with greater penetration rates.
Other Dependency	None
Data Needs from OBU	None
Data Needs from Infrastructure	None

Infographic	

Table 2.14: V2V Safety ‣ Blind Spot/Lane Change Warning

Title	Blind Spot/Lane Change Warning (BSW/LCW)
CVRIA Reference	Blind Spot Warning + Lane Change Warning
Description	BSW/LCW is an application that provides an advisory alert when another vehicle occupies the adjacent lane in the driver's blind spot. This advisory elevates to a warning when the driver signals an intent to change lanes through the activation of the turn signal. LCW is activated when vehicles are traveling at varying speeds between the host vehicle and remote vehicle to align more closely with the safety need. The application also provides the driver with advisory information that another vehicle in an adjacent lane is positioned in the original vehicle's "blind spot" zone when a lane change is not being attempted.
Category	Vehicle to Vehicle Safety
ODOT Application Number	--
Benefits/Impact	Drivers infrequently use turn signals in lane change near-crash events (<26 percent turn signal use, based upon an unpublished analysis of IVBSS data). This application has the potential to address at least 19 percent of the crashes in the lane change crash group.
Maturity	Different automotive manufacturers have been proposing implementation of this application but NHTSA recommends that the technology is recommended that more indicators of driver intent and vehicle movement be identified in addition to the turn signal should be tested.
Interface Requirements	V2V Safety applications need to broadcast the performance of their vehicle in the transportation environment.
Infrastructure Requirements	Map Update System
Vehicle Component Requirements	Vehicle Platform Vehicle On-Board Equipment (OBE)
Applicability	**Priority 3: Leadership by Others, ODOT Monitor**
Physical RSE Installation	None
Roadside Interface to Local	No
Backhaul Communications	None
Backhaul Restrictions	N/A
Mapping Support	None
Siting Dependency	Not Critical
Management of	No

Collected Data	
Back Office Services/Applications	No
Latency	Low
Vehicle Data Connection	Not Required
Benefits vs. Deployment Level	Benefits will increase with greater penetration
Other Dependency	N/A
Data Needs from OBU	None
Data Needs from Infrastructure	None

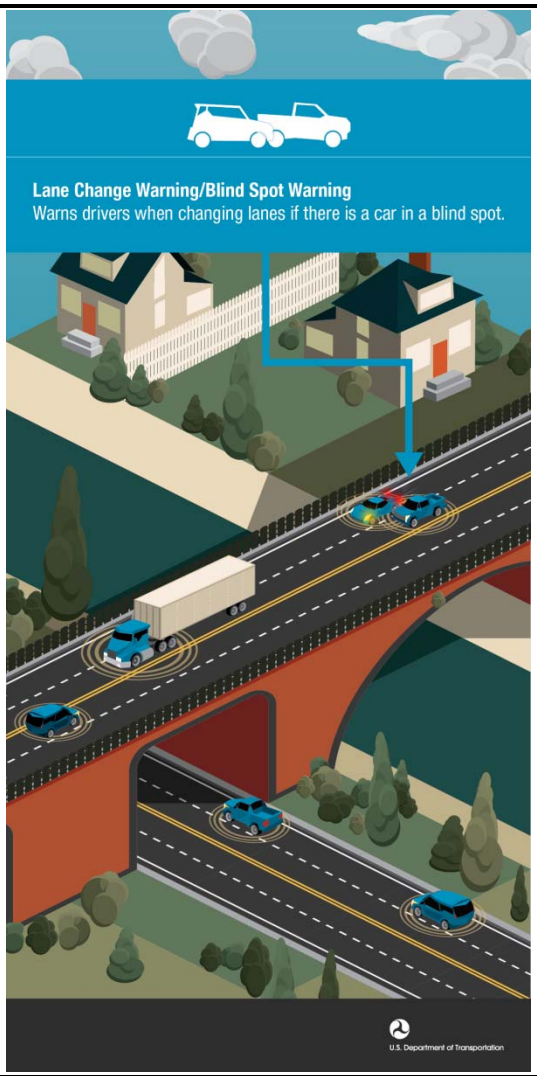
Infographic	
Other Image	 (Source : http://articles.sae.org/4545/)

Table 2.15: V2V Safety ‣ Do Not Pass Warning

Title	Do Not Pass Warning (DNPW)
CVRIA Reference	Do Not Pass Warning
Description	The Do Not Pass Warning (DNPW) application warns the driver during a passing maneuver when a vehicle ahead and in the same lane as the overtaking vehicle cannot be safely passed.
Category	Vehicle to Vehicle Safety
ODOT Application Number	--
Benefits/Impact	The safety application is in reducing the head on crash scenario. Although safety data indicate that the vast majority (approximately 90 percent) of opposite direction crashes occur when a driver unintentionally drifts into a lane with oncoming traffic (as opposed to drivers conducting a passing maneuver) *(Harding et al. 2014)* the collision is nonetheless dangerous.
Maturity	The DNPW application currently has a less robust set of performance and test metrics compared to other V2V safety applications studied. DNPW addresses only a subset of opposite direction crashes because it addresses situations where the driver is intentionally conducting a passing maneuver using the lane of opposing traffic. The current test metrics that are available also do not test the DNPW application's ability to function under a wide variety of roadway conditions.
Interface Requirements	V2V Safety applications need to broadcast the performance of their vehicle in the transportation environment.
Infrastructure Requirements	Map Update System
Vehicle Component Requirements	Vehicle Platform Vehicle On-Board Equipment (OBE), DSRC in the overtaking vehicle and the vehicle travelling in the opposite direction for communication.
Applicability	**Priority 3: Leadership by Others, ODOT Monitor**
Physical RSE Installation	None
Roadside Interface to Local	None
Backhaul Communications	None
Backhaul Restrictions	None
Mapping Support	None
Siting Dependency	None
Management of Collected Data	No

Back Office Services/Applications	No
Latency	Low
Vehicle Data Connection	Not required
Benefits vs. Deployment Level	Benefits will increase with greater penetration rates.
Other Dependency	None
Data Needs from OBU	None
Data Needs from Infrastructure	None

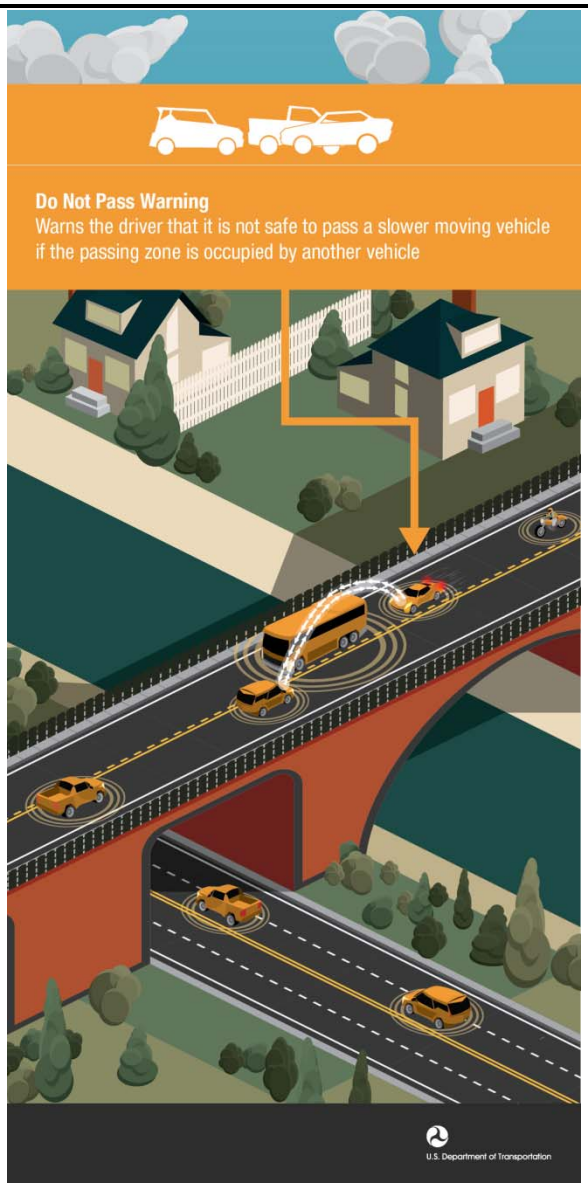
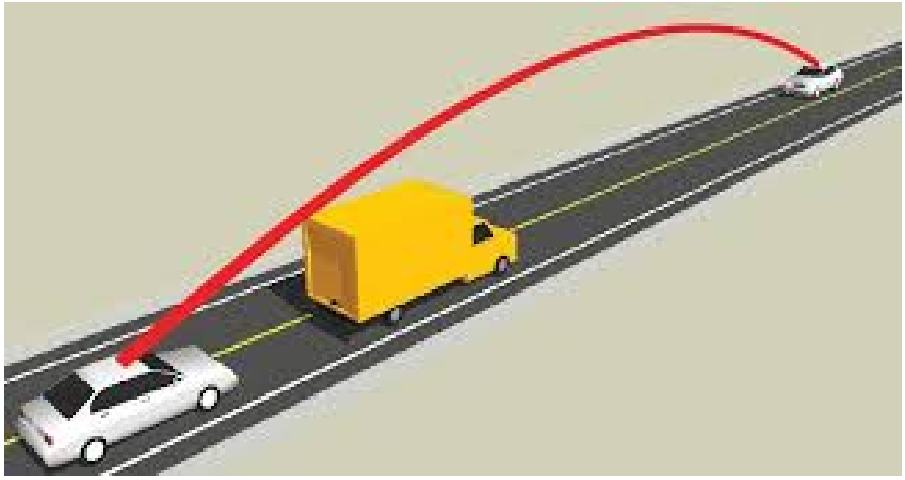
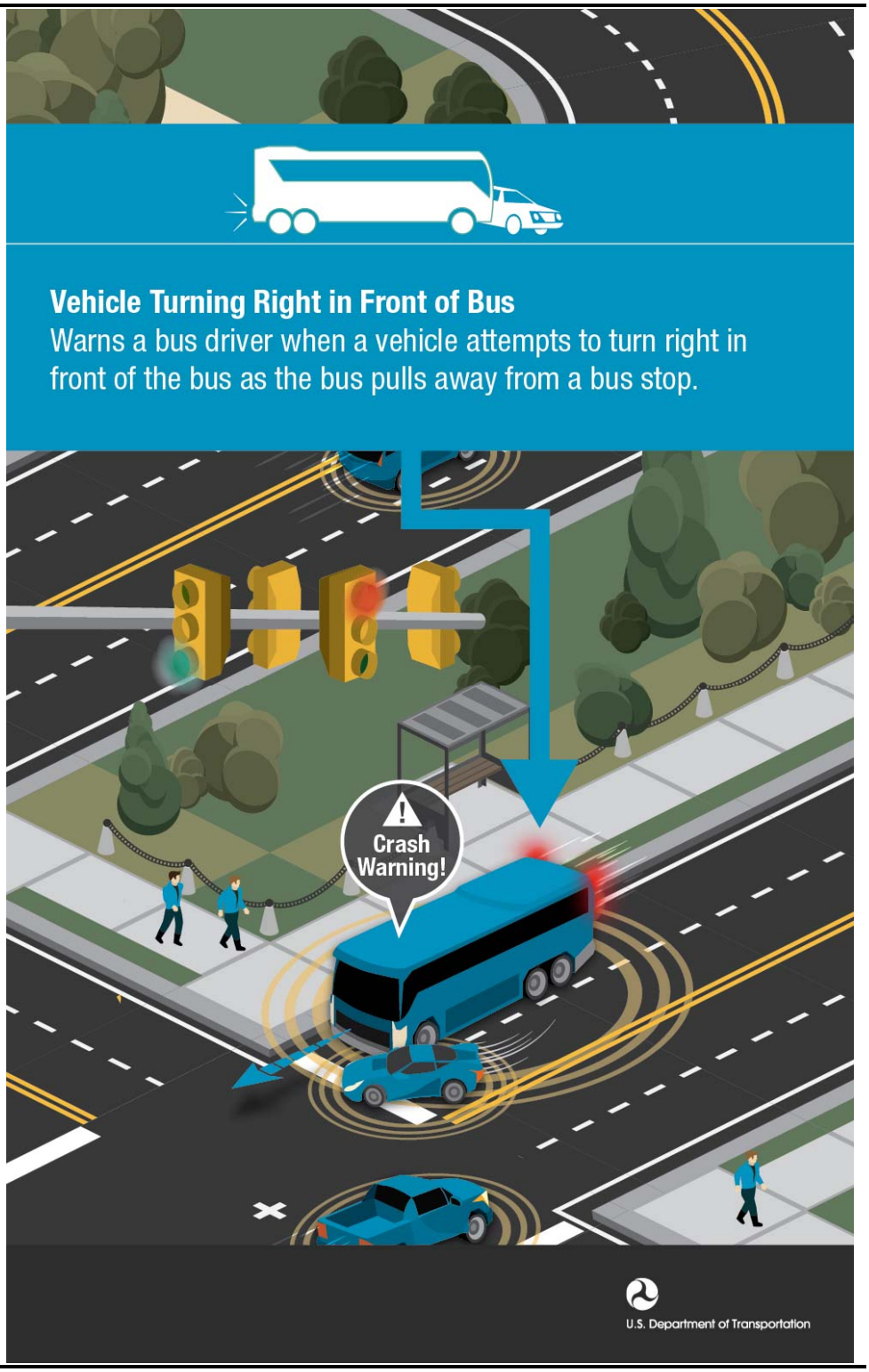
Infographic	
Other Image	 (Source : http://cohdacommunications.com/applications/fieldtrials/fieldtrials.html)

Table 2.16: V2V Safety ‣ Vehicle Turning Right in Front of Bus Warning

Title	Vehicle Turning Right in Front of Bus Warning (TRANSIT)
CVRIA Reference	Vehicle Turning Right in Front of a Transit Vehicle
Description	The TRANSIT application warns a bus operator when another vehicle is passing on the left and turning in front of the bus, either to re-enter the right-hand lane or to complete a right turn in front of the bus, as a bus is departing a bus stop. This situation often occurs when a bus stop is located on the near side of an intersection and the bus is stopped in the right lane at the bus stop loading and unloading passengers. Another vehicle traveling behind the bus (and planning to turn right at the intersection) is unsure of the bus's dwell time. As a result, the other vehicle passes the bus on its left and attempts to make a right turn at the intersection. If the bus is pulling away from the bus stop at the same time the other vehicle is turning, there is a potential for a collision.
Category	Vehicle to Vehicle Safety
ODOT Application Number	--
Benefits/Impact	This application will thwart potential right angle collision between transit vehicles and right turning vehicles especially when the transit stop is at a proximity to an intersection.
Maturity	The technology is mature enough and several implementation architecture scenarios have been put forward.
Interface Requirements	V2V Safety applications need to broadcast the performance of their vehicle in the transportation environment.
Infrastructure Requirements	Map Update System
Vehicle Component Requirements	Vehicle Platform Vehicle On-Board Equipment (OBE)
Applicability	**Priority 3: Leadership by Others, ODOT Monitor**
Physical RSE Installation	None
Roadside Interface to Local	None
Backhaul Communications	None
Backhaul Restrictions	None
Mapping Support	None
Siting Dependency	None
Management of Collected Data	No

Back Office Services/Applications	No
Latency	Low
Vehicle Data Connection	Not required
Benefits vs. Deployment Level	Benefits will increase with greater penetration rates.
Other Dependency	None
Data Needs from OBU	None
Data Needs from Infrastructure	None

Infographic	

2.3 AGENCY DATA APPLICATIONS

Table 2.17: Agency Data ‣ Probe-Based Pavement Maintenance

Title	Probe-Based Pavement Maintenance (PDPM)
CVRIA Reference	--
Description	• PDPM Users: include the organizations, agencies, and individuals that are necessary for installing, maintaining, operating, and interacting with a functioning PDPM system. • Automobile original equipment manufacturer (OEMs): responsible for original equipment, and for vehicle-related equipment and software actions necessary to establish and maintain the in-vehicle PDPM system. Automobile OEMs may incorporate their role into existing organizational structures. There are additional roles that they will assume to help ensure that PDPM remains in operation over the long-term. • State and Local DOTs: responsible for applying the reported information to pavement management programs. State and local DOTs have the primary role as end users of pavement quality data. They may process raw data themselves if collected via DSRC-based, or they may purchase data from Data Providers. This includes maintain the equipment for reliable operation (when used), installation of backend connectivity from roadside equipment to Data Centers, and participation in standards development activities. • FHWA responsible for developing high level guidance to state and local agencies in the deployment and operation of PDPM systems *(Dawkins and Powell 2011).*
Category	Agency Data Applications
ODOT Application Number	**ODOT 19.**
Benefits/Impact	There are also potential positive long-term secondary and tertiary benefits which accompany the implementation of such a probe-vehicle system. One such benefit is serving as a proof of concept for secondary applications of the connected vehicle program, adding value to the ITS program and maximizing return on USDOT's research funds and efforts. A well-planned and executed roughness data collection system can also serve as a proof-of-concept for other types of data-gathering systems; for example, an attempt to gather data on the effect of weather on vehicle dynamics or driver behavior.
Maturity	The application is mature and implementation ready.
Interface Requirements	Probe vehicles, accelerometers, data server
Infrastructure	Infrastructure data interface

Requirements	
Vehicle Component Requirements	Vehicle on–board equipment
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Portable or Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	None
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Not Required
Benefits vs. Deployment Level	Benefits Require Threshold Deployment Level
Other Dependency	None
Data Needs from OBU	Position
Data Needs from Infrastructure	None

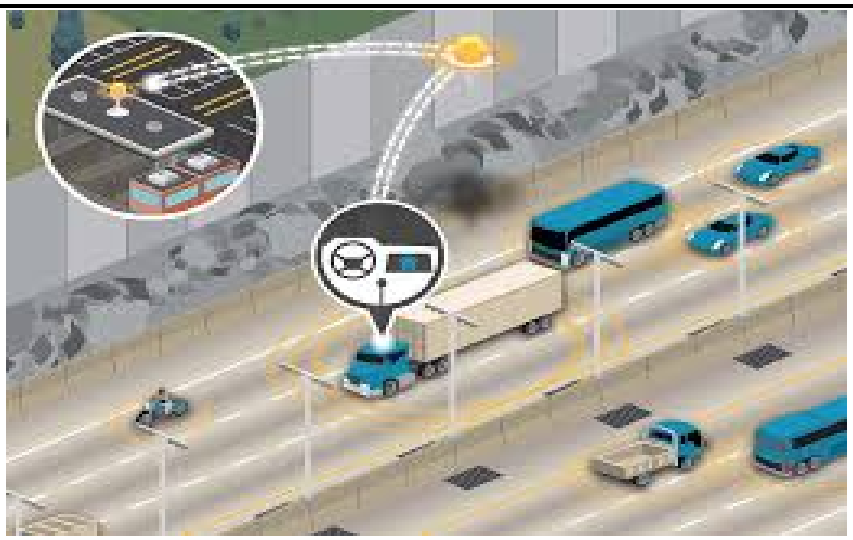
Infographic	 (Source: http://www.its.dot.gov/pilots/pdf/Pilot_%20I876.pdf)

Table 2.18: Agency Data ‣ Probe-Based Pavement Maintenance

Title	Probe-Based Pavement Maintenance (PDPM)
CVRIA Reference	--
Description	• PDPM Users: include the organizations, agencies, and individuals that are necessary for installing, maintaining, operating, and interacting with a functioning PDPM system. • Automobile original equipment manufacturer (OEMs): responsible for original equipment, and for vehicle-related equipment and software actions necessary to establish and maintain the in-vehicle PDPM system. Automobile OEMs may incorporate their role into existing organizational structures. There are additional roles that they will assume to help ensure that PDPM remains in operation over the long-term. • State and Local DOTs: responsible for applying the reported information to pavement management programs. State and local DOTs have the primary role as end users of pavement quality data. They may process raw data themselves if collected via DSRC-based, or they may purchase data from Data Providers. This includes maintain the equipment for reliable operation (when used), installation of backend connectivity from roadside equipment to Data Centers, and participation in standards development activities. • FHWA responsible for developing high level guidance to state and local agencies in the deployment and operation of PDPM systems *(Dawkins and Powell 2011).*
Category	Agency Data Applications
ODOT Application Number	**ODOT 19.**
Benefits/Impact	There are also potential positive long-term secondary and tertiary benefits which accompany the implementation of such a probe-vehicle system. One such benefit is serving as a proof of concept for secondary applications of the connected vehicle program, adding value to the ITS program and maximizing return on USDOT's research funds and efforts. A well-planned and executed roughness data collection system can also serve as a proof-of-concept for other types of data-gathering systems; for example, an attempt to gather data on the effect of weather on vehicle dynamics or driver behavior.
Maturity	The application is mature and implementation ready.
Interface Requirements	Probe vehicles, accelerometers, data server
Infrastructure Requirements	Infrastructure data interface

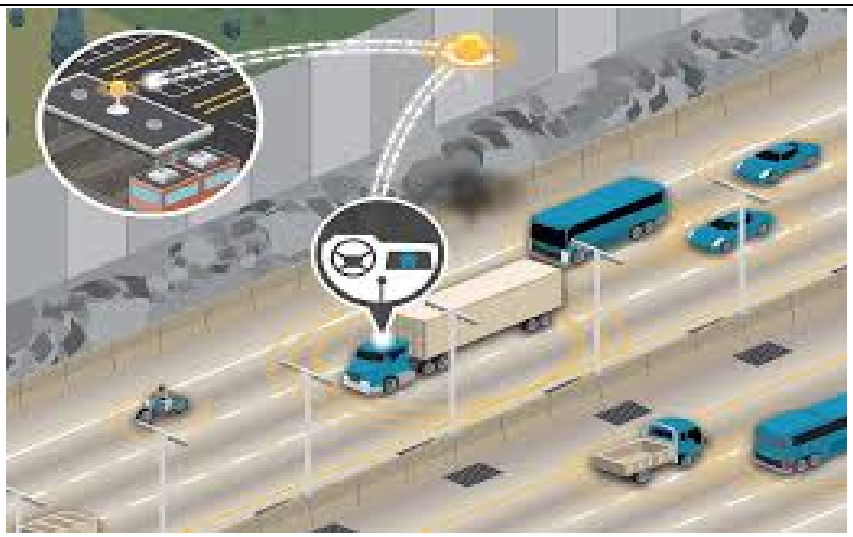
Vehicle Component Requirements	Vehicle on–board equipment
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Portable or Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	None
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Not Required
Benefits vs. Deployment Level	Benefits Require Threshold Deployment Level
Other Dependency	None
Data Needs from OBU	Position
Data Needs from Infrastructure	None
Infographic	 (Source: http://www.its.dot.gov/pilots/pdf/Pilot_%20I876.pdf)

Table 2.19: Agency Data ‣ Probe-Enabled Traffic Monitoring

Title	Probe-Enabled Traffic Monitoring
CVRIA Reference	Vehicle Data for Traffic Operations
Description	Real time traffic data supplied by connected vehicles. This application is a network traffic monitoring technology has been designed to be embedded within a switch or router. It provides the ability to continuously monitor application level traffic flows at wire speed on all ports simultaneously.
Category	Agency Data Applications
ODOT Application Number	ODOT 20.
Benefits/Impact	Agencies can save substantial resources devoted to real time data collection for traffic management.
Maturity	There are multiple companies that have constructed and provide probes that are in use today and it is ready to be implemented.
Interface Requirements	None
Infrastructure Requirements	Infrastructure data interface
Vehicle Component Requirements	Vehicle application and interface
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Portable or Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Not Required

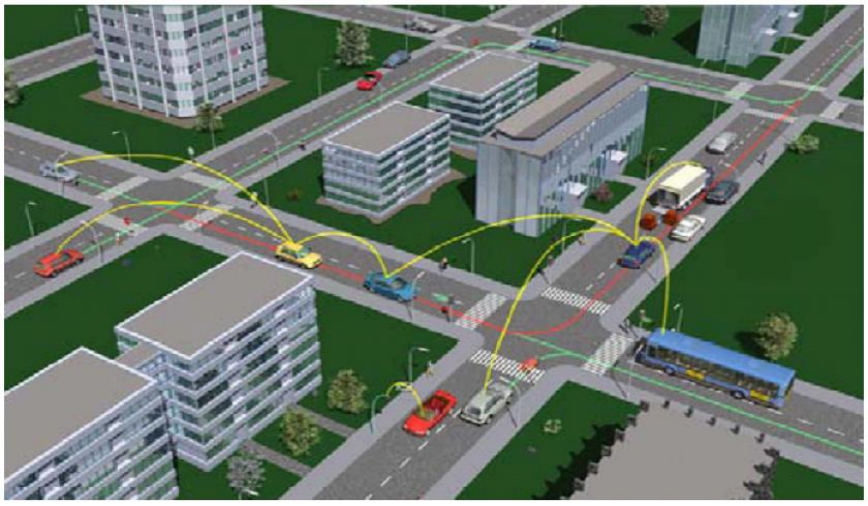
Benefits vs. Deployment Level	Benefits Require Threshold Deployment Level
Other Dependency	None
Data Needs from OBU	Position
Data Needs from Infrastructure	None
Infographic	 (Source: http://www3.imperial.ac.uk/pervasivesensing/projects/trafficmonitoring)

Table 2.20: Agency Data ‣ Vehicle Classification-Based Traffic Studies

Title	Vehicle Classification-Based Traffic Studies
CVRIA Reference	--
Description	Ability to associate vehicle type with vehicle behaviors.
Category	Agency Data Applications
ODOT Application Number	--
Benefits/Impact	Counting vehicles over a period of time on a busy intersection will help the concerned authority to efficiently control the duration of traffic signal on road thus reducing the level of traffic congestion during rush hours. It helps in minimizing the possibilities of fraudulent activities in toll collection. It is necessary to provide better traffic surveillance to reduce crashes.
Maturity	This has only been proven conceptually by academia. There is no technology, device, or program that has been created yet.
Interface Requirements	None
Infrastructure Requirements	Infrastructure data interface
Vehicle Component Requirements	Vehicle application and interface
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others**
Physical RSE Installation	Portable or Fixed
Roadside Interface to Local	No
Backhaul Communications	Optional
Backhaul Restrictions	Exclusive
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	No
Latency	High
Vehicle Data Connection	Not Required

Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	Privacy
Data Needs from OBU	BSM1+2
Data Needs from Infrastructure	None
Infographic	 (Source: http://www.kritikalsolutions.com/products/traffic-analyzer.html)

Table 2.21: Agency Data ‣ CV-Enabled Performance Measures

Title	AASHTO: CV-Enabled Performance Measures
CVRIA Reference	Performance Monitoring and Planning
Description	Since MAP-21, USDOT has been establishing performance measures for various components of the transportation system. These rules require state DOTs, MPOs and other stakeholders to implement systems and new processes, and to regularly report results as a requirement for eligibility to certain Federal-aid funding. Connected vehicle technology deployments can facilitate operational improvements in both gathering operations data and providing data back to maintenance personnel. Data gathering is improved by using vehicles as probes across an agency's region of operations—not just at fixed observing stations. Probe vehicles can gather data consistently across the entire road network at finer resolutions at any time the vehicles are in use. Operations and maintenance are improved by providing dynamic real-time information and plans (based on combining the probe data with other sources) to maintenance personnel. Connected vehicle technologies similarly have the potential to generate data that can support the gathering, calculation, and reporting of performance measures under MAP-21 and future USDOT rules. The net of these opportunities is that agency internal operations and maintenance costs could be reduced through connected vehicle capabilities.
Category	Agency Data Applications
ODOT Application Number	**ODOT 21.**
Benefits/Impact	More accurate data provided in a more timely fashion to agency staff would enable them to make smarter decisions about their operations, and to satisfy Federal performance management reporting requirements. Material costs of road treatment, for example, could be reduced if road conditions are more accurately known when routing and treatment plans are being set. Better information and planning ultimately also leads to safer conditions for both agency personnel and for the traveling public.
Maturity	CV deployments have generated probe data, which is similar to other probe-based data collection systems. While there is no operational system taking advantage of connected vehicles for performance measures yet, the technology is ripe for deployment.
Interface Requirements	None
Infrastructure Requirements	Infrastructure data interface
Vehicle Component Requirements	Vehicle application and interface
Applicability	**Priority 1: Near Term Focus for ODOT**

Physical RSE Installation	Portable or Fixed
Roadside Interface to Local	No
Backhaul Communications	Optional
Backhaul Restrictions	Exclusive
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	No
Latency	High
Vehicle Data Connection	Not Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	BSM1
Data Needs from Infrastructure	None
Infographic	None

Table 2.22: Agency Data ‣ CV-Enabled Turning Movement & Intersection Analysis

Title	CV-Enabled Turning Movement & Intersection Analysis
CVRIA Reference	Vehicle Data for Traffic Operations
Description	Use self-reported paths of vehicles to determine turning ratios, delays by maneuver and other characterizations of an intersection. Not intended for real time optimization of traffic flows. No data provided to vehicles.
Category	Agency Data Applications
ODOT Application Number	--
Benefits/Impact	This will help guide users to a less congested and reduced crash rate route. This will also help drive down emission and user stress.
Maturity	This has only been proven conceptually by academia. There is not enough data that has been gathered to create a program or technology yet.
Interface Requirements	None
Infrastructure Requirements	Infrastructure data interface
Vehicle Component Requirements	Vehicle application and interface
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others**
Physical RSE Installation	Portable or Fixed
Roadside Interface to Local	No
Backhaul Communications	Optional
Backhaul Restrictions	Exclusive
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	No
Latency	High
Vehicle Data Connection	Not Required

Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	BSM1
Data Needs from Infrastructure	None
Infographic	None

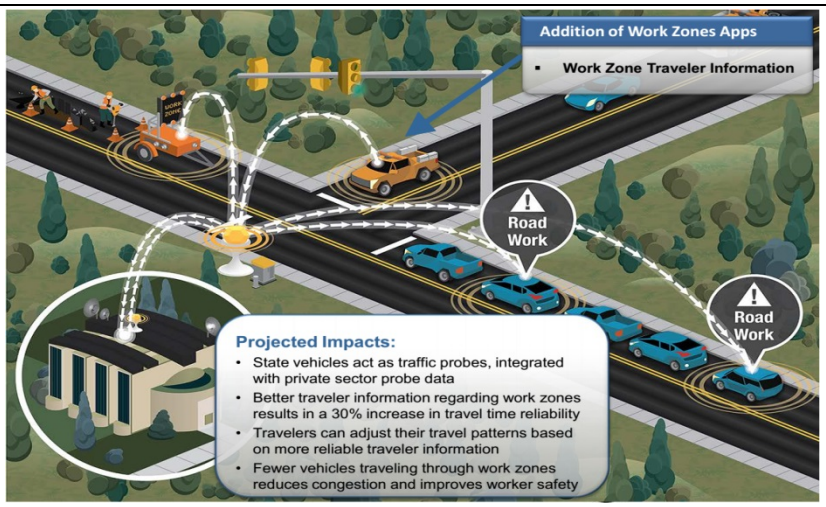
Table 2.23: Agency Data ‣ CV-Enabled Origin-Destination Studies

Title	CV-Enabled Origin-Destination Studies
CVRIA Reference	Performance Monitoring and Planning
Description	Obtain a general location near a vehicle's start and end of trip, provides path in between, or when the vehicle passes certain locations (freeway on ramps and off ramps).
Category	Agency Data Applications
ODOT Application Number	--
Benefits/Impact	This will help guide users to a less congested and reduced crash rate route. This will also help drive down emission and user stress.
Maturity	This has only been proven conceptually by academia. There is not enough data that has been gathered to create a program or technology yet.
Interface Requirements	None
Infrastructure Requirements	Infrastructure data interface
Vehicle Component Requirements	Vehicle application and interface
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others**
Physical RSE Installation	Portable or Fixed
Roadside Interface to Local	No
Backhaul Communications	Optional
Backhaul Restrictions	Exclusive
Mapping Support	None
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	No
Latency	High
Vehicle Data Connection	Required

Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	Privacy
Data Needs from OBU	BSM1
Data Needs from Infrastructure	None
Infographic	None

Table 2.24: Agency Data ‣ Work Zone Traveler Information

Title	Work Zone Traveler Information
CVRIA Reference	Warning about Upcoming Work Zone Warnings about Hazards in a Work Zone
Description	The intention of using this technology is to inform the road user of upcoming work zones in order to prevent rear-end crashes. Motorists could from this information for avoiding lane changes or traffic queues by changing their travel route.
Category	Agency Data Applications
ODOT Application Number	**ODOT 22.**
Benefits/Impact	This system helps in improving safety and vehicles mobility through the work zones in addition to provide accurate information that can increase motorists' satisfaction.
Maturity	Work Zone Traveler Information Technology without connectivity is already being used in industry.
Interface Requirements	Back office interface, infrastructure data interface, roadside interface, driver-vehicle interface, vehicle systems interface, infrastructure communications interface, vehicle application and interface.
Infrastructure Requirements	None
Vehicle Component Requirements	None
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Portable or Fixed
Roadside Interface to Local	No
Backhaul Communications	Optional
Backhaul Restrictions	Exclusive
Mapping Support	None
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	No
Latency	High
Vehicle Data Connection	Required

Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	Privacy
Data Needs from OBU	BSM1
Data Needs from Infrastructure	None
Infographic	 (Source: http://www.its.dot.gov/pilots/pdf/Pilot_District13.pdf)

2.4 ENVIRONMENT APPLICATION – APPLICATIONS FOR THE ENVIRONMENT: REAL-TIME INFORMATION SYNTHESIS (AERIS)

Table 2.25: Environment ‣ Eco-Approach and Departure at Signalized Intersections

Title	Eco-Approach and Departure at Signalized Intersections
CVRIA Reference	Eco-Approach and Departure at Signalized Intersections
Description	Wirelessly transmitted data from Roadside equipment (RSE) enable connected vehicles to adopt efficient deceleration approaches to intersections. This vehicle-based technology uses GIS data and signal phase and timing (SPaT) data using V2I networks. V2V data would also be collected to enable lane-changing vehicle automation.
Category	AERIS
ODOT Application Number	--
Benefits/Impact	5 to 10% fuel consumption reduction for uncoordinated corridors. 13% fuel consumption reduction for coordinated corridors, of which 8% is due to signal coordination and 5% is due to the application
Maturity	Well researched and considered in the AERIS operational scenario.
Interface	Archive the data collected for comparison to past and current operations

Requirements	
Infrastructure Requirements	Coordination of signals along corridor Disseminate data that improves the traffic signal system to end users
Vehicle Component Requirements	Connected vehicles capable of V2I and V2V communication Roadside equipment for I2V communication
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others**
Physical RSE Installation	Fixed
Roadside Interface to Local	Yes
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	Localized Geometric
Siting Dependency	Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	Medium
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	BSM1+2
Data Needs from Infrastructure	SPaT+GIDs

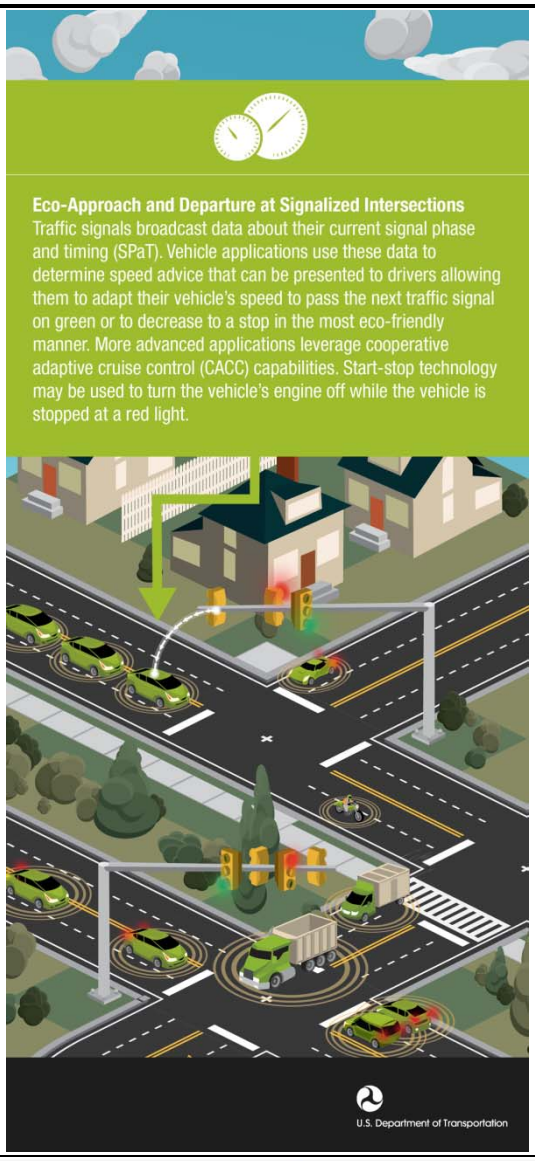
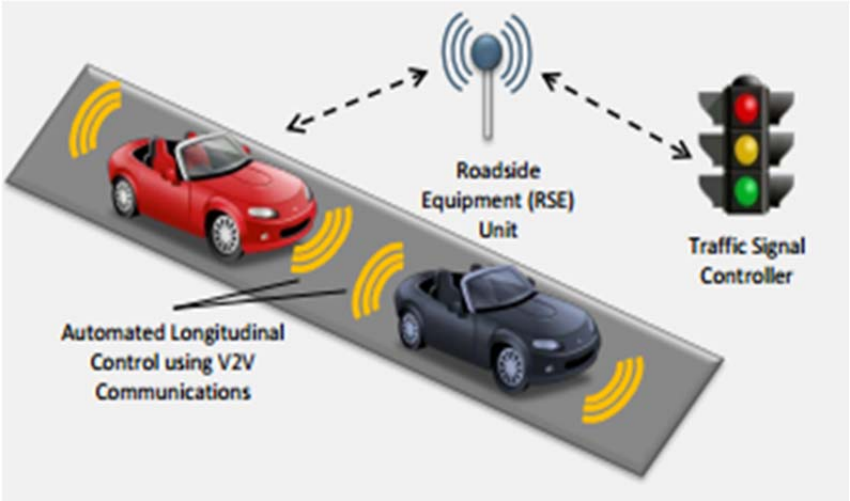
Infographic	
Other Image	 (Source: http://www.its.dot.gov/aeris/pdf/2014_AERIS_WorkshopReadAheadFINAL.pdf)

Table 2.26: Environment ‣ Eco-Traffic Signal Timing

Title	Eco-Traffic Signal Timing
CVRIA Reference	Eco-Traffic Signal Timing
Description	Wirelessly transmitted data from Roadside equipment (RSE) enable connected vehicles to adopt efficient deceleration approaches to intersections. This vehicle-based technology uses GIS data and signal phase and timing (SPaT) data using V2I networks. V2V data would also be collected to enable lane-changing vehicle automation.
Category	AERIS
ODOT Application Number	--
Benefits/Impact	1% to 5% fuel consumption reduction with partial to total vehicle fleet penetration.
Maturity	Well researched and considered in the AERIS operational scenario.
Interface Requirements	None
Infrastructure Requirements	Roadside equipment for V2I communication
Vehicle Component Requirements	Connected cars capable of V2I and V2V communication
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others**
Physical RSE Installation	Fixed
Roadside Interface to Local	Optional
Backhaul Communications	Optional
Backhaul Restrictions	Exclusive
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	No
Back Office Services/Applications	Yes
Latency	Medium
Vehicle Data Connection	Required

Benefits vs. Deployment Level	Benefits Require Threshold Deployment Level
Other Dependency	None
Data Needs from OBU	BSM1+other
Data Needs from Infrastructure	SPaT

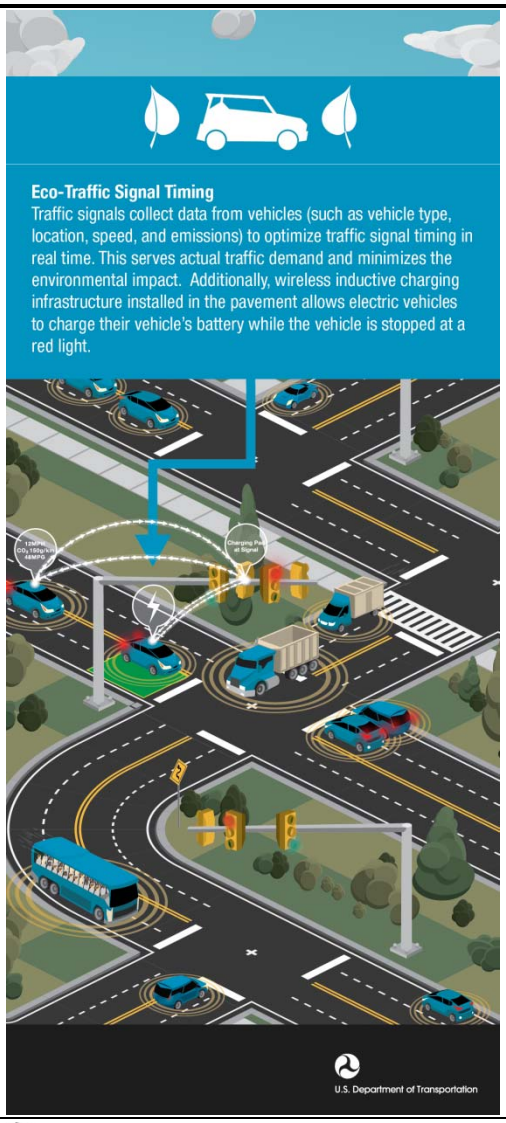
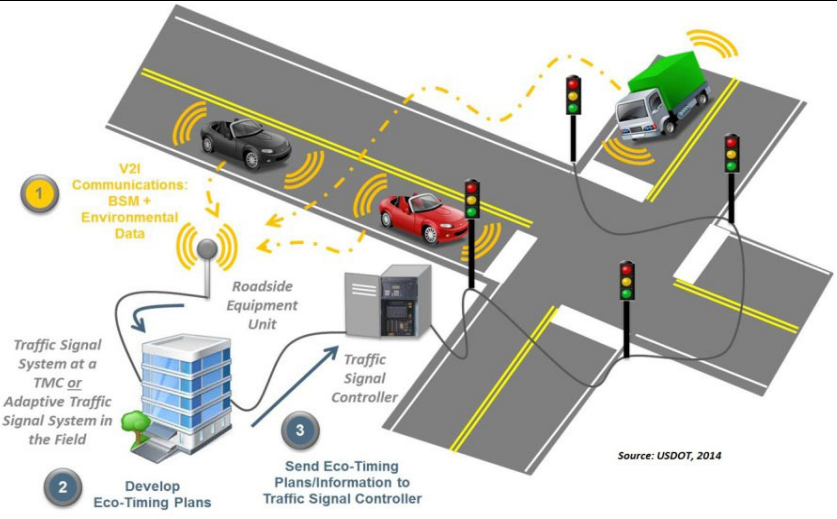
Infographic	
Other Image	 (Source http://www.itsknowledgeresources.its.dot.gov/its/bcllupdate/ArterialTrafficContro

Table 2.27: Environment ‣ Eco-Traffic Signal Priority

Title	Eco-Traffic Signal Priority
CVRIA Reference	Eco-Traffic Signal Priority
Description	Transit and freight vehicles may request signal priority depending on their location, speed, vehicle type, and emissions. For transit vehicles this information might include number of passengers and schedule adherence.
Category	AERIS
ODOT Application Number	--
Benefits/Impact	2% fuel consumption reduction for transit vehicles. 4% fuel consumption reduction for freight vehicles.
Maturity	The application was Concept Pilot deployment under consideration by USDOT in the near future.
Interface Requirements	None
Infrastructure Requirements	Roadside equipment for V2I communication
Vehicle Component Requirements	Connected cars capable of V2I and V2V communication
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others**
Physical RSE Installation	Fixed
Roadside Interface to Local	Yes
Backhaul Communications	Optional
Backhaul Restrictions	Exclusive
Mapping Support	Localized Geometric
Siting Dependency	Non-Critical
Management of Collected Data	No
Back Office Services/Applications	No
Latency	Medium
Vehicle Data Connection	Required

Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	BSM1+other
Data Needs from Infrastructure	App-specific

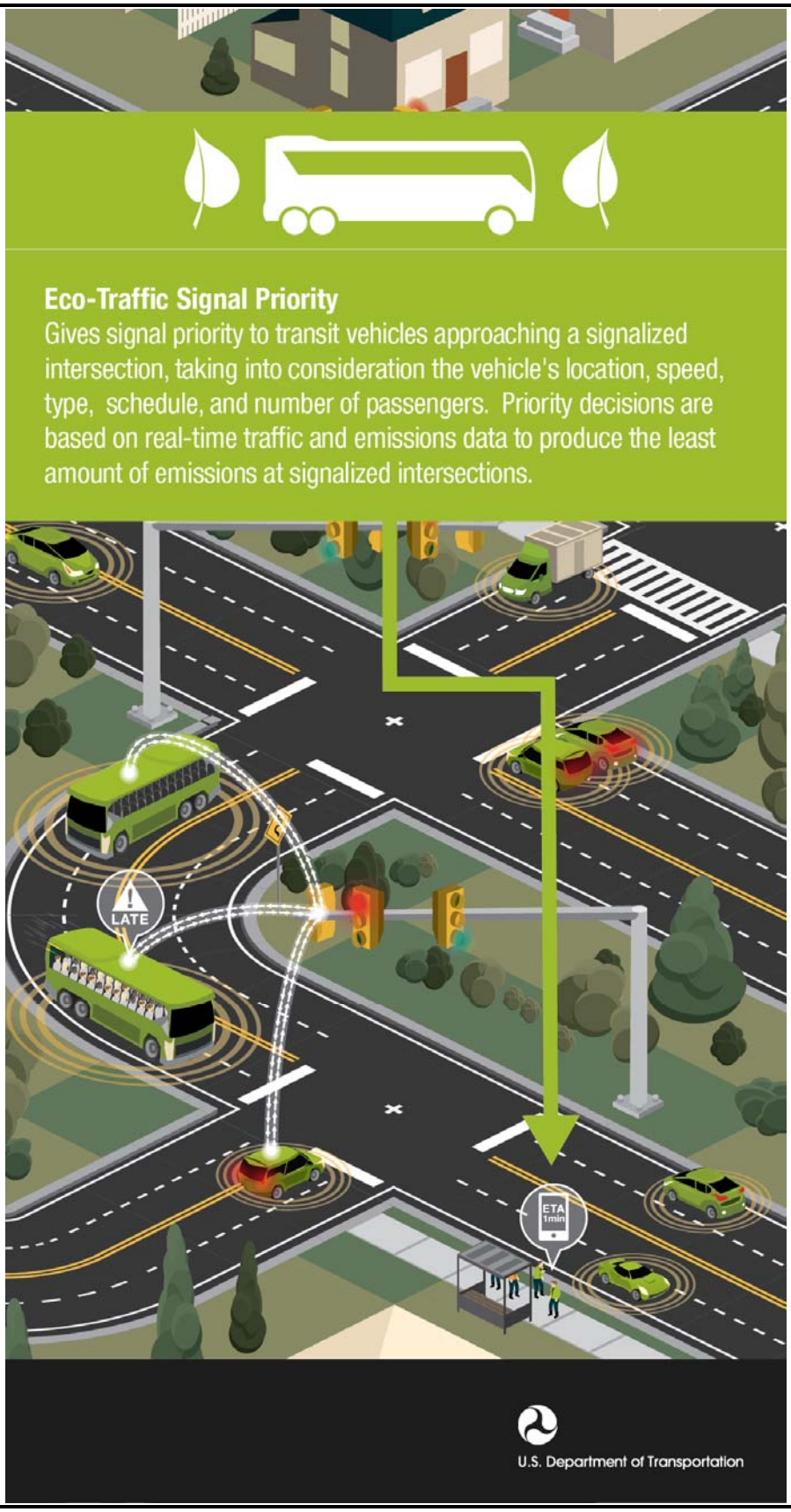
Infographic	

Table 2.28: Environment ‣ Connected Eco-Driving

Title	Connected Eco-Driving
CVRIA Reference	Connected Eco-Driving
Description	Application supplies real-time driver guidance in order to improve driving to save fuel and emissions including optimal speed, acceleration, and deceleration. The application may be enabled to adjust driving according to most efficient driving strategy.
Category	AERIS
ODOT Application Number	--
Benefits/Impact	2% fuel consumption reduction with total vehicle fleet penetration.
Maturity	Well researched and considered in the AERIS operational scenario
Interface Requirements	None
Infrastructure Requirements	Roadside equipment for V2I communication
Vehicle Component Requirements	Connected cars capable of V2I and V2V communication
Applicability	**Priority 3: Leadership by Others, ODOT Monitor**
Physical RSE Installation	Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	Privacy

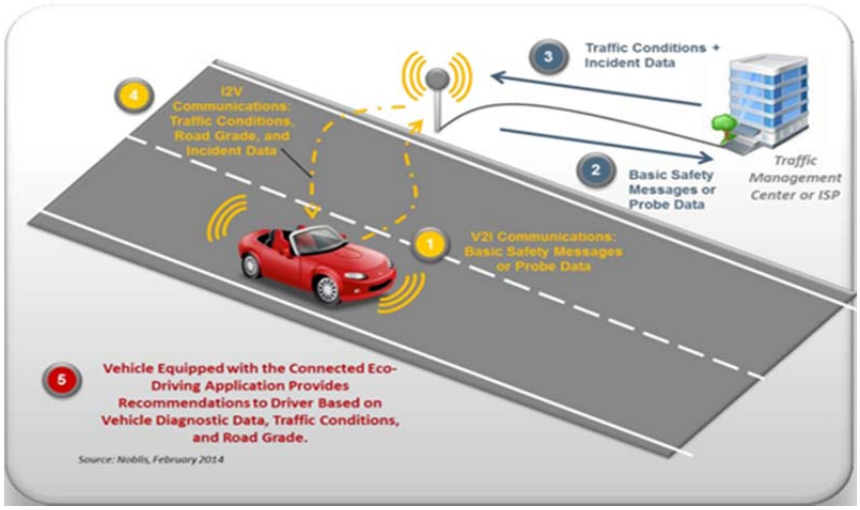
Data Needs from OBU	BSM1+other
Data Needs from Infrastructure	TI
Infographic	 (Source: http://www.its.dot.gov/aeris/pdf/Eco-Signal_Operations_Combined_Modeling_webinar_final_062414.pdf)

Table 2.29: Environment ‣ Wireless Inductive/Resonance Charging

Title	Wireless Inductive/Resonance Charging
CVRIA Reference	--
Description	Magnetic fields generated from inlaid charging infrastructure along roadways recharge electric vehicles at standstills such as traffic signals or linear along highways for recharging moving vehicles.
Category	AERIS
ODOT Application Number	--
Benefits/Impact	Benefits related to emission and fuel efficiency are expected.
Maturity	Dynamic wireless charging is not yet commercialized and technical standards will be available in the next 1-2 years.
Interface Requirements	None
Infrastructure Requirements	Roadway charging infrastructure and on-vehicle electricity collection system
Vehicle Component Requirements	Connected electric vehicles which can use V2I systems to tender electric charge transaction
Applicability	**Priority 3: Leadership by Others, ODOT Monitor**
Physical RSE Installation	--
Roadside Interface to Local	--
Backhaul Communications	--
Backhaul Restrictions	--
Mapping Support	--
Siting Dependency	--
Management of Collected Data	--
Back Office Services/Applications	--
Latency	--
Vehicle Data Connection	--
Benefits vs. Deployment Level	--
Other Dependency	--

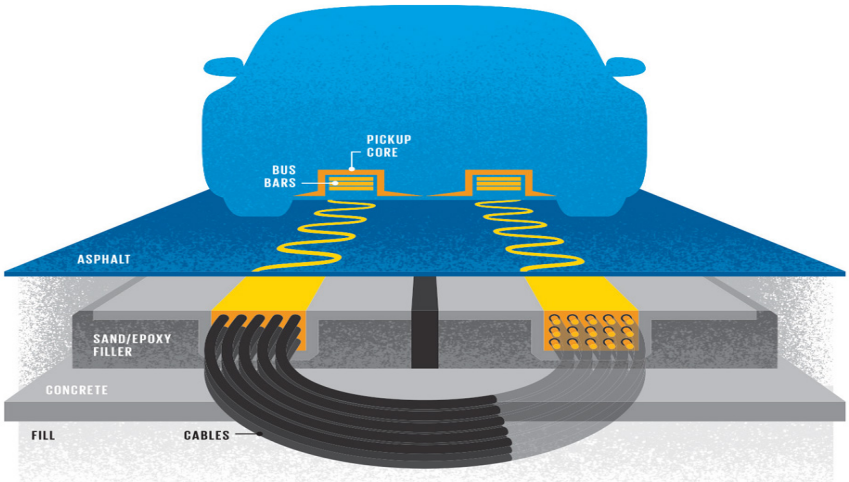
Data Needs from OBU	--
Data Needs from Infrastructure	--
Infographic	 (Source: http://insideevs.com/are-plugless-electric-vehicles-the-future-of-transportation/)

Table 2.30: Environment ‣ Eco-Lanes Management

Title	Eco-Lanes Management
CVRIA Reference	Eco-Lanes Management
Description	Geo-fenced lane only permits vehicles with certain characteristics enter and controls speed and driving characteristics to optimize traffic flow and emissions. Similar to existing managed lanes but optimized for the environment.
Category	AERIS (http://www.its.dot.gov/aeris/pdf/Eco-LanesConOps021814.pdf)
ODOT Application Number	--
Benefits/Impact	Fuel saving and emission reduction are expected due to optimize traffic flow.
Maturity	Well researched and considered in the AERIS operational scenario *(U.S. DOT ITS JPO 2013).*
Interface Requirements	None
Infrastructure Requirements	Roadway charging infrastructure and on-vehicle electricity collection system
Vehicle Component Requirements	Connected electric vehicles which can use V2I systems to tender electric charge transaction
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others**
Physical RSE Installation	Fixed
Roadside Interface to Local	Optional
Backhaul Communications	Required
Backhaul Restrictions	Limited domains
Mapping Support	Localized geometric
Siting Dependency	Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	Low
Vehicle Data Connection	Not required

Benefits vs. Deployment Level	Benefits realizable day one
Other Dependency	Privacy
Data Needs from OBU	BSM1+other
Data Needs from Infrastructure	App-specific
Infographic	 (Source: USDOT 2014)

Table 2.31: Environment ‣ Eco-Speed Harmonization

Title	Eco-Speed Harmonization
CVRIA Reference	Eco-Speed Harmonization
Description	This application adjusts speed limits according to weather, traffic and emissions conditions. By changing speed on approaches to congestion, the application aims to reduce start/stopping.
Category	AERIS
ODOT Application Number	--
Benefits/Impact	Detection equipment for Green House Gases, pollutants Databases with algorithms for emission limits and variable speed limit adjustment V2V and V2I communication
Maturity	Well researched and considered in the AERIS operational scenario
Interface Requirements	None
Infrastructure Requirements	Roadway charging infrastructure and on-vehicle electricity collection system
Vehicle Component Requirements	Connected electric vehicles which can use V2I systems to tender electric charge transaction
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others**
Physical RSE Installation	Fixed
Roadside Interface to Local	No
Backhaul Communications	Optional
Backhaul Restrictions	Exclusive
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	No
Back Office Services/Applications	Optional
Latency	High
Vehicle Data Connection	Required

Benefits vs. Deployment Level	Benefits Require Threshold Deployment Level
Other Dependency	None
Data Needs from OBU	BSM1
Data Needs from Infrastructure	App-specific
Infographic	None

Table 2.32: Environment ‣ Eco-Cooperative Adaptive Cruise Control

Title	Eco-Cooperative Adaptive Cruise Control
CVRIA Reference	Eco-Cooperative Adaptive Cruise Control
Description	This application includes longitudinal vehicle automation to optimize eco-driving. In addition to radar and LIDAR measurements of preceding vehicle speed, roadway grade and geometry, acceleration/deceleration and weather information is transmitted between vehicles and used to optimize safety and fuel consumption.
Category	AERIS
ODOT Application Number	--
Benefits/Impact	10% to 15% fuel savings on freeway corridors. Up to 42% travel time savings. Combination with dedicated “eco-lane” significantly increases capacity
Maturity	Well researched and considered in the AERIS operational scenario
Interface Requirements	V2V communication
Infrastructure Requirements	None
Vehicle Component Requirements	High proportion of connected vehicles in fleet
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others**
Physical RSE Installation	Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	Lane Level
Siting Dependency	Non-critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	Low
Vehicle Data Connection	Not Required

Benefits vs. Deployment Level	Benefits require threshold deployment level
Other Dependency	None
Data Needs from OBU	BSM1
Data Needs from Infrastructure	App-specific
Infographic	None

Table 2.33: Environment ‣ Eco-Traveler Information

Title	Eco-Traveler Information
CVRIA Reference	Eco-Multimodal Real-Time Traveler Information
Description	Application notifies vehicles of travel time and fuel savings of Eco-Lanes and regular lanes, traffic, crashes, wireless charging availability, vehicle platooning rules and parameters, transit options, parking information, etc.
Category	AERIS
ODOT Application Number	--
Benefits/Impact	Fuel saving and emission reduction are expected due to and advanced warning or information meant to optimize traffic flow.
Maturity	Well researched and considered in the AERIS operational scenario
Interface Requirements	Transportation authority maintained information portals, V2I communication
Infrastructure Requirements	None
Vehicle Component Requirements	None
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	No
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Realizable Day one
Other Dependency	None

Data Needs from OBU	BSM1
Data Needs from Infrastructure	TI
Infographic	None

Table 2.34: Environment ‣ Eco-Ramp Metering

Title	Eco-Ramp Metering
CVRIA Reference	Eco-Ramp Metering
Description	This application monitors the rate of vehicles entering freeways to improve environmental efficiency of freeways and rate of entering vehicles.
Category	AERIS
ODOT Application Number	--
Benefits/Impact	Fuel saving and emission reduction are expected due to and advanced warning or information meant to optimize traffic flow.
Maturity	The technology for this application is already in use in the form of ramp-metering
Interface Requirements	Back office interface, infrastructure data interface, roadside interface, weather service.
Infrastructure Requirements	Roadside equipment (RSE), management centers (traffic, weather and emission).
Vehicle Component Requirements	Vehicle OBE, dedicated short range communications (DSRC)
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Fixed
Roadside Interface to Local	Yes
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	None
Siting Dependency	Not critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	Medium
Vehicle Data Connection	Not required
Benefits vs. Deployment Level	Day one
Other Dependency	None

Data Needs from OBU	None
Data Needs from Infrastructure	TI, SPaT (if applicable, e.g. a short ramp that is located near a signal)
Infographic	None

Table 2.35: Environment ‣ Low Emissions Zone Management

Title	Low Emissions Zone Management
CVRIA Reference	Low Emissions Zone Management
Description	The Low Emissions Zone Management application supports the operation of a low emissions zone that is responsive to real-time traffic and environmental conditions. Low emissions zones are geographic areas that seek to restrict or deter access by specific categories of high-polluting vehicles into the area to improve the air quality within the geographic area. The application uses data collected from vehicles using connected vehicle technologies and from roadside equipment as input to the system. The Low Emissions Zone Management application supports the geo-fencing of a cordon that may be scalable and moveable (e.g., created for a day, removable, flexible in its boundaries) and would be less dependent on conventional ITS infrastructure. The application would establish parameters including the types of vehicles permitted to enter the zone, exemptions for transit vehicles, emissions criteria for entering the zone, fees or incentives for vehicles based on emissions data collected from the vehicle, and geographic boundaries for the low emissions zone. The application would also include electronic toll collection functions that support payments of fees or collection of incentives for registered vehicles using connected vehicle technologies. Finally, this application provides information about the low emissions zone to traveler information centers, including information about criteria for entering the zone, expected fees and incentives, current and predicted traffic conditions, and geographic boundaries of the zone.
Category	AERIS
ODOT Application Number	--
Benefits/Impact	Preliminary modeling shows a 3% to 5% emission savings with partial vehicle fleet penetration and improved transit service.
Maturity	Well researched and considered in the AERIS operational scenario
Interface Requirements	Back office interface, infrastructure data interface, roadside interface, weather service.
Infrastructure Requirements	Roadside equipment (RSE), management centers (traffic, weather and emission).
Vehicle Component Requirements	Vehicle OBE, dedicated short range communications (DSRC)
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others**
Physical RSE Installation	Fixed
Roadside Interface to	Optional

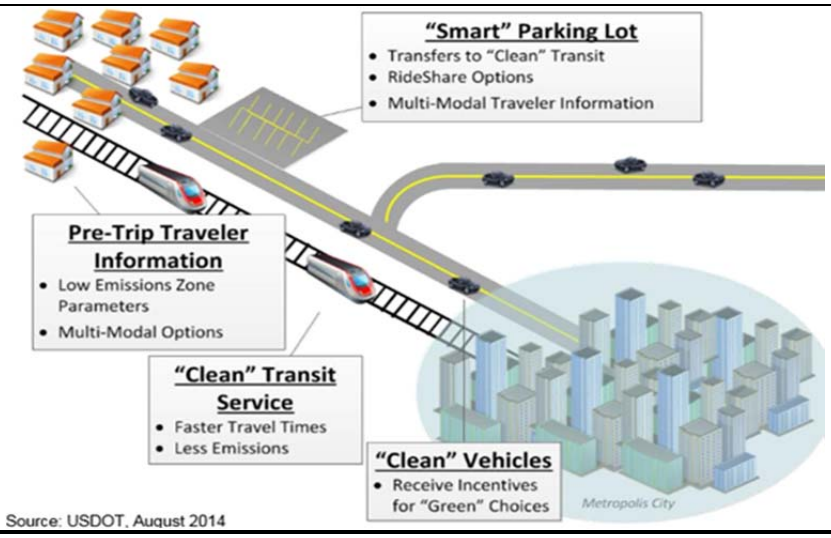
Local	
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	Road Network
Siting Dependency	Non-critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Not Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	Privacy
Data Needs from OBU	Other
Data Needs from Infrastructure	App-specific
Infographic	

Table 2.36: Environment ‣ AFV Charging/Fueling Information

Title	AFV Charging/Fueling Information
CVRIA Reference	Electric Charging Stations Management
Description	The Electric Charging Station Management application provides an exchange of information between vehicle and charging station to manage the charging operation. The agency or company operating the charging station can use vehicle information such as the capability of the vehicle (e.g. operational status of the electrical system, how many amps can the vehicle handle, and % charge complete) to determine that the charge is being properly applied and determine an estimated time to complete charging.
Category	AERIS
ODOT Application Number	**ODOT 6**.
Benefits/Impact	By switching to alternative fuels benefits related to emission and fuel efficiency are expected.
Maturity	The technology for this application is already in use.
Interface Requirements	Back office interface, infrastructure data interface, roadside interface, weather service.
Infrastructure Requirements	Roadside equipment (RSE)
Vehicle Component Requirements	Vehicle OBE, dedicated short range communications (DSRC)
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Limited Domains
Mapping Support	Localized Geometric
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	Medium
Vehicle Data Connection	Not Required

Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	Other
Data Needs from Infrastructure	App-specific
Infographic	None

Table 2.37: Environment ‣ Eco-Smart Parking

Title	Eco-Smart Parking
CVRIA Reference	Eco-Smart Parking Traveler Information – Smart Parking Smart Park and Ride System
Description	This application transmits parking space location, availability, price, type (on-street, Electric Vehicle (EV) only, etc.), it supports dynamic parking space pricing based on demand, emissions and vehicle types and allows parking space reservation.
Category	AERIS
ODOT Application Number	--
Benefits/Impact	Fuel saving and emission reduction are expected due to reduced vehicle idling.
Maturity	The technology for this application is already in use in the form of dynamic parking management
Interface Requirements	Back office interface, infrastructure data interface, roadside interface, driver-vehicle interface
Infrastructure Requirements	Roadside equipment (RSE), parking management systems
Vehicle Component Requirements	Vehicle OBE
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Limited Domains
Mapping Support	Localized Geometric
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	Medium
Vehicle Data Connection	Not Required

Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	Other
Data Needs from Infrastructure	App-specific
Infographic	None

Table 2.38: Environment ‣ Dynamic Eco-Routing

Title	Dynamic Eco-Routing (Light Vehicle, Transit, Freight)
CVRIA Reference	Dynamic Eco-Routing
Description	This application calculates most fuel and emission efficient route. Similar to current navigation systems, this application is supplemented by real-time environmental and weather data along possible routes.
Category	AERIS
ODOT Application Number	--
Benefits/Impact	Fuel saving and emission reduction are expected due to optimal routing.
Maturity	Well researched and considered in the AERIS operational scenario.
Interface Requirements	Back office interface, infrastructure data interface, roadside interface, driver-vehicle interface
Infrastructure Requirements	None
Vehicle Component Requirements	None
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others**
Physical RSE Installation	Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	Privacy

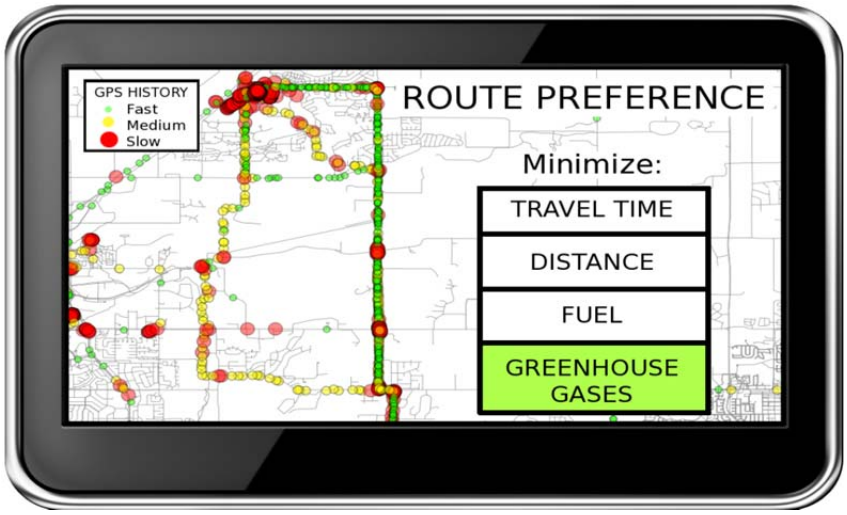
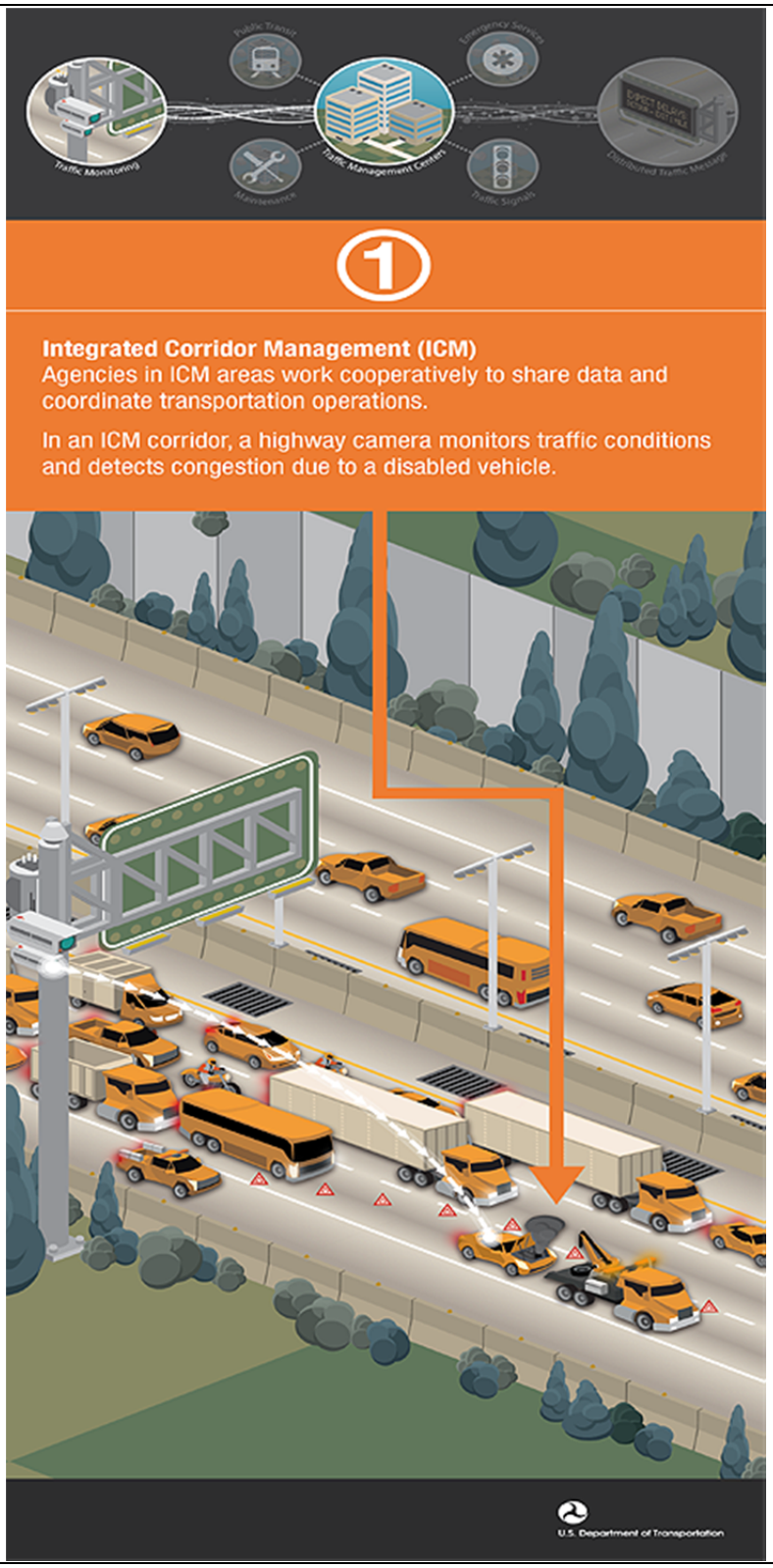
Data Needs from OBU	BSM1+other
Data Needs from Infrastructure	TI
Infographic	 (Source: http://www.spatial.cs.umn.edu/eco-routing/)

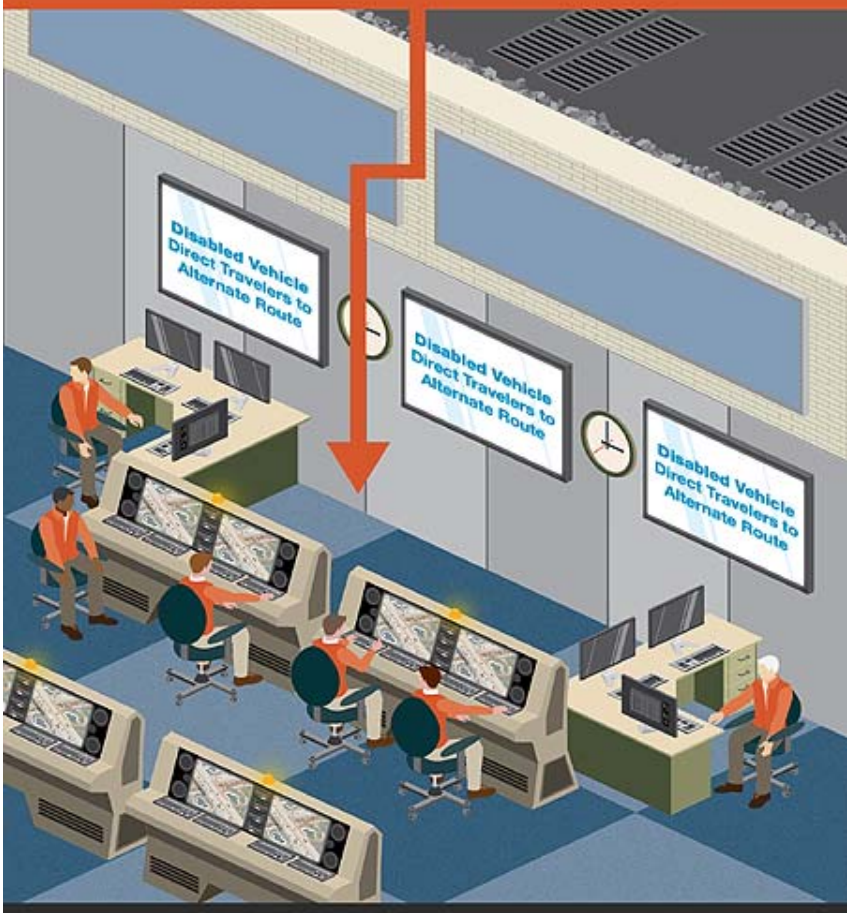
Table 2.39: Environment ‣ Eco-Integrated Corridor Management Decision Support System

Title	Eco-Integrated Corridor Management Decision Support System
CVRIA Reference	Eco-Integrated Corridor Management Decision Support System
Description	Operating system which combines eco-ramp metering, eco-speed limits, eco-signal timing with historical, real and predicted traffic and environmental data on the corridor in order to improve environmental impact.
Category	AERIS
ODOT Application Number	**ODOT 7.**
Benefits/Impact	Fuel saving and emission reduction are expected due to optimal routing.
Maturity	Well researched and considered in the AERIS operational scenario
Interface Requirements	Back office interface, infrastructure data interface, personal information device, roadside interface.
Infrastructure Requirements	Roadside equipment (RSE), management centers (traffic, transit, maintenance, construction, emergency, weather, and emission)
Vehicle Component Requirements	Vehicle OBE, dedicated short range communications (DSRC)
Applicability	**Priority 1: Near Term Focus for ODOT.**
Physical RSE Installation	Fixed
Roadside Interface to Local	Yes
Backhaul Communications	Required
Backhaul Restrictions	Limited Domains
Mapping Support	Lane Level
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Require Threshold Deployment Level
Other Dependency	Policy

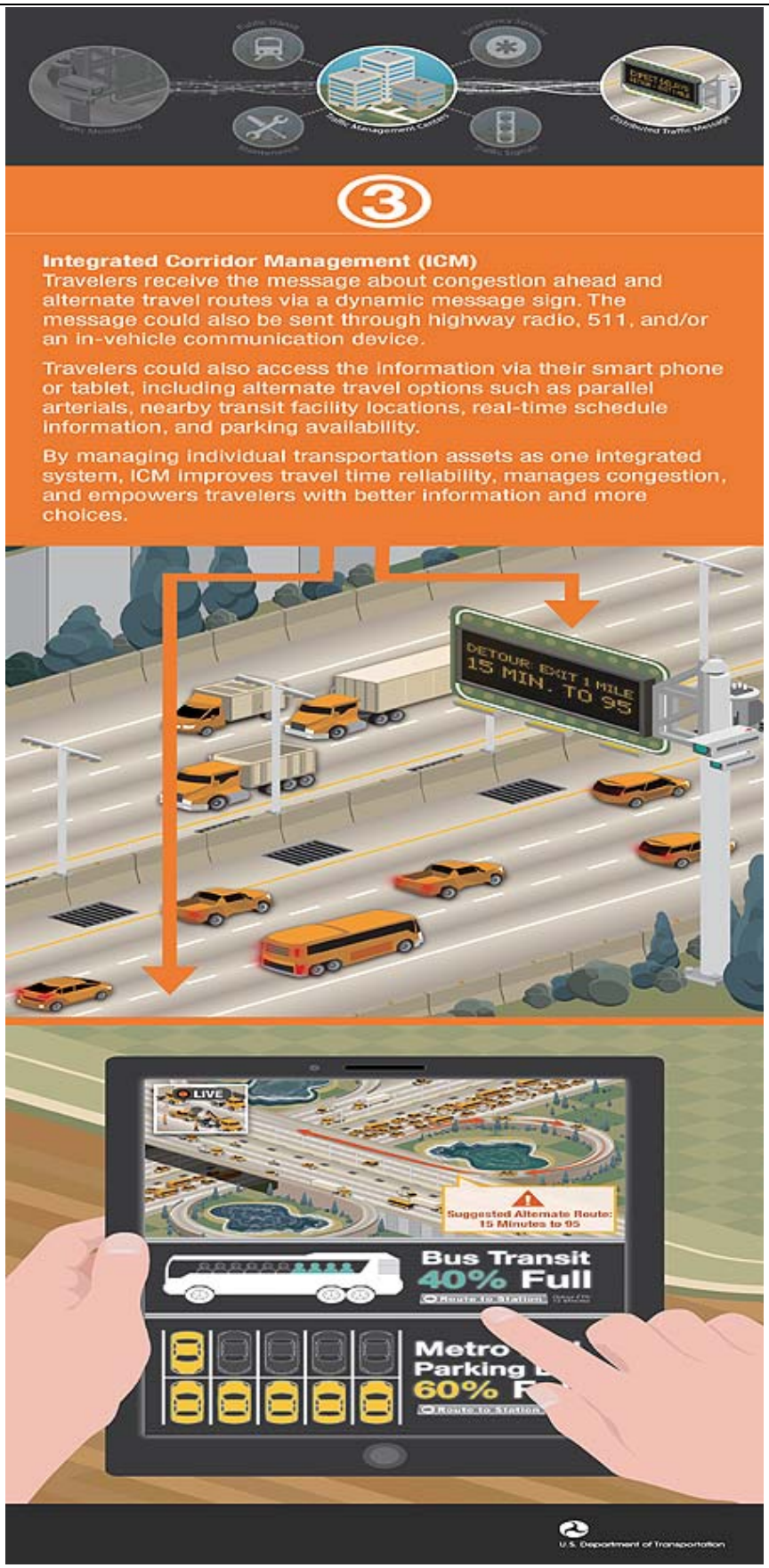
Data Needs from OBU	BSM1+2
Data Needs from Infrastructure	App-specific

Infographic	

Integrated Corridor Management (ICM)
Traffic management centers throughout the corridor receive and exchange data about the disabled vehicle and resulting congestion and delays, and process this information into a coordinated message for travelers. Traffic agencies may also change signal timing to accommodate traffic shifting onto nearby roadways.



U.S. Department of Transportation


3
Integrated Corridor Management (ICM)
Travelers receive the message about congestion ahead and alternate travel routes via a dynamic message sign. The message could also be sent through highway radio, 511, and/or an in-vehicle communication device.
Travelers could also access the information via their smart phone or tablet, including alternate travel options such as parallel arterials, nearby transit facility locations, real-time schedule information, and parking availability.
By managing individual transportation assets as one integrated system, ICM improves travel time reliability, manages congestion, and empowers travelers with better information and more choices.
DETOUR EXIT 1 MILE
15 MIN. TO 95
LIVE
Suggested Alternate Route:
15 Minutes to 95
Bus Transit
40% Full
Metro
Parking
60%
U.S. Department of Transportation

Other Image	 (Source: http://delcan.com/articles/san-diego-i-15-integrated-corridor-management-icm-project)

Table 2.40: Environment ‣ Dynamic Emissions Pricing

Title	AASHTO: Dynamic Emissions Pricing
CVRIA Reference	Low Emissions Zone Management
Description	See Application **33**.
Category	Environment
ODOT Application Number	--
Benefits/Impact	Preliminary modeling shows a 3% to 5% emission savings with partial vehicle fleet penetration and improved transit service.
Maturity	Well researched and considered in the AERIS operational scenario
Interface Requirements	Back office interface, infrastructure data interface, roadside interface, weather service.
Infrastructure Requirements	Roadside equipment (RSE), management centers (traffic, weather and emission).
Vehicle Component Requirements	Vehicle OBE, dedicated short range communications (DSRC)
Applicability	**Not on ODOT Priority List**; Similar to Application **33**.
Physical RSE Installation	Fixed
Roadside Interface to Local	Optional
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	Road Network
Siting Dependency	Non-critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Not Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	Privacy
Data Needs from OBU	Other

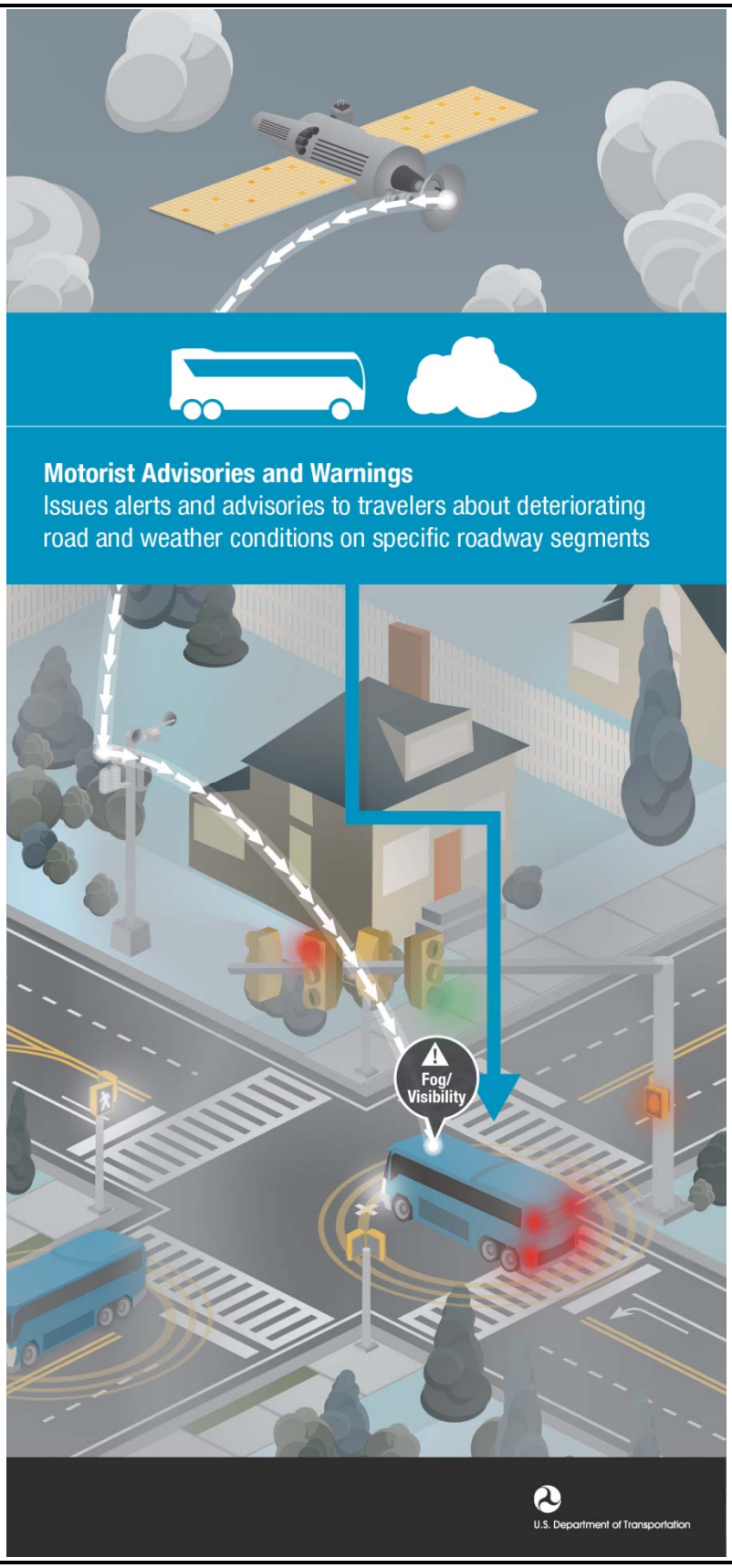
Data Needs from Infrastructure	App-specific
Infographic	None

2.5 ROAD WEATHER APPLICATIONS

Table 2.41: Road Weather ‣ Motorist Advisories & Warnings

Title	Motorist Advisories & Warnings (MAW)
CVRIA Reference	Road Weather Motorist Alert and Warning
Description	Provides advance warnings to drivers of adverse weather conditions, incidents, or slippery roads on specific segments. Information is gathered and transmitted between vehicles, satellites, and ground stations. Goals: reduce primary and secondary accidents, reduce congestion, and improve driver awareness of segment specific conditions.
Category	Road Weather
ODOT Application Number	**ODOT 23.**
Benefits/Impact	A high proportion of collisions are caused by adverse weather conditions. Though weather forecast is very reliable a real time weather advisories streamed to traffic management centers from connected vehicles can add robustness and pertinence to the prediction by giving the locally adequate warnings.
Maturity	With advances in RWIS, and other weather data collection and management systems, the weather related advisories and warning application is relatively mature and ready to be deployed once the infrastructure communications network and in-vehicle systems are available.
Interface Requirements	ITS Roadway Equipment, Maintenance and Construction Vehicle Platform, Weather Service
Infrastructure Requirements	Maintenance and Construction Management Center "Roadside Equipment" (RSE)
Vehicle Component Requirements	Maintenance and Construction Vehicle OBE, Dedicated Short Range Communications (DSRC)
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	None
Roadside Interface to Local	No
Backhaul Communications	None
Backhaul Restrictions	N/A

Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	BSM1+2
Data Needs from Infrastructure	App-specific

Infographic	

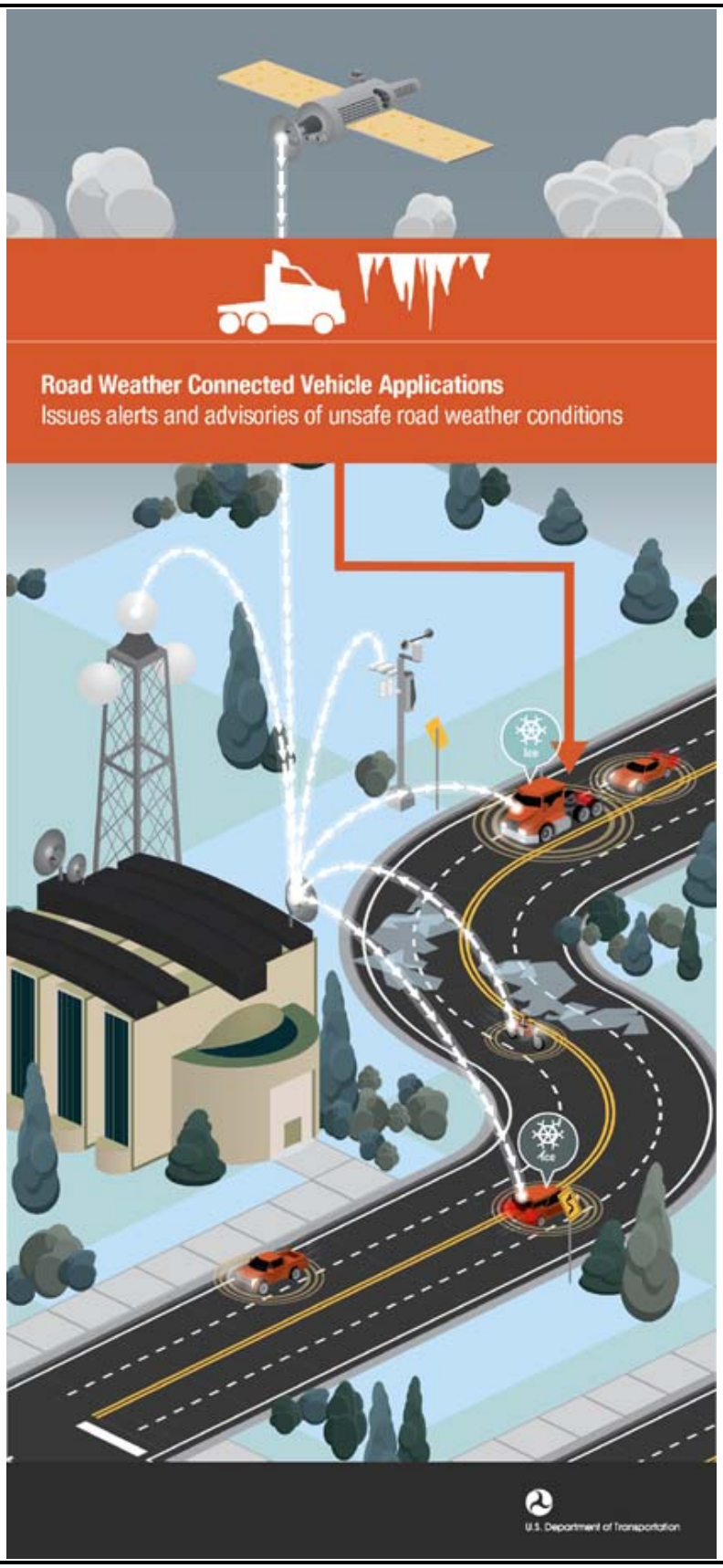
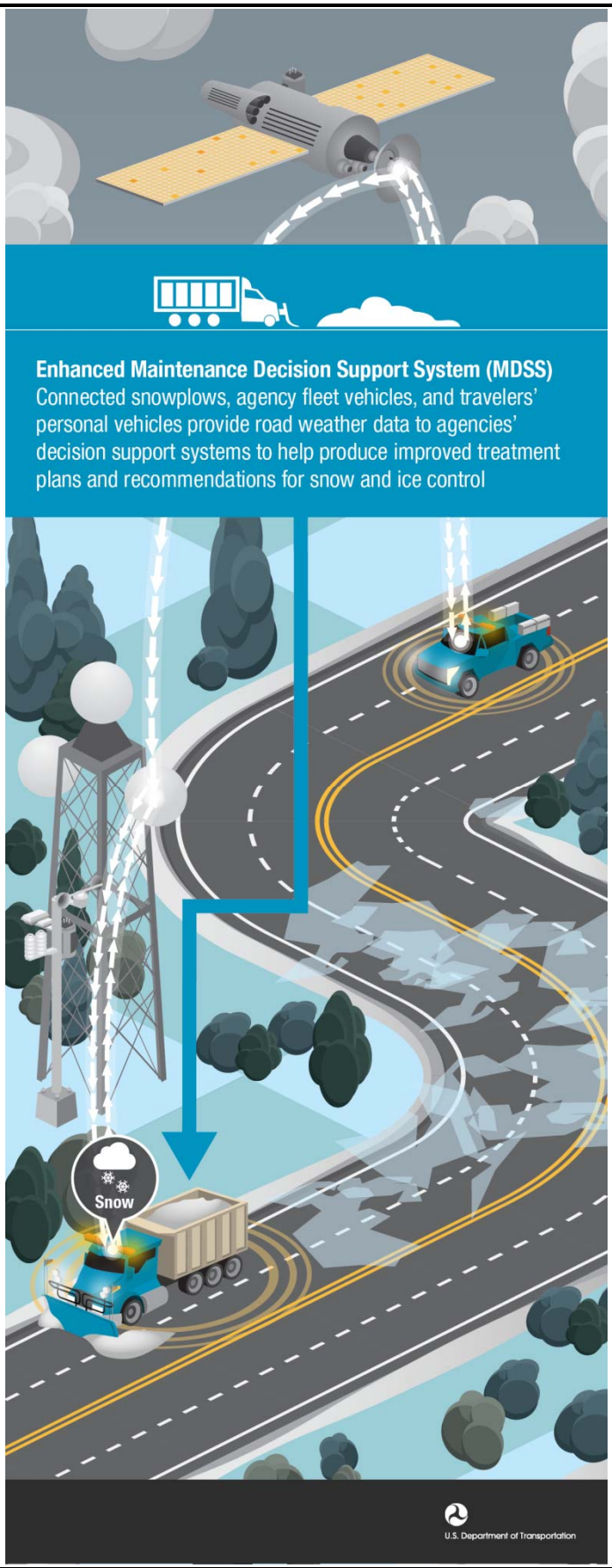
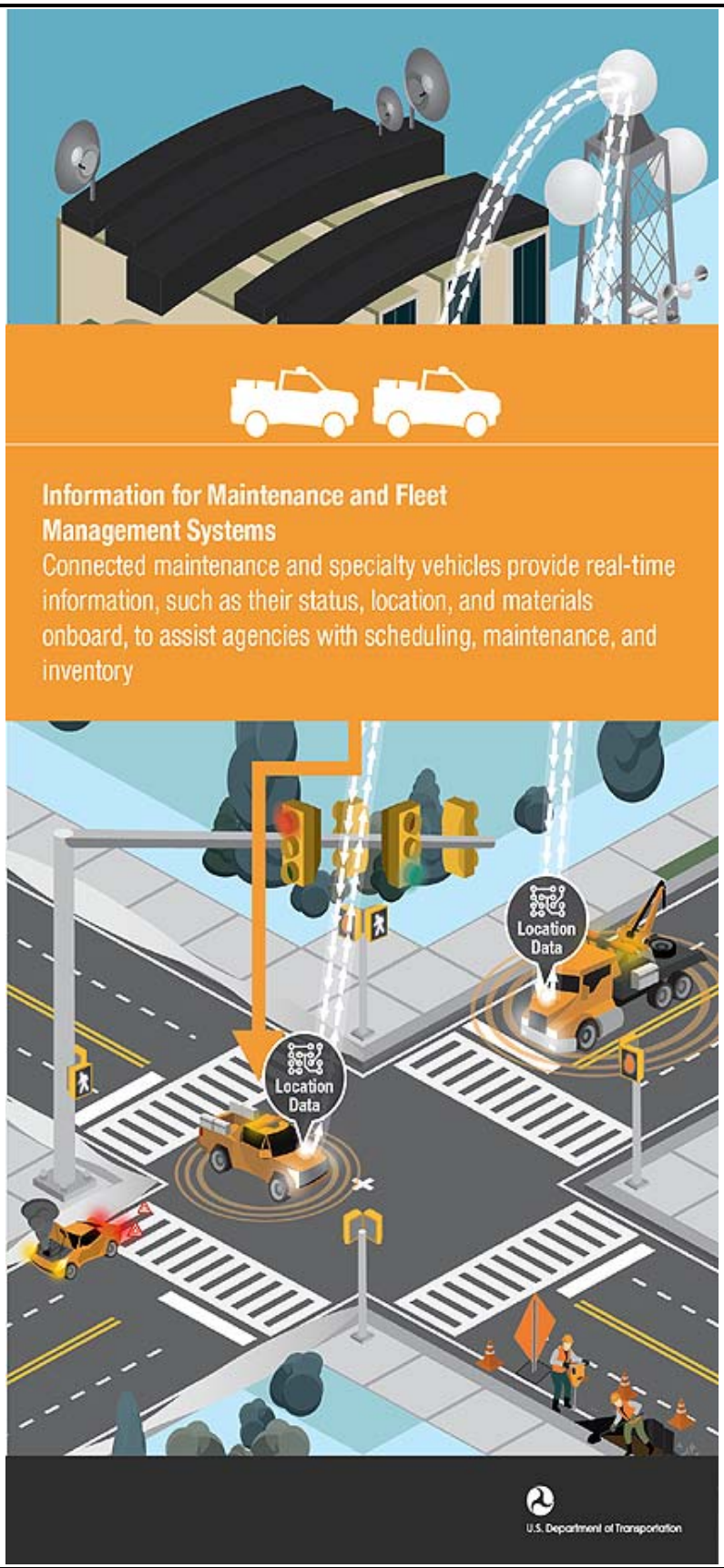
Infographic	

Table 2.42: Road Weather ‣ Enhanced Maintenance Decision Support System

Title	Enhanced Maintenance Decision Support System (MDSS)
CVRIA Reference	Enhanced Maintenance Decision Support System
Description	Prototype is a decision support tool that integrates relevant road weather forecasts, coded maintenance rules of practice, and maintenance resource data to provide winter maintenance managers with recommended road treatment strategies. “The Enhanced Maintenance Decision Support System application incorporates the additional information that can come from collecting road weather data from connected vehicles into the existing Maintenance Decision Support System (MDSS) capabilities” *(U.S. DOT 2015g)*.
Category	Road Weather
ODOT Application Number	**ODOT 24.**
Benefits/Impact	The application has the potential to enhance safety and efficiency and non-intrusive maintenance works.
Maturity	As of 2004, MDSS technologies were mature enough for private sector companies to incorporate MDSS capabilities into their product lines for State DOT clients.
Interface Requirements	ITS Roadway Equipment, Maintenance and Construction Vehicle Platform, Weather Service
Infrastructure Requirements	Maintenance and Construction Management Center "Roadside Equipment" (RSE)
Vehicle Component Requirements	Maintenance and Construction Vehicle OBE, Dedicated Short Range Communications (DSRC)
Applicability	**Priority 1: Near Term Focus for ODOT.**
Physical RSE Installation	Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Limited Domains
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	High

Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	BSM1+2
Data Needs from Infrastructure	App-specific

Infographic	

Infographic	

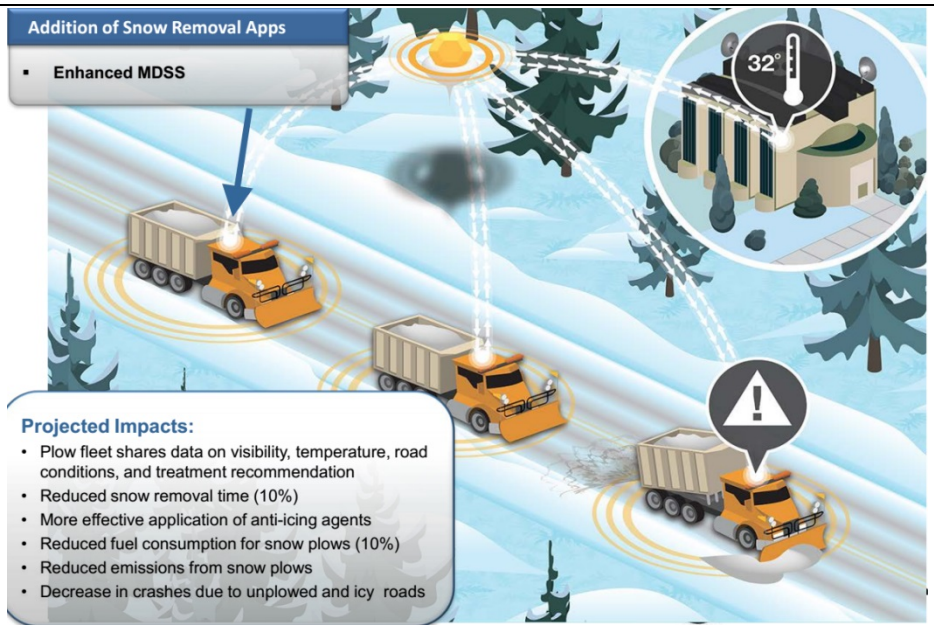
Other Image	 (Source: http://www.its.dot.gov/pilots/pdf/Pilot_District13.pdf)

Table 2.43: Road Weather ‣ Vehicle Data Translator

Title	Vehicle Data Translator (VDT)
CVRIA Reference	--
Description	The main function of the VDT is to quality-check individual vehicle probe data elements, such as temperature and pressure, and then combine them into “derived observations” that are valid along a given length of roadway over a given time period. The prototype VDT includes a data parser function that extracts relevant weather and road condition vehicle probe fields from the vehicle data network. The data elements selected for extraction will be determined by research results and feedback from stakeholders in both the atmospheric and surface transportation communities. Data elements can also be added or subtracted as needs vary. The data flowing out of the data parser is still considered raw as it has not been processed in any way *(Drobot et al. 2010)*.
Category	Road Weather
ODOT Application Number	--
Benefits/Impact	The application will aid drivers and traffic management personnel with decision support tools in the form of real time data pertained to weather and road condition and vehicle status.
Maturity	The technology for implementing this application are mature.
Interface Requirements	ITS Roadway Equipment, Maintenance and Construction Vehicle Platform, Weather Service
Infrastructure Requirements	Maintenance and Construction Management Center "Roadside Equipment" (RSE)
Vehicle Component Requirements	Maintenance and Construction Vehicle OBE, Dedicated Short Range Communications (DSRC)
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others**
Physical RSE Installation	Portable or Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	Yes

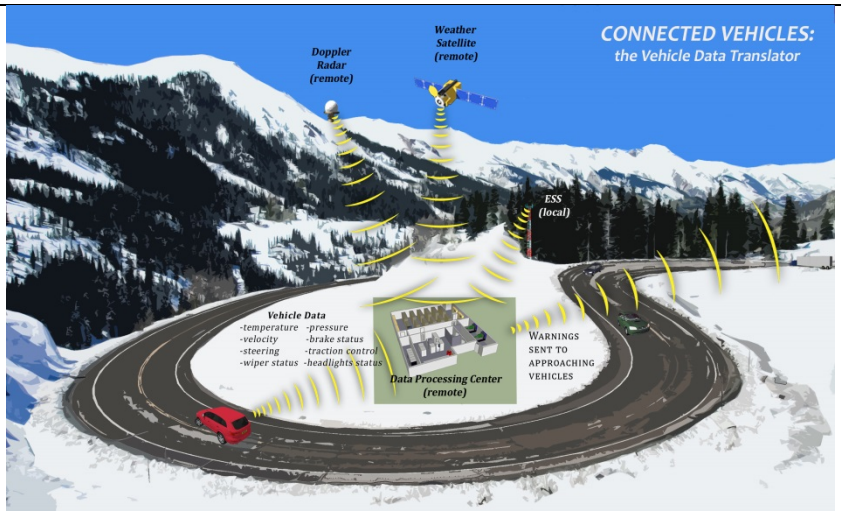
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Not Required
Benefits vs. Deployment Level	Benefits Require Threshold Deployment Level
Other Dependency	None
Data Needs from OBU	Position
Data Needs from Infrastructure	None
Infographic	 (Source: https://www2.ucar.edu/atmosnews/winter-weather/winter-drivingsafety-system-that-helps-you-stay-in-your-lane/)

Table 2.44: Road Weather ‣ Weather Response Traffic Info

Title	Weather Response Traffic Info (WxTINFO)
CVRIA Reference	Variable Speed Limits for Weather-Responsive Traffic Management
Description	Real time weather information streamed from connected vehicles and fixed stations to adjust and adapt the roadway network and travel conditions for other vehicles. Goal: reduce the impact of adverse weather on travelers.
Category	Road Weather
ODOT Application Number	--
Benefits/Impact	Weather has a large impact on safety, mobility, and productivity. Approximately 24 percent of all collisions are weather related, through the use of adaptive strategies driven by real time weather on the vehicles, lives could be saved with WxTINFO. Adverse weather causes massive delays on the nations freeways, 23 percent of non-recurrent delay is due to adverse weather. All of these delays lead to more overhead for drivers on the road network. The WxTINFO could reduce all of these impacts significantly.
Maturity	This application is currently being tested in Michigan. Similar types of applications are used all around the country using only stationary sources of data.
Interface Requirements	Backhaul communication connection with cell provider, a means to utilize the information effectively.
Infrastructure Requirements	Server and software to process the data, weather recording devices.
Vehicle Component Requirements	Transmitting device from car to cell tower.
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others** State DOTs would be able to implement a system like this on their network today. The system could utilize fixed source data to post automatically to DMS's or they could use the weather to change the speed limits on a network. In urban areas this system could be used during large rainfall events to warn of flooding.
Physical RSE Installation	Yes, Fixed – Fixed Station Data None – Vehicle Streaming Data
Roadside Interface to Local	Yes – Fixed Station Data No – Vehicle Streaming Data
Backhaul Communications	Required – Fixed Station Data None – Vehicle Streaming Data
Backhaul Restrictions	Exclusive – Fixed Station Data

	N/A – Vehicle Streaming Data
Mapping Support	Road Network – Fixed Station Data Road Network – Vehicle Streaming Data
Siting Dependency	Non-Critical – Fixed Station Data Non-Critical – Vehicle Streaming Data
Management of Collected Data	Yes – Fixed Station Data Yes – Vehicle Streaming Data
Back Office Services/Applications	Yes – Fixed Station Data Yes – Vehicle Streaming Data
Latency	High – Fixed Station Data High – Vehicle Streaming Data
Vehicle Data Connection	Required – Fixed Station Data Required – Vehicle Streaming Data
Benefits vs. Deployment Level	Benefits Require Threshold Deployment Level – Fixed Station Data Benefits Require Threshold Deployment Level – Vehicle Streaming Data
Other Dependency	None – Fixed Station Data None – Vehicle Streaming Data
Data Needs from OBU	BSM1+2 – Fixed Station Data BSM1+2 – Vehicle Streaming Data
Data Needs from Infrastructure	Application Specific – Fixed Station Data Application Specific – Vehicle Streaming Data

Infographic	

2.6 FEE PAYMENT APPLICATIONS

Table 2.45: Fee Payment ‣ Tolling

Title	AASHTO: Tolling
CVRIA Reference	Electronic Toll Collection
Description	Vehicle encounters RSU at or prior to tolled facility (bridge, roadway entrance, etc.); RSU announces toll requirement. Vehicle sends request for toll payment (possibly indicating type of vehicle) to RSU. RSU executes payment (either directly or via back office account transaction). RSU provides receipt (generally including occupancy data) to vehicle. During subsequent RSU encounters on tolled facility, RSU requests validation of paid toll; vehicle sends receipt to RSU to avoid enforcement actions.
Category	Fee Payment
ODOT Application Number	**ODOT 8.**
Benefits/Impact	User fees are an integral part in supporting transportation systems by means of collecting revenue to fund transportation projects, recuperate funds from a past project and sustain maintenance and operations costs for transportation infrastructure.
Maturity	Concept is mature using traditional RFID toll tags. Ready to be deployed as connected vehicles emerge in the market.
Interface Requirements	Tolling presence detection with bi-directional exchange of supporting account and traveler information. Possible access to a payment transaction system.
Infrastructure Requirements	Sign or equipment gantries, bridge and tunnel structures, and ferry docks. One RSU can cover an entire road.
Vehicle Component Requirements	Vehicle based DSRC communication system with HMI
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Fixed
Roadside Interface to Local	Optional
Backhaul Communications	Required
Backhaul Restrictions	Limited Domains
Mapping Support	Localized Geometric
Siting Dependency	Critical
Management of Collected Data	Yes

Back Office Services/Applications	Yes
Latency	Low
Vehicle Data Connection	Not Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	Privacy
Data Needs from OBU	BSM1 + other
Data Needs from Infrastructure	App-specific
Infographic	None

Table 2.46: Fee Payment ‣ High Occupancy Toll Lanes

Title	AASHTO: High Occupancy Toll Lanes
CVRIA Reference	High-Occupancy Toll Lanes
Description	Toll lanes that provide higher occupancy vehicles such as buses, vanpools, and carpools with free or discounted passage, while all other vehicles are tolled. Goals: reduce delay at toll plazas and reduce congestion.
Category	Fee Payment
ODOT Application Number	**ODOT 9.**
Benefits/Impact	High Occupancy Toll (HOT) Lanes are managed lanes enabled by connected vehicles will provide a harmonized payment system across multiple jurisdictions, that is integrated with other multimodal payment mechanisms (including parking, transit, tolls, and other mobility solutions). Benefits of HOT Lanes can include reduced congestion, improved safety and air quality/energy consumption benefits as well.
Maturity	Idea is 20+ years old
Interface Requirements	None
Infrastructure Requirements	Reconfigured/new toll plazas, enforcement, signage
Vehicle Component Requirements	None
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Fixed
Roadside Interface to Local	Optional
Backhaul Communications	Required
Backhaul Restrictions	Limited domains
Mapping Support	Localized geometric
Siting Dependency	Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	Low
Vehicle Data	Not required

Connection	
Benefits vs. Deployment Level	Benefits realizable day one
Other Dependency	Privacy
Data Needs from OBU	BSM1+other
Data Needs from Infrastructure	App-specific
Infographic	 Photo: Minnesota Department of Transportation

Table 2.47: Fee Payment ‣ Congestion Pricing

Title	AASHTO: Congestion Pricing
CVRIA Reference	Congestion Pricing
Description	RSU at boundary of congestion management area sends out announcement that vehicles entering the area will be charged a specified toll/fee. Vehicles send request for fee payment to RSU, and RSU communicates with Back office system to execute payment transaction. Back office provides payment receipt to RSU, and RSU forwards receipt to vehicle. During subsequent RSU encounters, RSU requests validation of paid toll; vehicle sends receipt to RSU to avoid enforcement actions. Goals: reduce Congestion, improve travel times, reduce emissions.
Category	Fee Payment
ODOT Application Number	**ODOT 10.**
Benefits/Impact	User fees are an integral part in supporting transportation systems by means of collecting revenue to fund transportation projects, recuperate funds from a past project and sustain maintenance and operations costs for transportation infrastructure. Benefits include reduced congestion, improved safety and environmental benefits.
Maturity	Concept is mature using traditional RFID toll tags. Ready to be deployed as connected vehicles emerge in the market.
Interface Requirements	Tolling presence detection with bi-directional exchange of supporting account and traveler information. Possible access to a payment transaction system.
Infrastructure Requirements	Sign or equipment gantries, bridge and tunnel structures, and ferry docks. One RSU can cover an entire road.
Vehicle Component Requirements	Vehicle based DSRC communication system with HMI
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Fixed
Roadside Interface to Local	Optional
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	Road Network
Siting Dependency	Not Critical
Management of Collected Data	Yes

Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Not Required
Benefits vs. Deployment Level	Benefits realizable day one
Other Dependency	Privacy
Data Needs from OBU	Other
Data Needs from Infrastructure	App-Specific
Infographic	None

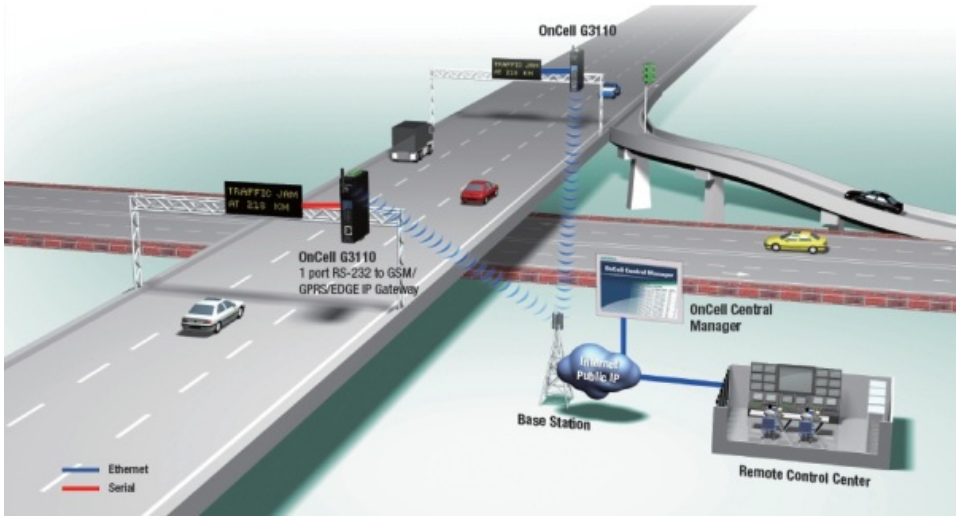
2.7 MOBILITY APPLICATIONS

2.7.1 Enable Advanced Traveler Information System (Enable ATIS)

Table 2.48: Enable ATIS ‣ Advanced Traveler Information System

Title	Advanced Traveler Information System (ATIS)
CVRIA Reference	Advanced Traveler Information Systems
Description	Enhanced traveler information services that record or infer user decisions and other contextual trip data that, when suitably processed can improve or transform system management functions. This service goal is to provide an effective way to provide travel information to users of the transportation system. This information may include like delays, incidents, oncoming work zones, emergency situations, and localized weather information updates *(TRAC 2005)*.
Category	Mobility
ODOT Application Number	**ODOT 1a & 1b.**
Benefits/Impact	The implementation of ATIS enabled via connected vehicles will improve safety issues by decreasing the number of crashes, injuries and fatalities, and in turn, reduce medical costs, insurance costs, and property damage.
Maturity	ATIS without connectivity is already being used in industry. ATIS with connectivity has been demonstrated. Increasing penetration rate of connected vehicles and DSRC increases ATIS capabilities and may reduce agency costs for sensors and surveillance.
Interface	Back Office Interface, Infrastructure Data Interface, Roadside Interface,

Requirements	Driver-Vehicle Interface, Vehicle Systems Interface
Infrastructure Requirements	Infrastructure Communications Interface, and Vehicle Communications Interface. Data collection, and information transfer to the main communication center through a complex system of camera surveillance, patrol reporters and electronic traffic sensors.
Vehicle Component Requirements	Vehicle ATIS Applications and In-Vehicle Warning Systems
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	No
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Realizable Day one
Other Dependency	None
Data Needs from OBU	BSM1
Data Needs from Infrastructure	TI

Infographic	 (Source: http://www.moxa.com/application/CMS_Highway.htm)

2.7.2 Multimodal Intelligent Traffic Signal System (MMITSS)

Table 2.49: MMITSS ‣ Intelligent Traffic Signal System

Title	Intelligent Traffic Signal System (I-SIG)
CVRIA Reference	Intelligent Traffic Signal System
Description	I-SIG is the future of traffic signal systems. It provides comprehensive traffic information for all modes. The system uses connected vehicle technology to accommodate signal priorities. The system incorporates the needs of emergency vehicles, transit, freight, pedestrians, bicycles, and passenger vehicles. This system allows preemption for emergency vehicles and pedestrians, while increasing performance across the arterial network *(U.S. DOT 2005)*.
Category	Mobility
ODOT Application Number	--
Benefits/Impact	Improved mobility for all users. More efficient preemptive signal timing for emergency vehicles. Reduced wait time for all users. Less congestion. Less air pollution, due to reduction in idling. Safe simultaneous accommodation of emergency vehicles, transit, and pedestrians.
Maturity	I-SIG has been demonstrated, particularly in the Anthem, Arizona test bed. I-SIG is mature and does not require development of new technology *(UA et al. 2014)*.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside interface, Driver-Vehicle Interface, Vehicle Systems Interface, Infrastructure Communications Interface, and Vehicle Communications Interface.

Infrastructure Requirements	Infrastructure I-SIG Application (intersection geometric intersection description (GID), information on each vehicle (position, speed, and heading), minor road vehicle data (position and heading), infrastructure signage information).
Vehicle Component Requirements	Vehicle I-SIG Application and In-Vehicle Warning System.
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others** State Highway System. Intersections operated under ODOT.
Physical RSE Installation	Fixed: RSE Intersection Management, RSE Situation Monitoring, RSE Environmental Monitoring, RSE Traffic Monitoring
Roadside Interface to Local	Yes
Backhaul Communications	Optional
Backhaul Restrictions	Exclusive
Mapping Support	Lane Level
Siting Dependency	Non-Critical
Management of Collected Data	No
Back Office Services/Applications	Yes: monitor and control RSE
Latency	Low
Vehicle Data Connection	required
Benefits vs. Deployment Level	Benefits Require Threshold Deployment Level
Other Dependency	None
Data Needs from OBU	BSM1
Data Needs from Infrastructure	App-specific

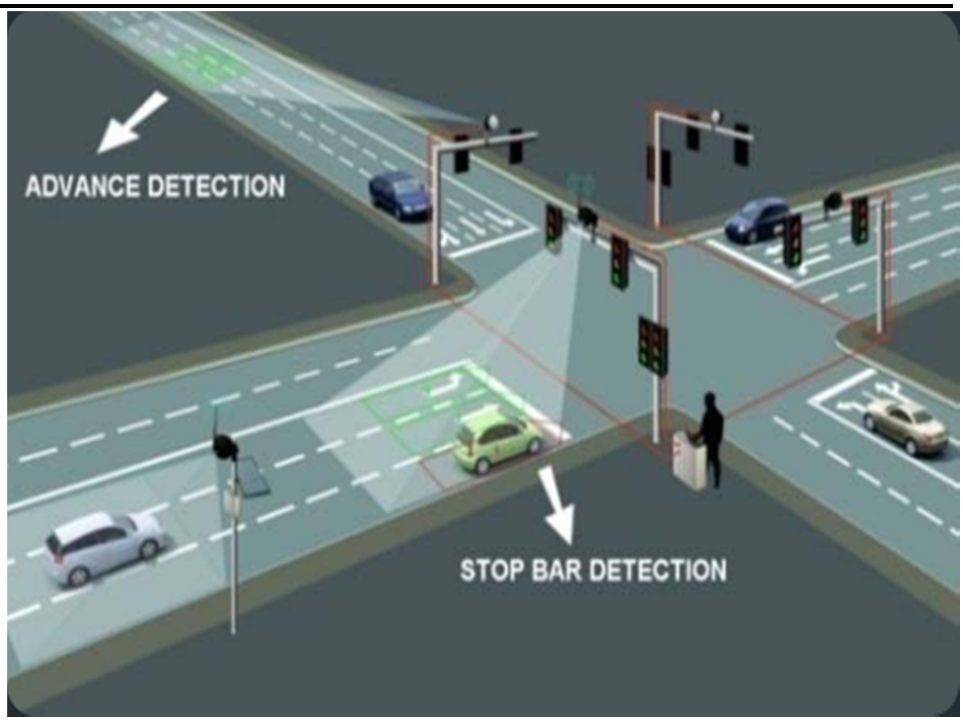
Infographic	 (Source http://www.riviera-maya-news.com/playa-del-carmen-to-receive-first-intelligent-traffic-light-systems/2015.html)

Table 2.50: MMITSS ‣ Signal Priority (Transit & Freight)

Title	Transit Signal Priority (TSP) and Freight Signal Priority (FSP)
CVRIA Reference	Transit Signal Priority and Freight Signal Priority
Description	This technology is used to improve the travel time of certain priority vehicles by providing traffic signal phasing priority according to the importance of the situation. Usually priority is granted through extending a green phase (green extension) or shortening a red phase (early green), while attempting to maintain signal progression that may exist on an arterial. Priority vehicles may include emergency vehicles, transit vehicles (including bus rapid transit) and/or commercial vehicles/trucks, and situations vary *(Narrigan et al. 2007)*.
Category	Mobility
ODOT Application Number	--
Benefits/Impact	A Signal Priority system to complement an I-SIG and in coordination with the PREEMPT system would have a significant positive impact on safety related issues, by improving traffic flow, increasing the mobility of the emergency vehicles, and overall mobility enhancement.
Maturity	Signal priority is already being used in industry without connectivity. This application has been successfully demonstrated so no new technology needs to be developed. Widespread and consistent integration into existing and future fleets and roadside equipment remains a challenge.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside interface, Driver-Vehicle Interface, Vehicle Systems Interface.
Infrastructure Requirements	Infrastructure Communications Interface, and Vehicle Communications Interface. Priority Application (intersection GID, information on each vehicle (position, speed, and heading), minor road vehicle data (position and heading), infrastructure signage information).
Vehicle Component Requirements	Vehicle Signal Priority Application and In-Vehicle Warning System.
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others.**
Physical RSE Installation	Fixed
Roadside Interface to Local	Yes
Backhaul Communications	Optional

Backhaul Restrictions	Exclusive
Mapping Support	Localized geometric
Siting Dependency	Non-critical
Management of Collected Data	No
Back Office Services/Applications	No
Latency	Medium
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits realizable day one
Other Dependency	None
Data Needs from OBU	BSM1+other
Data Needs from Infrastructure	App-specific

Infographic	
Other Image	 (Source : https://goo.gl/8zxfPY)

Table 2.51: MMITSS ‣ Mobile Accessible Pedestrian Signal

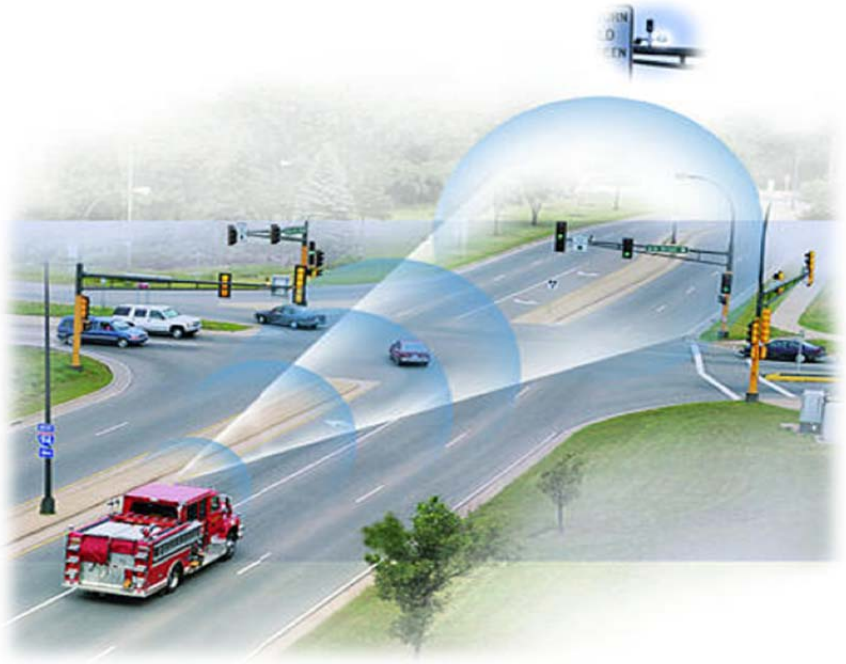
Title	Mobile Accessible Pedestrian Signal System (PED-SIG)
CVRIA Reference	Pedestrian Mobility
Description	The concept of this application is to use a smartphone-type application to assist persons with vision impairment to cross intersections safely. This application would provide Signal Phasing and Timing (SPaT) information to the pedestrians via smartphone-type application. Providing the SPaT information would enhance safety and mobility at signalized intersection through enhancing the V2I cooperation *(Liao 2013)(Liao et al. 2011).*
Category	Mobility
ODOT Application Number	--
Benefits/Impact	As most fatal crashes occur in intersections, this technology would increase intersection crossing safety especially for people with visual impairment.
Maturity	At present some cities are providing SPaT data to application developers through certain channels (e.g. Enlighten by Connected Signals).
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside Interface, and Infrastructure Communications Interface.
Infrastructure Requirements	Infrastructure (PED-SIG) Application (intersection GID, information on each vehicle (position, speed, and heading), minor road vehicle data (position and heading), infrastructure signage information).
Vehicle Component Requirements	Vehicle (PED-SIG) Application and In-Vehicle Warning System.
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others.**
Physical RSE Installation	Fixed
Roadside Interface to Local	Yes
Backhaul Communications	Optional
Backhaul Restrictions	Exclusive
Mapping Support	Localized Geometrics
Siting Dependency	Critical
Management of Collected Data	No

Back Office Services/Applications	Yes
Latency	Low
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Require Threshold Deployment Level
Other Dependency	Privacy
Data Needs from OBU	BSM1+other
Data Needs from Infrastructure	SPaT
Infographic	 (Source : https://goo.gl/8zxfPY)

Table 2.52: MMITSS ‣ Emergency Vehicle Preemption

Title	Emergency Vehicle Preemption (PREEMPT)
CVRIA Reference	Emergency Vehicle Preemption
Description	This system is used to provide emergency vehicles responding to a certain situation a green light as they approach a signalized intersection (and a green wave along a signalized arterial), and provide all red indications to any conflicting movements. After the emergency vehicle clears the intersection, the signals return to their normal operations. Preemption is

	subtly different than signal priority in that the phase transitions are immediate and concerns for maintaining progression are ignored for the sake of the emergency.
Category	Mobility
ODOT Application Number	--
Benefits/Impact	The use of PREEMPT System would have a significant impact toward decreasing emergency vehicle response time, which contributes to the improvement of safety, and cost savings. The improvement in safety occurs by reducing the probability of delay of the responding vehicle in a conflicting intersection or encountering queuing issues. In addition, the probability of an emergency vehicle intersection crash is reduced. Finally, the reduced response time improves survivability for victims of medical emergencies.
Maturity	A non-connected (passive, no feedback) version of this technology is being used in industry, relying primarily on infrared emitters, not as an intelligent system. Several kind of emergency vehicles detection technology are currently available, which rely on infrared/visual light based systems and others that rely on audio detection.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside interface, Driver-Vehicle Interface, Vehicle Systems Interface, Infrastructure Communications Interface, and Vehicle Communications Interface.
Infrastructure Requirements	Infrastructure PREEMPT Application (intersection GID, information on the detected emergency vehicle (position, speed, heading and destination), minor road vehicle data (position and heading), and infrastructure signage information.
Vehicle Component Requirements	Vehicle PREEMPT Application and In-Vehicle Warning System.
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others.**
Physical RSE Installation	Fixed
Roadside Interface to Local	Yes
Backhaul Communications	Optional
Backhaul Restrictions	Exclusive
Mapping Support	Localized Geometric
Siting Dependency	Non-Critical
Management of	No

Collected Data	
Back Office Services/Applications	No
Latency	Medium
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	BSM1+other
Data Needs from Infrastructure	App-specific
Infographic	 (Source:http://ops.fhwa.dot.gov/publications/fhwahop08024/chapter9.htm)

2.7.3 Intelligent Network Flow Optimization (INFLO)

Table 2.53: INFLO ‣ Dynamic Speed Harmonization

Title	Dynamic Speed Harmonization (SPD-HARM)
CVRIA Reference	Speed Harmonization
Description	The intention of using this technology is to adjust the maximum appropriate speed limit based on current traffic, road surface, demand and weather conditions through dynamic speed limit signs displayed on the intended segments of freeways and other roadways.

Category	Mobility
ODOT Application Number	**ODOT 2.**
Benefits/Impact	The implementation of this technology will help in the reduction of traffic congestion, through delaying the formation of traffic queues and smoothing traffic flow by eliminating dangerous speed differentials which would reduce the potential for crashes to occur due to this traffic situation, maintaining a smooth, safe traffic flow.
Maturity	At present variable speed limit and traffic flow smoothing systems are deployed in a limited number of permanent U.S. applications (as well as in Europe), and is also deployed in temporary work zone applications.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside Interface, and Infrastructure Communications Interface.
Infrastructure Requirements	Infrastructure (SPD-HARM) Application: Posted variable speed limit signs (traffic, weather and road condition information), information on each vehicle (position, speed, and heading)
Vehicle Component Requirements	Vehicle (SPD-HARM) Application and In-Vehicle Warning System.
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	Lane level
Siting Dependency	Localized Geometric
Management of Collected Data	Non-critical
Back Office Services/Applications	No
Latency	No
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	BSM1+other

Data Needs from Infrastructure	App-specific
Infographic	 (Source: http://goo.gl/l5smC1)

Table 2.54: INFLO ‣ Queue Warning

Title	Queue Warning (Q-WARN)
CVRIA Reference	Queue Warning
Description	The intention of using this technology is to alert the road user of upcoming traffic congestion (queue) in order to prevent rear-end crashes. It is likely that this application would be combined with Dynamic Speed Harmonization (SPD-HARM). Drivers may choose to use this information for avoiding congestion by changing their travel route.
Category	Mobility
ODOT Application Number	**ODOT 3.**
Benefits/Impact	By anticipating the downstream traffic condition, drivers can reduce their speed gradually and avoid emergency braking reducing rear-end and queuing-related crashes.
Maturity	Queue warning systems are in place in a limited number of locations in the U.S. and also in Europe, so the technology is relatively mature. The extension to the connected/cooperative environment is still to be implemented.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside Interface, and Infrastructure Communications Interface.
Infrastructure Requirements	Infrastructure (Q-WARN) Application: Posted dynamic warning signs (traffic, weather and road condition information), information on each vehicle (position, speed, and heading).
Vehicle Component Requirements	Vehicle (Q-WARN) Application and In-Vehicle Warning System.
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	Lane level
Siting Dependency	Non-critical
Management of Collected Data	No
Back Office Services/Applications	Yes
Latency	Low

Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits require threshold deployment level
Other Dependency	None
Data Needs from OBU	BSM1
Data Needs from Infrastructure	TI
Infographic	 (Source: http://www.mobilevms.co.uk/)

Table 2.55: INFLO ‣ Cooperative Adaptive Cruise Control

Title	Cooperative Adaptive Cruise Control (CACC)
CVRIA Reference	Cooperative Adaptive Cruise Control
Description	This technology functions similar to traditional in-vehicle cruise control systems but with one exception. When the leading vehicles slow down, the following equipped vehicle receives this information immediately and can react much faster than the driver can. When the CACC system detects that the leading vehicles have accelerated, the equipped vehicle returns to its set speed *(Jones and Philips 2013, Park et al. 2011).*
Category	Mobility
ODOT Application Number	--
Benefits/Impact	With this technology, the communication between the vehicles and infrastructure increase the capability of maintaining safety and at the same time, increase overall traffic safety and efficiency.

Maturity	Adaptive cruise control systems are on the market that relies in extensive in-vehicle sensing capabilities. Cooperative/connected systems are on the horizon.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside Interface, and Infrastructure Communications Interface.
Infrastructure Requirements	Infrastructure (CACC) Application (traffic, weather and road condition information), information on each vehicle (position, speed, and heading)
Vehicle Component Requirements	Vehicle (CACC) Application and In-Vehicle Warning System.
Applicability	**Priority 2: ODOT Should Monitor, Possibly Collaborate, Leadership by Others**
Physical RSE Installation	Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	Lane Level
Siting Dependency	Non-critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	Low
Vehicle Data Connection	Not Required
Benefits vs. Deployment Level	Benefits require threshold deployment level
Other Dependency	None
Data Needs from OBU	BSM1
Data Needs from Infrastructure	App-specific

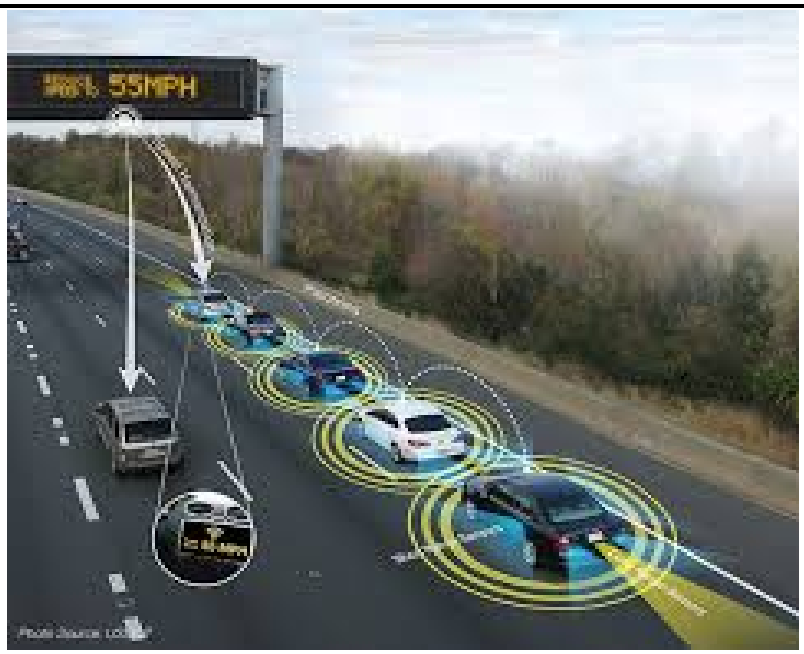
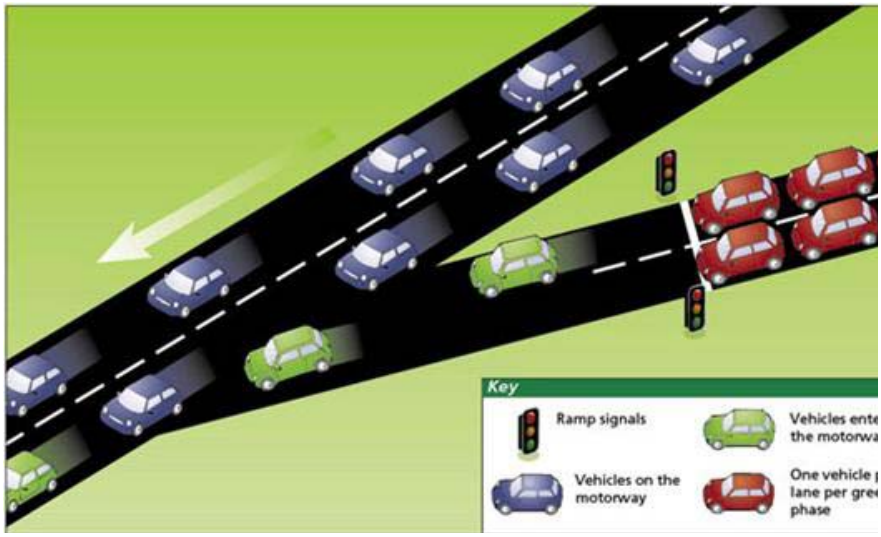
Infographic	 (Source: http://www.its.dot.gov/image_gallery/image36.htm)

Table 2.56: INFLO ‣ Next Generation Ramp Metering

Title	AASHTO: Next Generation Ramp Metering (RAMP)
CVRIA Reference	Eco-Ramp Metering
Description	Converting existing ramps to use density-based actuation, rather than capacity based. Additionally, systematic breakdowns related to the ramp filling to capacity are reduced. This will reduce delay and improve ramp metering options
Category	Mobility
ODOT Application Number	**ODOT 4.**
Benefits/Impact	The primary benefit is the improvement in travel times. Through the change from capacity to demand-based actuation, and from better metrics to reduce the occurrence of system breakdown, travel delay can be reduced. This will allow travelers to reach their destinations faster, reduce emissions, and reduce congestion.
Maturity	While RAMP is still in its infancy, the systems it is based on have been in existence for decades.
Interface Requirements	None
Infrastructure Requirements	Existing ramp meters that are able to be recalibrated, or the equipment and personnel for new ramp meters

Vehicle Component Requirements	None
Applicability	**Priority 1: Near Term Focus for ODOT** As ODOT is in charge of all freeways, and ramps are used almost exclusively on freeways, RAMP is highly applicable.
Physical RSE Installation	Fixed
Roadside Interface to Local	Yes
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	None
Siting Dependency	Not critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	Medium
Vehicle Data Connection	Not required
Benefits vs. Deployment Level	Day one
Other Dependency	None
Data Needs from OBU	None
Data Needs from Infrastructure	TI, SPaT (if applicable, e.g. a short ramp that is located near a signal)

Infographic	 (Source: https://goo.gl/N62RzZ)

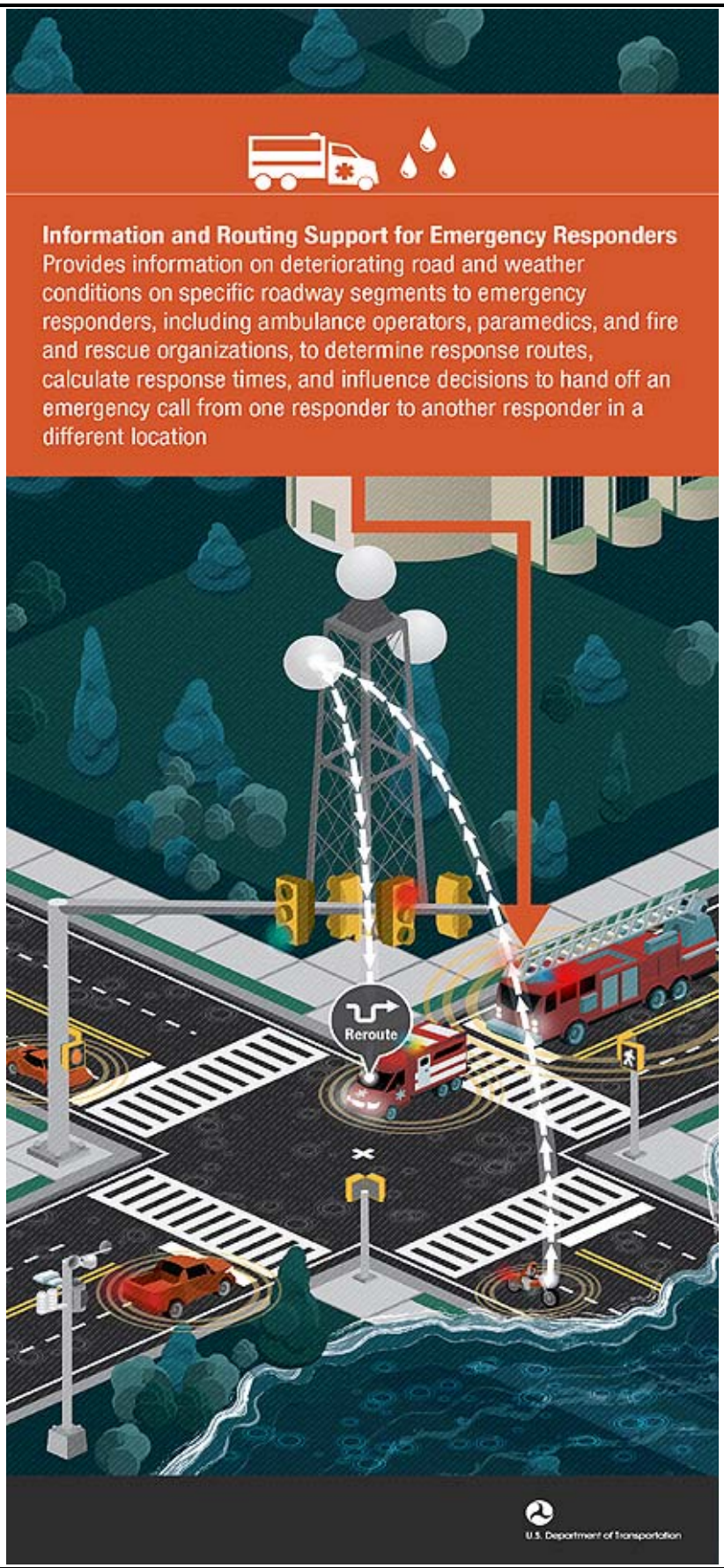
2.7.4 Response, Emergency Stating, Communication, Uniform Management, and Evaluation (RESCUME)

Table 2.57: RESCUME ‣ Incident Guidance Emergency Response

Title	Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
CVRIA Reference	Incident Scene Pre-Arrival Staging Guidance for Emergency Responders
Description	The purpose of RESP-STG is to provide situational awareness of the incident to the emergency responders and emergency centers. Additionally, it aims to coordinate among all emergency responders, upon dispatch and en-route in order to address the incident in an efficient manner and deploy secondary responders, if necessary. Data sources will include staging plans, satellite imagery, geographic information system (GIS) maps, current weather data, sensor readings, and real-time modeling outputs. *(U.S. DOT RESCUME 2012)*
Category	Mobility
ODOT Application Number	**ODOT 16.**
Benefits/Impact	• Provide prompt response to the victims. • Clear the incidents sooner to provide care for victims involved in the incident and to facilitate mobility. • Increase awareness among emergency responders, providing the location and arrival of other responders. • Improve preparedness of response teams with status updates of victims in involved in incident.
Maturity	Incident management systems and computer-aided dispatch are already prevalent in industry. The connected/cooperative capability is not yet implemented.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside Interface, and Infrastructure Communications Interface.
Infrastructure Requirements	Infrastructure (RESP-STG) Application (information on each vehicle i.e. position, speed, and heading, minor road vehicle data i.e. position and heading, infrastructure signage information).
Vehicle Component Requirements	Vehicle (RESP-STG) Application and In-Vehicle Warning System
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Equipment is fixed in the emergency response vehicle in the form of a Mobile Data Terminal (MDT)
Roadside Interface to Local	Roadside interface to local would be beneficial for emergency responders to be able to contact the local roadway users involved in an incident but it is not necessary.
Backhaul	Backhaul communication is required since there will need to be

Communications	communication between emergency responders, dispatchers, and local emergency centers.
Backhaul Restrictions	Some of the restrictions involved with communication include a lack of interoperability among emergency responder and a lack of shared situational awareness.
Mapping Support	Digital mapping, road network, topography
Siting Dependency	Siting is critical for this application since it is dependent on providing the situational awareness of the incident to the emergency responders. For example, still and video images will play a large role in supporting the assessment and approach of emergency responders.
Management of Collected Data	Management of the collected data will not be critical for the use of this application. For emergency responders to all be equally informed of the incident, all the collected data should be shared amongst responders. However, should the amount of data become excessive, it will need to be downsized to a more manageable amount that provides for efficient communication.
Back Office Services/Applications	Yes; dispatchers and emergency treatment centers
Latency	Medium; much of the data is available but transmitting it collectively to multiple emergency responders provides a challenge.
Vehicle Data Connection	Required, between all emergency responders and dispatchers
Benefits vs. Deployment Level	Potential to show rapid benefits, by reducing fatalities of incidents due to more efficient response services.
Other Dependency	Dependency on emergency treatment center communications and medical care.
Data Needs from OBU	Geographic location of all emergency responders, response equipment available, and intended approach for response to the incident.
Data Needs from Infrastructure	SPaT – allowing emergency vehicles to take priority GIDs – showing current location of all response vehicles

Infographic



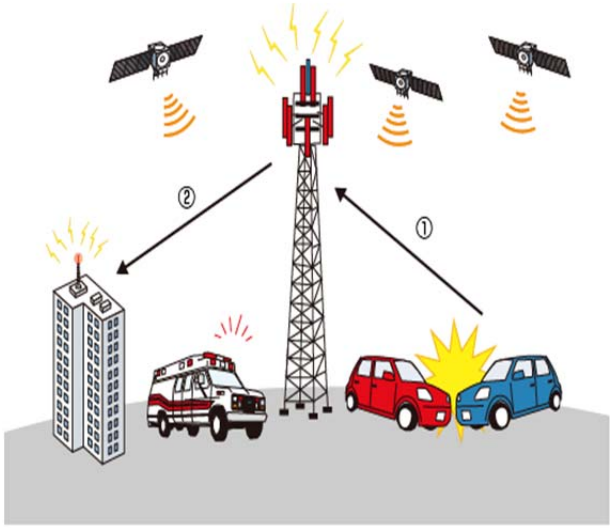
Infographic	 (Source : https://goo.gl/14V5k7)

Table 2.58: RESCUME ‣ Incident Scene Work Zone Alerts

Title	Incident Scene Work Zone Alerts (INC-ZONE)
CVRIA Reference	Incident Scene Work Zone Alerts for Drivers and Workers
Description	INC-ZONE is an ITS application that is part of the Response, Emergency Staging and Communications, Uniform Management, and Evacuation (RESCUME) bundle. The RESCUME bundle is designed to provide advance vehicle-to-vehicle safety messaging short-range communications to improve the safety of emergency responders and travelers. INC-ZONE, as a part of this bundle, is designed to improve the safety of workers in work zones along highways and drivers. The application is made up of two components, one that warns drivers that they are approaching a temporary work zone, and another that informs public safety personnel and other workers in the zone of potentially unsafe conditions.
Category	Mobility
ODOT Application Number	**ODOT 17.**
Benefits/Impact	The benefits of INC-ZONE are increasing safety on the highways in temporary work zones. The application will reduce the likelihood of work zone incidents, and communicate real-time roadside alerts for various temporary conditions on highways from work zones to traffic stops.
Maturity	Testing completed in Columbus, Ohio and Aberdeen, Maryland during Spring 2014.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside Interface, and Infrastructure Communications Interface.
Infrastructure	Infrastructure (INC-ZONE) Application (information on each vehicle i.e.

Requirements	position, speed, and heading, infrastructure signage information)
Vehicle Component Requirements	Vehicle (INC-ZONE) Application and In-Vehicle Warning System *(U.S. DOT RESCUME 2012).*
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Portable
Roadside Interface to Local	No
Backhaul Communications	Optional
Backhaul Restrictions	Exclusive
Mapping Support	None
Siting Dependency	Non-Critical
Management of Collected Data	No
Back Office Services/Applications	No
Latency	Medium
Vehicle Data Connection	Not Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	Position
Data Needs from Infrastructure	App-Specific

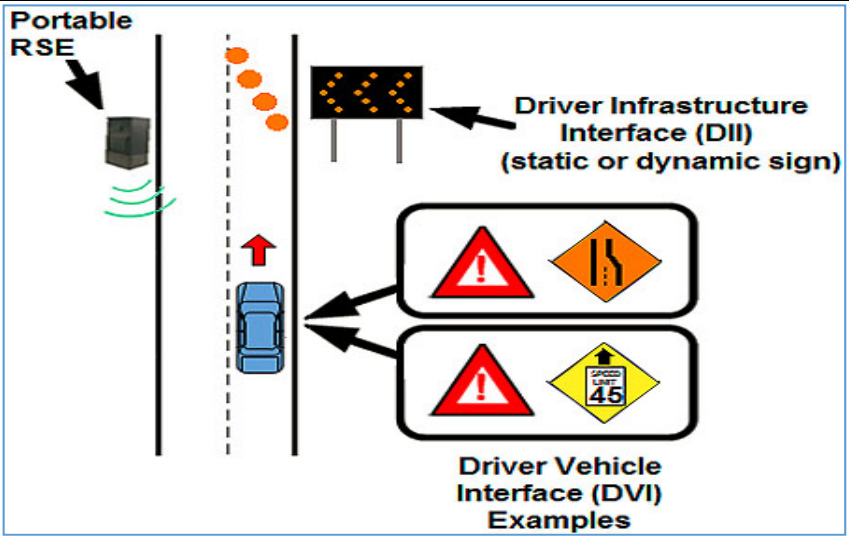
Infographic	 **(Source: https://www.pcb.its.dot.gov/eprimer/module13.aspx)**

Table 2.59: V2I Safety ▸ Reduced Speed Zone Warning

Title	Reduced Speed Zone Warning (RSZW)
CVRIA Reference	Reduced Speed Zone Warning / Lane Closure
Description	This technology is designed to be used to warn drivers of excessive speeds compared with the posted speed limit in reduced speed zones and changed roadway configurations. Reduced speed zones may include school zones, work zones, highly populated areas *(U.S. DOT 2015d)*.
Category	Vehicle to Infrastructure Safety
ODOT Application Number	--
Benefits/Impact	Rural areas have less staffing and law enforcement to help control traffic speed in work zones. Due to this they must rely on signage and other methods to slow drivers down. A reduce speed/work zone warning system in place is the smart drum speed enforcement system. This system causes drivers to reduce their speed when they see the flashing lights. The lights also warn workers that speeding vehicles are approaching, providing time to these workers to take precautions where before they had no warning. The combined effect of slowing traffic and warning workers is predicted to reduce the number and severity of collisions in work zones.
Maturity	Smart work zone systems have been deployed but the connected/cooperative elements are not deployed yet.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside Interface, Driver-Infrastructure Interface, Driver-Vehicle Interface, Vehicle Systems Interface, Infrastructure Communications Interface, and Vehicle Communications Interface.
Infrastructure Requirements	Infrastructure RSZW Application, Posted Speed Limit, Roadway Work Zone Configuration Information, Roadway Work Zone Operations Information (legal movements), Vehicle Speed (of the detected vehicle or highest vehicle speed if more than one vehicle is), and Current DII Message (alert/warning/default).
Vehicle Component Requirements	Vehicle RSZW Application and In-Vehicle Warning System
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Portable
Roadside Interface to Local	No
Backhaul Communications	None
Backhaul Restrictions	N/A
Mapping Support	None

Siting Dependency	Non-Critical
Management of Collected Data	No
Back Office Services/Applications	No
Latency	Low
Vehicle Data Connection	Not Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	None
Data Needs from Infrastructure	App-specific

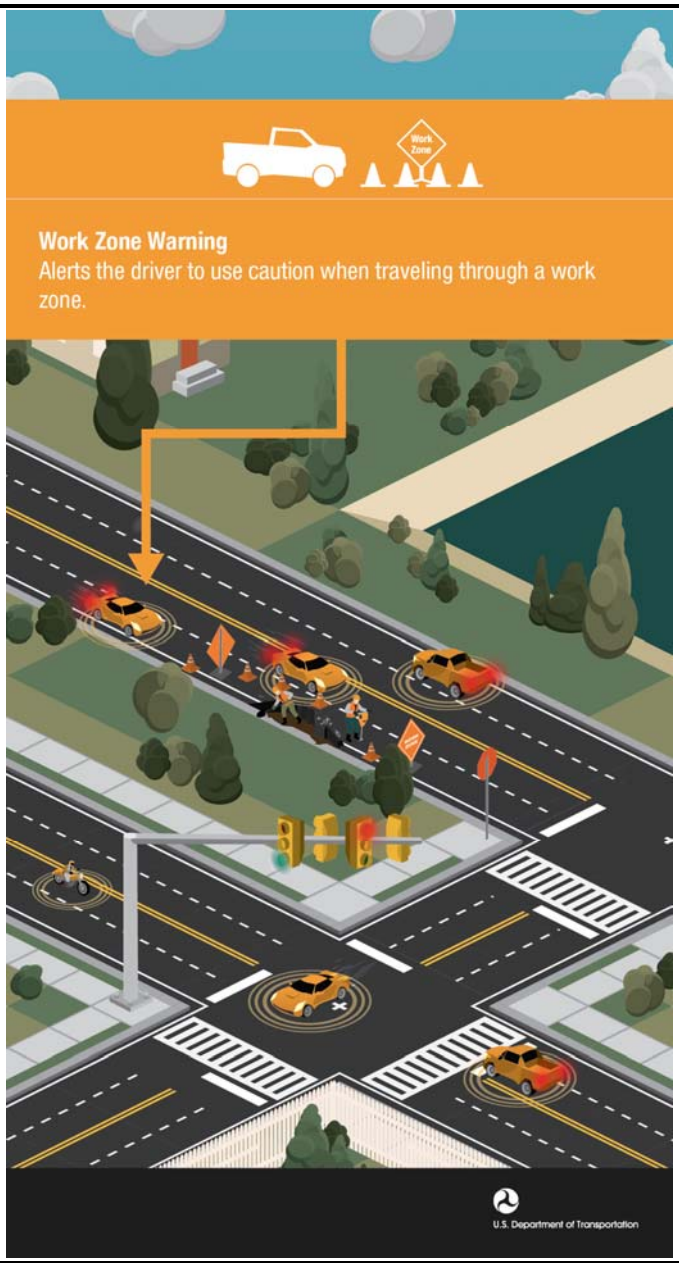
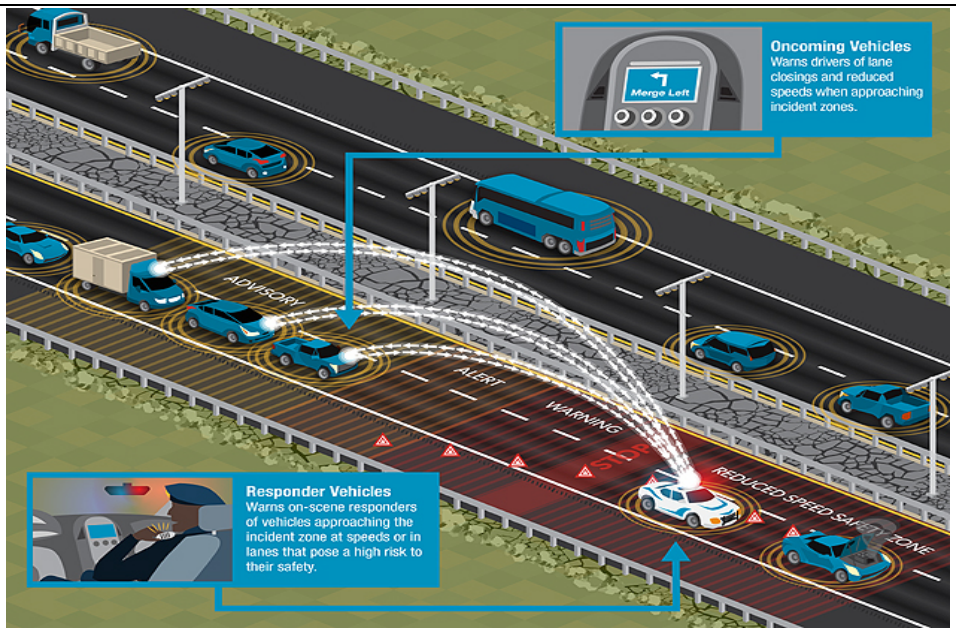
Infographic	
Other Image	 (Source: http://ops.fhwa.dot.gov/wz/workersafety/wzfrwebinar/fl/index.htm)

Table 2.60: RESCUME ‣ Emergency Communications/Evacuation

Title	Emergency Communications and Evacuation (EVAC)
CVRIA Reference	Emergency Communications and Evacuation
Description	This technology provides important information for emergency evacuation situations relating to people who require assistance and guidance by providing information about assistance providers, and other resources. In addition, this technology provides information for traffic and road conditions, fuel and other important essential requirements for travelers required to evacuate an area due to an emergency situation *(U.S. DOT 2015h)*.
Category	Mobility
ODOT Application Number	**ODOT 18.**
Benefits/Impact	This technology increase the safety for people by providing information for people in need of assistance, providing nearby resources information, and providing situational information for the travelers about the traffic and emergency situation.
Maturity	Emergency evacuation communications is currently not centralized or individual specific. Components of this technology are mature, but the assembled products are not fully developed.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside Interface, and Infrastructure Communications Interface.
Infrastructure Requirements	Infrastructure (EVAC) Application (information on each vehicle i.e. position, speed, and heading, infrastructure signage information)
Vehicle Component Requirements	Vehicle (EVAC) Application and In-Vehicle Warning System *(U.S. DOT RESCUME 2012)*.
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Portable
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Limited Domains
Mapping Support	Lane Level
Siting Dependency	Non-Critical
Management of Collected Data	No

Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Not Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	Position
Data Needs from Infrastructure	App-specific
Infographic	 (Source: http://www.its.dot.gov/infographs/rescume.htm)

2.7.5 Integrated Dynamic Transit Operations (IDTO)

Table 2.61: IDTO ‣ Connection Protection

Title	Transit Connection Protection (T-CONNECT)
CVRIA Reference	Transit Connection Protection
Description	Application that enables improved coordination between public transportation profilers and travelers to improve the probability of successful transit transfers. Application would result in trip time reduction and increase travelers' satisfaction using public, private and shared-ride transportation systems.
Category	Mobility
ODOT Application	--

Number	
Benefits/Impact	Reduces safety risks for transit transfers by eliminating uncertainty from perspectives of operators and users. Reduces risk in ridesharing situations through identity verification.
Maturity	Transit providers already provide useful schedule and real time information to users via mobile applications. Linkages toward guaranteeing connections are still not developed but hold significant promise.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside Interface, and Infrastructure Communications Interface.
Infrastructure Requirements	Infrastructure (T-Connect) Application
Vehicle Component Requirements	Vehicle (T-Connect) Application and interface with CAD/AVL system *(U.S. DOT IDTO 2012).*
Applicability	**Priority 3: Leadership by Others, ODOT Monitor**
Physical RSE Installation	None
Roadside Interface to Local	No
Backhaul Communications	None
Backhaul Restrictions	N/A
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	Other

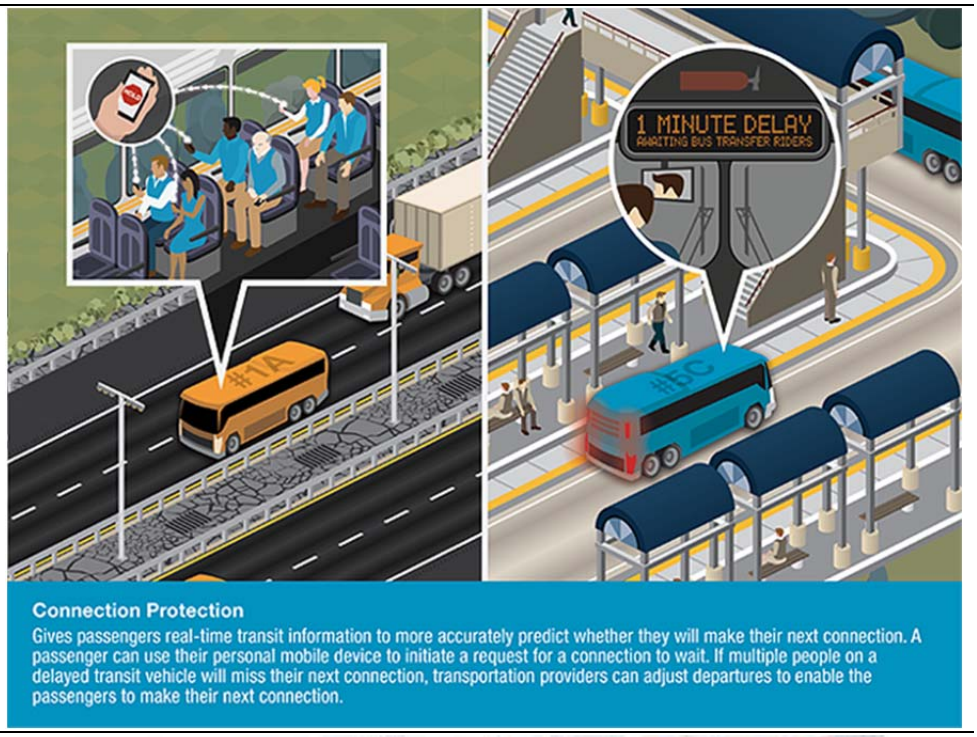
Data Needs from Infrastructure	TI
Infographic	
Other Image	 (Source: http://ntl.bts.gov/lib/jpodocs/repts_te/14074.htm)

Table 2.62: IDTO ‣ Dynamic Transit Operations

Title	Dynamic Transit Operations (T-DISP)
CVRIA Reference	Dynamic Transit Operations
Description	This application will allow travelers to request trips using a variety of media and seeks to enhance existing on-board and central systems to provide public transportation and shared-ride services. A central system, such as a Travel Management Coordination Center, or decentralized system would dynamically schedule and dispatch or modify the route of an in-service vehicle by matching compatible trips together. The

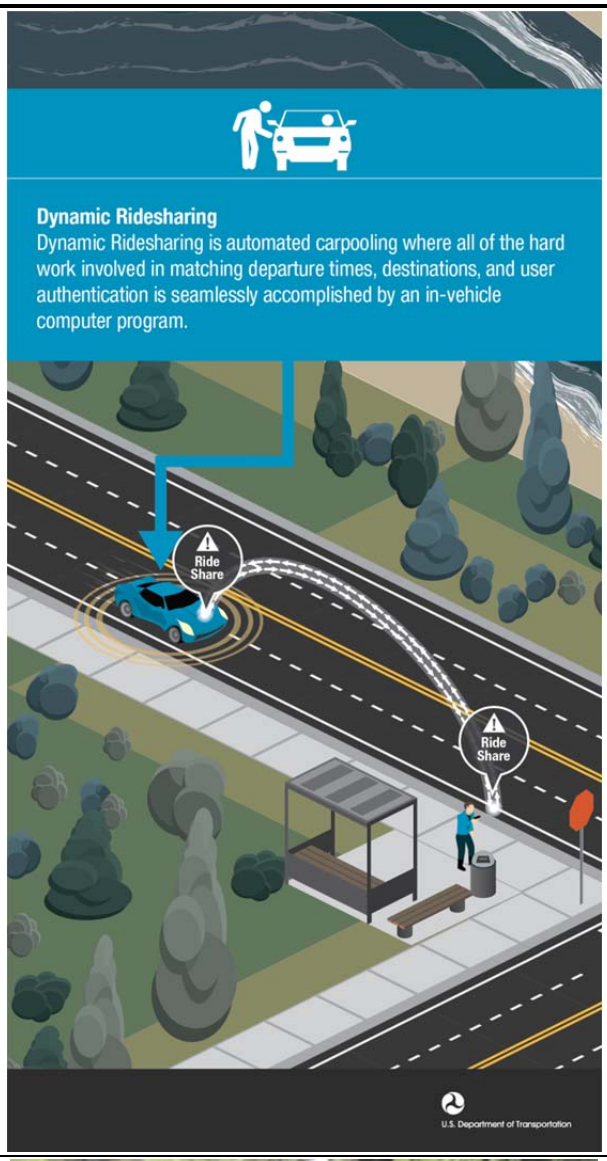
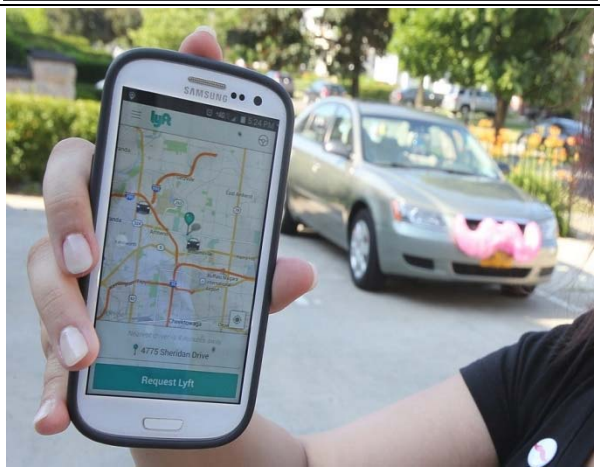
	application may consider both public and private (e.g., taxi) transportation providers and may include para-transit, fixed -route bus, flex-route bus, and rail transit services. Travelers would be able to request a trip via a handheld mobile device (or phone or personal computer) and have itineraries containing multiple transportation services (public transportation modes, private transportation services, shared-ride, walking, and biking) sent to them via the same handheld device. The goal of this application is to provide greater links between available transportation service resources with travelers through dynamic transit vehicle scheduling, dispatching, and routing capabilities.
Category	Mobility
ODOT Application Number	--
Benefits/Impact	The major benefit to T-DISP is that the traveler has the ability to access real-time information about available travel options in order to best manage their commute. This improves the efficiency of travel by transit or rideshare. This also improves accessibility to transit as availability is more flexible to the user which in turn can encourage travelers to choose transit over autos and assist in reducing congestion.
Maturity	There are two T-DISP programs in the U.S.: • USDOT's United We Ride / Mobility Services for All Americans (UWR/MSAA) – 8 sites across the U.S. were chosen for grant awards for the planning and designing of traveler management coordination centers. This includes the integration of dispatching and scheduling information from multiple regional transportation providers, introduction of a universal cashless fare and call center improvement to include customer-oriented features, such as automated telephone and internet-based trip reservations and management. • Lynx – Transit agency in Orlando, FL working toward bus systems that would serve stations at designated locations according to the user's request rather than by a fixed schedule.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside interface, and Infrastructure Communications Interface
Infrastructure Requirements	Infrastructure (T-DISP)
Vehicle Component Requirements	Vehicle (T-DISP) Application links with CAD/AVL systems *(U.S. DOT IDTO 2012)*.
Applicability	**Priority 3: Leadership by Others, ODOT Monitor**
Physical RSE Installation	None
Roadside Interface to Local	No

Backhaul Communications	None
Backhaul Restrictions	N/A
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	Other
Data Needs from Infrastructure	Other
Infographic	 (Source : https://goo.gl/L8vYjW)

Table 2.63: IDTO ‣ Dynamic Ridesharing

Title	Dynamic Ridesharing (D-RIDE)
CVRIA Reference	Dynamic Ridesharing
Description	This technology expands the traditional carpooling approach, and builds on the more recent mobile app-based on-demand ride services linking demand for destinations even if they are not served by public transportation. This system would reduce the demand on the public

	transportation during the peak hours of the day. This system depends on gathering passenger information system to help in supporting the non-transit ride sharing and on-demand services.
Category	Mobility
ODOT Application Number	--
Benefits/Impact	There would be increased security benefits due to guarantees of identity.
Maturity	This system builds on existing ridesharing/matching systems and more recent app-based on-demand ride services.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside interface, and Infrastructure Communications Interface.
Infrastructure Requirements	Infrastructure (D-RIDE) Application.
Vehicle Component Requirements	Vehicle (D-RIDE) Application
Applicability	**Priority 3: Leadership by Others, ODOT Monitor**
Physical RSE Installation	None
Roadside Interface to Local	No
Backhaul Communications	None
Backhaul Restrictions	N/A
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	Other
Data Needs from Infrastructure	TI

Infographic	
Other Image	 (Source : http://goo.gl/6XTX8a)

2.7.6 Freight Advanced Traveler Information System (FRATIS)

Table 2.64: FRATIS ‣ Freight Dynamic Travel Planning & Performance

Title	Freight-Specific Dynamic Travel Planning and Performance
CVRIA Reference	Freight-Specific Dynamic Travel Planning
Description	This technology uses traveler and freight information including dynamic routing, and performance monitoring elements. Information such as wait times at ports, road closures, work zones and route restrictions would be included. Adding to that, this system enhances the efficiency of freight mobility, energy consumption, and safety for shippers.
Category	Mobility
ODOT Application Number	**ODOT 5.**
Benefits/Impact	This application could enhance enforcement and regulatory activities including safety checks and hours of service.
Maturity	Many states already have weigh-in-motion and weigh stations for freight related enforcement. This system builds on those existing systems.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside interface, and Infrastructure Communications Interface.
Infrastructure Requirements	Infrastructure Application.
Vehicle Component Requirements	Vehicle Application
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Limited Domains
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Required

Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	BSM1+other
Data Needs from Infrastructure	TI
Infographic	None

Table 2.65: FRATIS ‣ Drayage Optimization

Title	Drayage Optimization
CVRIA Reference	Freight Drayage Optimization
Description	Drayage is the transport of goods over a short distance, often as part of a longer overall move and is typically completed in a single work shift. This application would optimize truck/load movements between freight facilities, balancing early and late arrivals.
Category	Mobility
ODOT Application Number	--
Benefits/Impact	Reductions in truck miles will proportionally reduce propensity for crashes *(U.S. DOT 2012)*.
Maturity	Private industry is already performing freight optimization internally. Future potential for incorporating connected vehicle data will further enhance the system's capabilities.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside interface, and Infrastructure Communications Interface.
Infrastructure Requirements	Infrastructure Application.
Vehicle Component Requirements	Vehicle Application
Applicability	**Priority 3: Leadership by Others, ODOT Monitor**
Physical RSE Installation	Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Required

Benefits vs. Deployment Level	Benefits Require Threshold Deployment Level
Other Dependency	Privacy
Data Needs from OBU	BSM1+other
Data Needs from Infrastructure	TI
Infographic	None

2.8 SMART ROADSIDE APPLICATIONS

Table 2.66: Smart Roadside ‣ Wireless Inspection

Title	Wireless Inspection
CVRIA Reference	Smart Roadside Initiative
Description	An application that will utilize roadside sensors to transit identification, hours of service, and sensor data directly from trucks to carriers and government agencies. It will increase the number of electronic screenings and provide enhanced safety and credentials assessments such as basic identification of the driver and carrier, hours of service and general mechanical conditions of the vehicle.
Category	Mobility
ODOT Application Number	**ODOT 25**.
Benefits/Impact	The safety benefits are freight efficiency, operational cost saving.
Maturity	This application is under research *(U.S. DOT JPO 2011)*.
Interface Requirements	Roadside interface to local, Backhaul, Back-Office services
Infrastructure Requirements	Roadside Equipment (RSE)
Vehicle Component Requirements	Vehicle OBE, Dedicated Short Range Communications (DSRC)
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Fixed
Roadside Interface to Local	Yes
Backhaul Communications	Yes, required

Backhaul Restrictions	Limited Domains
Mapping Support	Road Network
Siting Dependency	Noncritical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	Medium latency
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits realizable by day one.
Other Dependency	None
Data Needs from OBU	Required: BSM 1+2+Other
Data Needs from Infrastructure	App-specific
Infographic	 **(Source https://www.kapsch.net/us/ktc-system-that-helps-you-stay-in-your-lane/)**

Table 2.67: Smart Roadside ‣ Smart Truck Parking

Title	Smart Truck Parking
CVRIA Reference	Smart Roadside Initiative
Description	An application that will provide information such as hours of service constraints, location and supply of parking, travel conditions, and loading/unloading scheduling to allow commercial drivers to make advanced route planning decisions.
Category	Mobility
ODOT Application Number	**ODOT 26.**
Benefits/Impact	Reduces the potential of accident due to fatigued driving, safer parking decision and removes trucks from shoulders.
Maturity	This application is under research.
Interface Requirements	Roadside interface to local, Backhaul, Back-Office services
Infrastructure Requirements	Roadside Equipment (RSE)
Vehicle Component Requirements	Vehicle OBE, Dedicated Short Range Communications (DSRC)
Applicability	**Priority 1: Near Term Focus for ODOT**
Physical RSE Installation	Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Limited Domains
Mapping Support	Localized Geometric
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	Medium
Vehicle Data Connection	Not Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None

Data Needs from OBU	Other
Data Needs from Infrastructure	App-Specific
Infographic	 (Source http://www.overdriveonline.com/national-smart-truck-parking-system-in-the-works-will-show-real-time-parking-info/)

3.0 REFERENCES

Dawkins, J., and B. Powell. *Investigation of Pavement Maintenance Applications of Intellidrive (Final Report): Implementation and Deployment Factors for Vehicle Probe-based*. Auburn University, 2011.

Drobot, S., M. Chapman, P. Pisano, B. McKeever, E. Schuler, B. Lambi, G.M. Wiener, and W.P. Mahoney. Overview of the Vehicle Data Translator. 15th Standing International Road Weather Commission Conference, Quebec City, Canada. 2010. https://staff.ucar.edu/browse/people/16087/OSGC-000-000-003-799. Viewed 2015.

Harding, J., G. Powell, R. Yoon, J. Fikentscher, C. Doyle, D. Sade., M. Lukuk, J. Simons, and J. Wang. *Vehicle-to-Vehicle Communications: Readiness of V2V Technology for Application.* DOT HS 812 014. U.S. Department of Transportation, National Highway Traffic Safety Administration, 2014.

Huang, H., R. Hughes, C. Zegeer, and M. Nitzburg. *An Evaluation of the LightGuard Pedestrian Crosswalk Warning System*. Highway Safety Research Center, University of North Carolina, Chapel Hill, NC, 1999. http://www.dot.state.fl.us/safety/4-Reports/Bike-Ped/lgresrch.pdf. Viewed 2015.

Jones, S., and B. Philips. Cooperative Adaptive Cruise Control: Critical Human Factors Issues and Research Questions. In Proceedings of the Seventh International Driving Symposium on Human Factos in Driver Assessment, Training and Vehicle Design. Bolton Landing, New York, 2013.

Kristof, T., M.B. Lowry, G.S. Rutherford. *Assessing the Benefits of Traveler and Transportation Information Systems*. Report No. WA-RD 597.1. Washington State Transportation Center, Seattle, WA, 2005.

Liao, C. Using a Smartphone Application to Support Visually Impaired Pedestrians at Signalized Intersection Crossings. In *Transportation Research Record: Journal of the Transportation Research Board*, No. 2393, Transportation Research Board of the National Academies, Washington, D.C., 2013, pp. 12-20.

Liao, C., M. Rakauskas, and A. Rayankula. *Development of Mobile Accessible Pedestrian Signals (MAPS) for Blind Pedestrians at Signalized Intersections*. Report No. CTS 11-11. University of Minnesota, Center for Transportation Studies, 2011.

Malone, K., M. de Kievit, and S. Maas. Defining the Required Infrastructure Supporting Co-operative Systems. 19th ITS World Congress, 2012.

Narrigan, T.R., J.R. Herr, and T. Doherty. The Successful Deployment of a Transit Signal Priority System; Sumner Avenue, Springfield, Massachusetts. Presented at Bus and Paratransit Conference and International Roadeo, American Public Transportation Association, Nashville, TN, 2007.

Park, B., K. Malakorn, and J. Lee. Quantifying Benefits of Cooperative Adaptive Cruise Control Toward Sustainable Transportation System. Final Report. Mid-Atlantic Universities Transportation Center (MAUTC), 2011. http://www.mautc.psu.edu/docs/UVA-2009-01.pdf. Viewed 2015.

Stephens, D.R.; T.J. Timcho; E. Young; R.A. Klein; and J.L. Schroeder. Accelerated Vehicle-to-Infrastructure (V2I) Safety Applications: Concept of Operations Document, Report No. FHWA-JPO-13-058, U.S. Department of Transportation, Washington, D.C., 2012. http://ntl.bts.gov/lib/48000/48500/48523/272C82A5.pdf Viewed 2015.

University of Arizona, University of California PATH Program, Savari Networks, Inc. SCSC, and Econolite. *Multi-Modal Intelligent Traffic Signal System - System Design*. 2013.

U.S. Department of Transportation (U.S. DOT). *Freight Advanced Traveler Information System Concept of Operations*, Final Report, FHWA-JPO-12-065. 2012. http://ntl.bts.gov/lib/54000/54100/54104/12-065.pdf. Viewed 2015.

U.S. Department of Transportation (U.S. DOT). *Intelligent Transportation Systems for Traffic Signal Control*. 2005.

U.S. Department of Transportation (U.S. DOT). *Connected Vehicle Reference Implementation Architecture, Red Light Violation Warning*. 2015a. http://www.iteris.com/cvria/html/applications/app57.html. Viewed 2015.

U.S. Department of Transportation (U.S. DOT). *Connected Vehicle Reference Implementation Architecture, Stop Sign Gap Assist*. 2015b. http://www.iteris.com/cvria/html/applications/app70.html. Viewed 2015.

U.S. Department of Transportation (U.S. DOT). *Connected Vehicle Reference Implementation Architecture, Spot Weather Impact Warning*. 2015c http://www.iteris.com/cvria/html/applications/app74.html. Viewed 2015.

U.S. Department of Transportation (U.S. DOT). *Connected Vehicle Reference Implementation Architecture, Reduced Speed Zone Warning / Lane Closure*. 2015d. http://www.iteris.com/cvria/html/applications/app60.html. Viewed 2015.

U.S. Department of Transportation (U.S. DOT). *Connected Vehicle Reference Implementation Architecture, Pedestrian in Signalized Crosswalk Warning*. 2015e. http://www.iteris.com/cvria/html/applications/app51.html. Viewed 2015.

U.S. Department of Transportation (U.S. DOT). *Connected Vehicle Reference Implementation Architecture, Emergency Electronic Brake Light*. 2015f. http://www.iteris.com/cvria/html/applications/app23.html. Viewed 2015.

U.S. Department of Transportation (U.S. DOT). *Connected Vehicle Reference Implementation Architecture, Enhanced Maintenance Decision Support System*. 2015g. http://www.iteris.com/cvria/html/applications/app25.html. Viewed 2015.

U.S. Department of Transportation (U.S. DOT). *Connected Vehicle Reference Implementation Architecture, Emergency Communications and Evacuation*. 2015h. http://www.iteris.com/cvria/html/applications/app30.html. Viewed 2015.

U.S. Department of Transportation, Integrated Dynamic Transit Operations (U.S. DOT IDTO) *Concept of Operations*. 2012. http://ntl.bts.gov/lib/54000/54000/54067/12-083.pdf. Viewed 2015.

U.S. Department of Transportation, Intelligent Transportation Systems Joint Program Office (U.S. DOT ITS JPO). *Smart Roadside Fact Sheet*. 2011. http://www.its.dot.gov/factsheets/pdf/SmartRoadside.pdf. Viewed 2015.

U.S. Department of Transportation, Intelligent Transportation Systems Joint Program Office (U.S. DOT ITS JPO). *Eco-Lanes Operational Concept*. 2013. http://ntl.bts.gov/lib/51000/51700/51774/114.pdf. Viewed 2015.

U.S. Department of Transportation, Response, Emergency Staging, Communications, Uniform Management, and Evacuation (U.S. DOT RESCUME) *Concept of Operations*. Vol.2, 2012. http://ntl.bts.gov/lib/48000/48500/48520/66C294FF.pdf. Viewed 2015.

4.0 EUROPEAN COMMISSION REFERENCES

E1. Definition of Necessary Vehicle and Infrastructure Systems for Automated Driving, SMART 2010/0064, Study Report, 2011.

E2. Overview SMARTS 63-64-65, iMobility Forum Plenary Session, 25 October 2011.

E3. Defining the Required Infrastructure Supporting Co-operative Systems, Stakeholder Meeting SMART 0063, 27 May, 2011.

E4. New Services Enabled by the Connected Car, SMART 2010/0065, Final Report, TNO-RPT-2011-01277, 30 June, 2011.

E5. Defining the Required Infrastructure Supporting Co-operative Systems, Final Report, SMART 2010/0063, TNO-060-DTM-2011-03163, 16 December 2011.

E6. Defining the Required Infrastructure Supporting Co-operative Systems, Interim Report, SMART 2010/0063, TNO-060-DTM-2011-03163 VER 4.0 SMART 63 Annexes, 19 December 2011.

APPENDIX A

AASHTO APPLICATIONS NOT ON ODOT LIST

Table A. 1: List of AASHTO Applications Not on ODOT List

No.	Source	Group	Application Name	Acronym	CVRIA Application Name	Similar Application
V2I SAFETY						
A.2.	AASHTO	**V2I Safety**	AASHTO: Stop Sign Violation		Stop Sign Violation Warning	See Application **4.**
A.3.	AASHTO	**V2I Safety**	AASHTO: Driver Gap at Signalized Intersections		Red Light Violation Warning	See Application **2.**
AGENCY DATA						
A.4.	AASHTO	**Agency Data Applications**	AASHTO: CV-Enabled Traffic Model Baselining			See Application **17.**
A.5.	AASHTO	**Agency Data Applications**	AASHTO: CV-Enabled Predictive Traffic Studies			See Application **17.**
MOBILITY: EnableATIS • MMITSS • INFLO • RESCUME • IDTO • FRATIS						
A.6.	AASHTO	**FRATIS**	AASHTO: Real-Time Reliable Information	F-ATIS	Real-Time Reliable Information (F-ATIS)	
A.7.	AASHTO	**FRATIS**	AASHTO: Dynamic Route Guidance	F-DRG	Dynamic Route Guidance (F-DRG)	
A.8.	AASHTO	**FRATIS**	AASHTO: Information for Freight Carriers		Road Weather Information for Freight Carriers	

Table A. 2: V2I Safety ‣ AASHTO: Stop Sign Violation

Title	AASHTO: Stop Sign Violation
CVRIA Reference	Stop Sign Violation Warning
Description	See Application **4.** RSU in vicinity of stop sign sends out stop sign locations and directions. Vehicle OBU receives stop sign info and determines if a warning is appropriate.
Category	Vehicle to Infrastructure Safety
ODOT Application Number	--
Benefits/Impact	Improves safety at un-signalized intersections with posted stop signs by providing warnings to the driver approaching an un-signalized intersection.
Maturity	Elements in the application have been developed and individual components are relatively mature, but this does not exist as a stand-alone package at this stage.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside Interface, Driver-Infrastructure Interface, Driver-Vehicle Interface, Vehicle Systems Interface.
Infrastructure Requirements	Infrastructure Communications Interface, and Vehicle Communications Interface, Infrastructure SSGA Application.
Vehicle Component Requirements	Vehicle SSGA Application, and In-Vehicle Warning System.
Applicability	**Not on ODOT Priority List**; Similar to Application **4.**
Physical RSE Installation	Fixed
Roadside Interface to Local	No
Backhaul Communications	None
Backhaul Restrictions	N/A
Mapping Support	Localized Geometric
Siting Dependency	Non-Critical
Management of Collected Data	No
Back Office Services/Applications	No
Latency	Low
Vehicle Data Connection	Required

Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	None
Data Needs from Infrastructure	GIDs/Maps
Infographic	None

Table A. 3: V2I Safety ‣ AASHTO: Driver Gap at Signalized Intersections

Title	AASHTO: Driver Gap at Signalized Intersections
CVRIA Reference	Red Light Violation Warning
Description	See Application **2.** Road Side Equipment at signalized intersection determines the locations and speeds of oncoming vehicles. This information plus SPAT data is broadcast in vicinity of intersection. Vehicle OBU receives oncoming vehicle information and SPAT information, and determines if a warning is appropriate.
Category	Vehicle to Infrastructure Safety
ODOT Application Number	--
Benefits/Impact	The application in the vehicle uses the vehicle's speed and acceleration profile, along with the signal timing and geometry information to determine if it appears the vehicle will enter the intersection in violation of a traffic signal laws for that state. If the violation seems likely to occur, a warning can be provided to the driver.
Maturity	Red light enforcement systems already are in widespread use. In-vehicle warning systems have been tested and the individual technology components are mature but the system as a package has not yet been deployed.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside Interface, Driver-Vehicle Interface, Vehicle Systems Interface, Infrastructure Communications Interface, and Vehicle Communications Interface.
Infrastructure Requirements	Infrastructure RLVW Application (intersection GID, count of detected vehicles, information on each detected vehicle i.e. position, speed, and heading, minor road vehicle data i.e. position and heading, infrastructure signage information).
Vehicle Component Requirements	Vehicle RLVW Application and In-Vehicle Warning System.
Applicability	**Not on ODOT Priority List**; Similar to Application **2.**
Physical RSE Installation	Fixed
Roadside Interface to Local	Yes
Backhaul Communications	Optional
Backhaul Restrictions	Exclusive
Mapping Support	Localized Geometric
Siting Dependency	Critical
Management of Collected Data	No

Back Office Services/Applications	No
Latency	Low
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	None
Data Needs from Infrastructure	SPaT
Infographic	None

Table A. 4: Agency Data Applications ‣ AASHTO: CV-Enabled Traffic Model Baselining

Title	AASHTO: CV-Enabled Traffic Model Baselining
CVRIA Reference	
Description	See Application **17.** Vehicles provide speed information as a function of location and time in order to build a baseline model for analysis, optimized timing plans and predictive studies. Does not require real time connection for the model, real time traffic necessary to capture perturbations to the model.
Category	Agency Data Applications
ODOT Application Number	--
Benefits/Impact	Agencies can save substantial resources devoted to data collection for traffic modeling.
Maturity	In general data collection for traffic modeling, traffic monitoring, and HPMS are very mature.
Interface Requirements	None
Infrastructure Requirements	Infrastructure data interface
Vehicle Component Requirements	Vehicle application and interface
Applicability	**Not on ODOT Priority List**; Similar to Application **17.**
Physical RSE Installation	Portable or Fixed
Roadside Interface to Local	No
Backhaul Communications	Optional
Backhaul Restrictions	Exclusive
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	No
Latency	High
Vehicle Data Connection	Not Required
Benefits vs.	Benefits Realizable Day One

Deployment Level	
Other Dependency	None
Data Needs from OBU	BSM1
Data Needs from Infrastructure	None
Infographic	None

Table A. 5: Agency Data Applications ‣ AASHTO: CV-Enabled Predictive Traffic Studies

Title	AASHTO: CV-Enabled Predictive Traffic Studies
CVRIA Reference	
Description	See Application **17.** Vehicles provide speed information as a function of location and time in order to build a baseline model for analysis, optimized timing plans and predictive studies. Does not require real time connection for the model, real time traffic necessary to capture perturbations to the model.
Category	Agency Data Applications
ODOT Application Number	--
Benefits/Impact	Agencies can save substantial resources devoted to data collection for predictive traffic studies.
Maturity	In general, data collection and processing for predictive traffic studies is very mature.
Interface Requirements	None
Infrastructure Requirements	Infrastructure data interface
Vehicle Component Requirements	Vehicle application and interface
Applicability	**Not on ODOT Priority List**; Similar to Application 77.
Physical RSE Installation	Portable or Fixed
Roadside Interface to Local	No
Backhaul Communications	Optional
Backhaul Restrictions	Exclusive
Mapping Support	Road Network

Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	No
Latency	High
Vehicle Data Connection	Not Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	BSM1
Data Needs from Infrastructure	None
Infographic	None

Table A. 6: FRATIS ‣ AASHTO: Real-Time Reliable Information

Title	AASHTO: Real-Time Reliable Information
CVRIA Reference	Real-Time Reliable Information (F-ATIS)
Description	FRATIS shall provide a specialized output interface to public sector agencies that will provide open-source data collected in the FRATIS system, such as sanitized route, speed, congestion, and alternate route selection information. This information shall support public sector freight planners and other public agencies in assessing both the needs and impacts of truck traffic in a metropolitan region (e.g., air quality reductions due to FRATIS applications, assessment of the best alternate routes, and information on where to potentially plan new connectors to support better dynamic routing). The format of the public sector output data shall be determined during the FRATIS System Development and Limited Testing phase. Similar to Applications **31.** And **46.**
Category	Mobility
ODOT Application Number	--
Benefits/Impact	The implementation of freight-specific ATIS enabled via connected vehicles will improve safety by decreasing the number of crashes, injuries and fatalities, and in turn, reduce medical costs, insurance costs, and property damage.
Maturity	Freight specific ATIS without connectivity is already being used in industry. Freight specific ATIS with connectivity has been demonstrated. Increasing penetration rate of connected vehicles and DSRC increases freight specific ATIS capabilities and may reduce agency costs for sensors and surveillance.
Interface Requirements	Back Office Interface, Infrastructure Data Interface, Roadside interface, and Infrastructure Communications Interface.
Infrastructure Requirements	Infrastructure Application.
Vehicle Component Requirements	Vehicle Application
Applicability	**Not on ODOT Priority List**
Physical RSE Installation	Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Limited Domains
Mapping Support	Road Network

Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	BSM1+other
Data Needs from Infrastructure	TI
Infographic	None

Table A. 7: FRATIS ‣ AASHTO: Dynamic Route Guidance

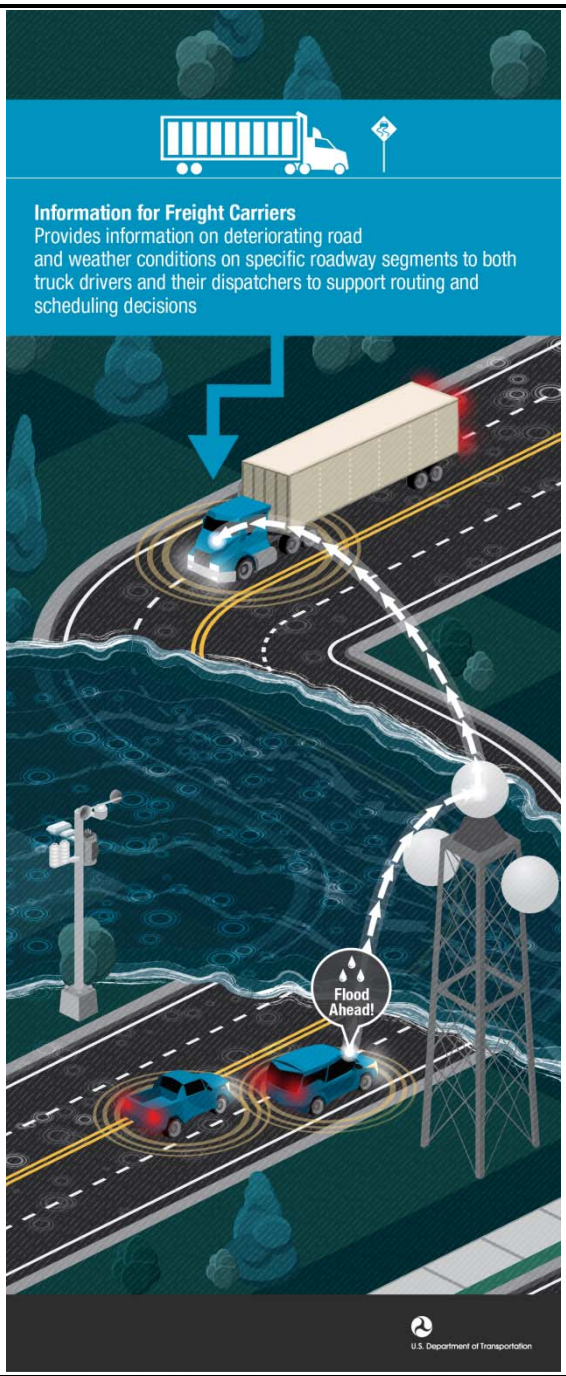
Title	AASHTO: Dynamic Route Guidance
CVRIA Reference	Dynamic Route Guidance (F-DRG)
Description	Vehicle passes an RSU and provides speed, location and destination information. RSU relays information to central server where data is compounded with other data to derive the optimum route. Route is passed back to RSU and on to vehicle. Similar to Application **36.**
Category	Mobility
ODOT Application Number	--
Benefits/Impact	Fuel saving and emission reduction are expected due to optimal routing.
Maturity	Well researched and considered in the FRATIS operational scenario.
Interface Requirements	Back office interface, infrastructure data interface, roadside interface, driver-vehicle interface
Infrastructure Requirements	None
Vehicle Component Requirements	None
Applicability	**Not on ODOT Priority List**
Physical RSE Installation	Fixed

Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Exclusive
Mapping Support	Road Network
Siting Dependency	Non-Critical
Management of Collected Data	Yes
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Require Threshold Deployment Level
Other Dependency	Privacy
Data Needs from OBU	BSM1+other
Data Needs from Infrastructure	TI
Infographic	 (Source: http://goo.gl/RLc1Du)

Table A. 8: FRATIS ‣ AASHTO: Information for Freight Carriers

Title	AASHTO: Information for Freight Carriers
CVRIA Reference	Road Weather Information for Freight Carriers
Description	This application can be considered a special case of the Road-Weather Motorist Advisory and Warning System. Truck drivers have similar access to the variety of traveler information systems that are available to all road users. However, the available traveler information options are almost always intended for use by passenger car drivers. The limitations of the existing systems with respect to the type and quality of information provided have particular impacts on motor carriers. See Application **39.**
Category	Road Weather
ODOT Application Number	--
Benefits/Impact	A high proportion of collisions are caused by adverse weather conditions. Though weather forecast is very reliable a real time weather advisories streamed to traffic management centers from connected vehicles can add robustness and pertinence to the prediction by giving the locally adequate warnings.
Maturity	With advances in RWIS, and other weather data collection and management systems, the weather related advisories and warning application is relatively mature and ready to be deployed once the infrastructure communications network and in-vehicle systems are available.
Interface Requirements	ITS Roadway Equipment, Maintenance and Construction Vehicle Platform, Weather Service
Infrastructure Requirements	Maintenance and Construction Management Center "Roadside Equipment" (RSE)
Vehicle Component Requirements	Maintenance and Construction Vehicle OBE, Dedicated Short Range Communications (DSRC)
Applicability	**Not on ODOT Priority List**
Physical RSE Installation	Fixed
Roadside Interface to Local	No
Backhaul Communications	Required
Backhaul Restrictions	Limited Domains
Mapping Support	Lane Level
Siting Dependency	Non-Critical
Management of	Yes

Collected Data	
Back Office Services/Applications	Yes
Latency	High
Vehicle Data Connection	Required
Benefits vs. Deployment Level	Benefits Realizable Day One
Other Dependency	None
Data Needs from OBU	BSM1+2
Data Needs from Infrastructure	App-specific

Infographic	

APPENDIX B

EUROPEAN COMMISSION APPLICATIONS NOT ON ODOT LIST

APPENDIX B: EUROPEAN COMMISSION APPLICATIONS NOT ON ODOT LIST

Table B. 1: European Commission Long List of Services Including the Results of the Assessment

ODOT No.	No.	Name Of Service	Short Description	Reference	Category	EU Wide Implementation	Technical Maturity	Impact			Total	Remarks
								Safety	Efficiency	Comfort		
8. 50.	1	Emergency Vehicle Warning	Warns drivers to yield right of way to an approaching emergency vehicle.	PREDRIVE C2X 3.1.1 Emergency vehicle warning DRIVE Approaching emergency vehicle warning	Safety	3	3	4	2	2	14	
14.	2	Overtaking Vehicle Warning	An overtaking (passing) vehicle signals its action to the vehicle being overtaken to secure the situation. SAF: Integration of blind spot notification	PREDRIVE C2X 3.1.7 Overtaking vehicle warning SAFESPOT Safe overtaking	Safety	2	3	3	1	3	12	
13.	3	Lane Change Assistant	Provides information about cars on neighboring lanes when the driver intends to make a lane change. SAF: Safe lane change with blind spot for trucks	PREDRIVE C2X 3.1.13 Lane change assistant SAFESPOT Lane change maneuver	Safety	2	3	3	1	2	11	
54.	4	Cooperative Merging Assistance	Vehicles negotiate the merging process with each other and give advice to the driver.	PREDRIVE C2X 3.1.16 Co-operative merging assistance	Safety	2	2	3	3	4	14	
	5	Cooperative Glare Reduction	Enables automatic switching of headlights (high-beam to low-beam) of the vehicle when it approaches an oncoming vehicle	PREDRIVE C2X3.1.17 Co-operative glare reduction	Safety	1	3	2	1	4	11	
1.	6	Intersection	Crossing vehicle collision	PREDRIVE C2X 3.1.8	Safety	1	4	5	1	1	12	

ODOT No.	No.	Name Of Service	Short Description	Reference	Category	EU Wide Implementation	Technical Maturity	Impact			Total	Remarks
								Safety	Efficiency	Comfort		
2.		Collision Warning	warning Informs/warns driver in case of potential collision with crossing vehicles.	Intersection collision warning 3.2.6 Intersection management SAFESPOT road safety intersection								
1. 12.	7	Left (Right) Turn Collision Warning	Informs/warns driver in case of potential collision with oncoming vehicles.	PREDRIVE C2X 3.1.18 Left turn collision warning PREDRIVE C2X 3.1.19 Right turn collision avoidance	Safety	1	3	3	1	1	9	7
4.	8	Signal/Sign Violation Warning	Red traffic light violation warning warns drivers when they are going to violate a red traffic light signal	PREDRIVE C2X 3.1.11 Signal violation warning / signal preemption	Safety	3	4	4	1	2	14	8
4.	9	Stop Sign Violation Warning	Warns drivers when they are going to violate a Stop sign rule	DRIVE/PREDRIVE C2X 3.1.12 Stop sign violation	Safety	3	5	6	2	2	18	9
3.	10	Speed Limit Violation Warning	Warns drivers when they are going to violate a speed limit indication	CVIS Dynamic speed limit	Safety	1	3	3	2	3	12	10
9.	11	Emergency Electronic Brake Light	Warns drivers before driving into a (suddenly) hard breaking vehicle.	DRIVE/PREDRIVE C2X 3.1.2 Emergency electronic brake lights	Safety	3	4	5	2	4	18	11
	12	Wrong Way Driving Warning	Detects wrong way driving vehicles and warn affected, endangered drivers.	COOPERS S1c wrong-way driver warning; PREDRIVE C2X 3.1.3 Wrong way driving warning	Safety	5	5	9	3	2	24	12

ODOT No.	No.	Name Of Service	Short Description	Reference	Category	EU Wide Implementation	Technical Maturity	Impact			Total	Remarks
								Safety	Efficiency	Comfort		
				CVIS Ghost driver detection (a: Service Provider is owner of the Infrastructure) CVIS Ghost driver detection (b: Service Provider is not the owner of the Infrastructure)								
	13	Wrong Way Driving Warning In Gas Stations	Information of driver when entering gas stations in the wrong direction in order to improve traffic flow in gas stations especially on motorways	DRIVE Wrong way driving warning in gas stations	Efficiency	2	3	2	1	1	9	
10. 14.	14	Head On Collision Warning	Early warnings for situations where vehicles, travelling on opposite directions, may face the risk of an head on collision; specific use cases are presented where the advantages of V2V communication respect to ADAS sensing are emphasized;	SAFESPOT Head on collision warning	Safety	1	3	4	2	1	11	
	15	Pre-Crash Sensing	Prepares for imminent and unavoidable collisions by exchanging vehicle attributes after a non-avoidable crash is detected.	PREDRIVE C2X 3.1.14 Pre-crash sensing warning	Safety	1	3	3	1	1	9	
28. 44. 59.	16	Cooperative Flexible Lane Change	Considers the flexible allocation of a dedicated lane (e.g. reserved to public transport) to some vehicles, which get a permanent or temporary access right.	COOPERS S4a Lane banning COOPERS S4b Lane keeping; COOPERS S4c Auxiliary	Efficiency	3	5	4	6	1	19	

ODOT No.	No.	Name Of Service	Short Description	Reference	Category	EU Wide Implementation	Technical Maturity	Impact			Total	Remarks
								Safety	Efficiency	Comfort		
				Lane Accessibility?? PREDRIVE C2X 3.2.7 Co-operative flexible lane change CVIS Flexible bus lane								
10.	17	Cooperative Forward Collision Warning	Warns drivers when collisions (rear-end collisions, etc.) might happen. SAF: Warnings for head to tail collisions, where host vehicle is moving (static scenarios covered by the frontal collision warning function) and it risks the rear end collision due – for instance –to a slow down due to road shape (hills, curves)	PREDRIVE C2X 3.1.15 Cooperative forward collision warning SAFESPOT Rear end collision warning	Safety	3	3	3	2	1	12	
5. 39. 42.	18	Hazardous Location Notification	Warns drivers against upcoming bad weather road conditions (slippery road, fog, rain, etc.)	COOPERS S2 Weather condition warning PREDRIVE C2X 3.1.9 Hazardous location notification DRIVE Hazardous location notification DRIVE/Weather warning SAFESPOT Road condition status–slippery road	Safety	5	5	4	4	3	21	
55.	19	Car Breakdown Warning	Warns drivers when approaching a breakdown car either by the stranded car itself or by a following car that detects a	COOPERS S1a Accident warning COOPERS S1b Incident warning	Safety	4	5	5	4	2	20	

ODOT No.	No.	Name Of Service	Short Description	Reference	Category	EU Wide Implementation	Technical Maturity	Impact			Total	Remarks
								Safety	Efficiency	Comfort		
			disabled vehicle (e.g., detecting zero velocity).	DRIVE/PREDRIVE C2X 3.1.5 Car breakdown warning FOTSIS Safety Incident Management								
52.	20	Traffic Jam Ahead Warning	Warns drivers when approaching the tail end of a traffic jam.	COOPERS S6 Traffic congestion warning DRIVE/PREDRIVE C2X 3.1.10 Traffic jam ahead warning FOTSIS Safety Incident Management	Safety	7	5	5	3	1	21	
10.	21	Frontal Collision Warning	Warnings for head to tail collisions; risks of frontal collision due – for instance – to the presence of static or reduced speed traffic.	SAFESPOT Frontal collision warning	Safety	3	3	4	2	1	13	
8.	22	Slow Vehicle Warning	Warns drivers to prevent rear-end collisions to slow moving vehicles.	COOPERS S1b Incident warning DRIVE/PREDRIVE C2X 3.1.6 Slow vehicle warning FOTSIS Safety Incident Management?	Safety	4	5	4	3	2	18	
22. 56.	23	Road Works Warning	Informs drivers of ongoing road works and associated obstruction of road traffic in the vicinity.	COOPERS S3 Roadwork information DRIVE/PREDRIVE C2X 3.1.21 Road works warning	Safety	7	5	7	5	3	27	
	24	Post Crash	Warns drivers when approaching	COOPERS S1a	Safety	4	5	6	4	2	21	

ODOT No.	No.	Name Of Service	Short Description	Reference	Category	EU Wide Implementation	Technical Maturity	Impact			Total	Remarks
								Safety	Efficiency	Comfort		
		Warning	a crashed car either by the crashed car itself or by a following car that detects a crashed vehicle warning ahead.	Accident Warning DRIVE/PREDRIVE C2X 3.1.4 Post crash warning								
3.	25	Curve Speed Warning	Based on received curve information the safe speed is calculated for the vehicle entering the curve and the driver will be warned if current speed is higher than safe speed. SAF: Information is gathered and delivered with a sufficient anticipation to the driver about the road curvature and the adequate speed to keep in the specific black spot. Conditions that may dynamically change the speed and the trajectory to avoid going off the road (road works, static obstacles) are also tackled.	DRIVE/PREDRIVE C2X 3.1.20 Curve speed warning SAFESPOT Curve warning	Safety	2	4	4	1	2	13	
55.	26	Obstacle On Driving Surface Warning	Warns drivers to prevent collisions with stationary or moving obstacles in the carriageway	COOPERS S1b Incident warning FOTSIS Safety Incident Management? DRIVE Obstacle warning	Safety	3	5	6	4	2	20	
6. 49.	27	Vulnerable Road User Warning	Provides warning to driver of the presence of vulnerable road users, e.g. motorcycles in case of dangerous situations.	PREDRIVE C2X Vulnerable road user warning 3.1.23 Motorcycle warning DRIVE Motorcycle	Safety	3	5	8	3	3	22	

ODOT No.	No.	Name Of Service	Short Description	Reference	Category	EU Wide Implementation	Technical Maturity	Impact			Total	Remarks
								Safety	Efficiency	Comfort		
				approaching indication SAFESPOT Vulnerable Road User								
8.	28	Special Vehicle Tracking	Special vehicle communication critical in-vehicle information to the infrastructure. The infrastructure monitors the spatial vehicle conditions, and deploys intervention protocols should prevent an emergency occurs.	FOTSIS Special Vehicle Tracking	Safety	1	3	4	3	1	12	
	29	Advanced Enforcement	Integration of infrastructure data with vehicle data to control traffic offenses (speed, toll, kamikaze). Notification of rules and infractions to the drivers by I2V communications. Enforcement action if necessary (Han having).	FOTSIS Advanced Enforcement	Safety	1	2	5	8	1	17	This service may not enjoy user acceptance and therefore unlikely to be deployed EU-wide.
41.	30	Infrastructure Safety Assessment	Infrastructure safety assessment analyzing information provided by the infrastructure and in-vehicle information (concept of OBU as a black box). Reconstruction of specific safety-related situations and driving behaviour (post-processing). Evaluation of safety in specific stretches of a highway.	FOTSIS Infrastructure Safety Assessment	Safety	1	2	2	1	1	7	
20.	31	Traffic Control Assessment	Service which assesses local traffic strategies based on real time traffic information.	CVIS Traffic Control Assessment	Efficiency	1	3	3	4	2	13	

ODOT No.	No.	Name Of Service	Short Description	Reference	Category	EU Wide Implementation	Technical Maturity	Impact			Total	Remarks
								Safety	Efficiency	Comfort		
61.	32	Dangerous Goods Route Guidance	Service which supports a truck driver and fleet operator to transport dangerous goods safely. Sensitive areas are provided by the (local) government to the service provider, which uses this information to guide the trucks. A dangerous goods vehicle wants to start CVIS journey and has to register at a traffic management centre which is routing the vehicle during CVIS trip. The traffic management centre provides route guidance to the dangerous goods vehicle and the vehicle is sending back the information of CVIS position and CVIS status.	CVIS Route guidance (use case)	Safety	2	3	4	3	1	13	
61.	33	Dangerous Goods Monitoring	Service which enables a (local) government authority, emergency authorities and traffic control centers to follow trucks containing dangerous goods and to provide them with emergency routes or instructions in necessary cases. The fleet operator and further call centers like police and emergency services have the possibility to have a look at the registered dangerous vehicles by means of a map display. The traffic supervisor defines the	CVIS Monitoring (Use Case)	Safety	3	3	4	3	1	14	

ODOT No.	No.	Name Of Service	Short Description	Reference	Category	EU Wide Implementation	Technical Maturity	Impact			Total	Remarks
								Safety	Efficiency	Comfort		
			dangerous goods vehicle preferred network and in case of an incident he decides on temporary changes of this network to reroute the vehicle in an efficient and safe way.									
47. 51.	34	V2I Traffic Optimization	Optimize traffic flow by intelligently applying regulations to road side infrastructure	PREDRIVE C2X 3.2.9 V2I traffic optimization	Efficiency	2	3	2	4	2	13	
46.	35	Decentralized Floating Car Data	Informs the driver with advice about the conditions along his further route.	COOPERS S13 Floating Car Data not decentralized FCD but monitoring functionality DRIVE/PREDRIVE C2X 3.2.1 Decentralized floating car data	Safety	7	3	6	4	3	23	
23.	36	Green Light Optimal Speed Advisory	Drivers receive a recommendation in order to hit the next traffic lights in green phase and to avoid waste acceleration.	DRIVE/PREDRIVE C2X 3.2.3 Green light optimal speed advisory	Efficiency	3	4	1	4	3	15	
31. 35. 46.	37	Traffic Information and Recommended Itinerary	Recommends a route for the vehicle navigation system to direct the driver around congested locations and to distribute the traffic load on alternative routes. A special use case is the guidance to a parking place, which helps to avoid unnecessary drives searching for a free slot.	COOPERS S10 Estimated Journey Time COOPERS S11 Recommended next link DRIVE/PREDRIVE C2X 3.2.4 Traffic information and recommended itinerary FOTSIS Intelligent Congestion Control	Efficiency	6	5	2	5	4	22	

ODOT No.	No.	Name Of Service	Short Description	Reference	Category	EU Wide Implementation	Technical Maturity	Impact			Total	Remarks
								Safety	Efficiency	Comfort		
				FOTSIS Dynamic Route Planning CVIS CTA (Co-operative Traveller Assistance) CVIS Dynamic routing CVIS Strategy routing								
31. 36. 46. 61.	38	Enhanced Route Guidance	Exploits traffic information provided by a public traffic monitoring authority to empower a better navigation.	PREDRIVE C2X 3.2.5 Enhanced route guidance and navigation FOTSIS Dynamic Route Planning CVIS CTA (Co-operative Traveler Assistance)	Efficiency	6	4	2	5	4	21	
46.	39	Information Application	Services which provide drivers with real time information on traffic state, incident and travel time to the city center via various routes.	CVIS Information application	Efficiency	3	4	2	4	4	17	
31. 36. 46. 61.	40	Micro Routing	Service which provides drivers with an alternative route to avoid congestion in urban area and reduce travel time (e.g. caused by traffic lights).	CVIS Micro Routing	Efficiency	1	5	1	2	5	14	
24. 47.	41	Traffic Light Optimization	The intersection controller optimizes the traffic light phases based on the information from the vehicles at the intersection in order to reduce the overall waiting time for the vehicles		Efficiency	2	4	2	5	5	18	
51.	42	Speed Profile	Service which enables fluent traffic flow management,	CVIS Speed profile	Efficiency	2	4	2	6	4	18	

ODOT No.	No.	Name Of Service	Short Description	Reference	Category	EU Wide Implementation	Technical Maturity	Impact			Total	Remarks
								Safety	Efficiency	Comfort		
			supporting driver groups with a group specific, dynamic speed advice which enables the cars within the group to pass a green traffic light.									
43. 44. 45. 28.	43	Limited Access Warning	Controls the entrance to an area or road segment where some or most vehicles have limited access. An ITS Roadside Station at the entrance announces its presence and approaching vehicles may validate themselves to seek access.	PREDRIVE C2X 3.2.10 Limited access warning	Efficiency	2	4	1	2	4	13	
3. 4.	44	In-Vehicle Signage	Informs the driver about effective speed limits along the road including special or contextual variations. Also speed recommendations are included.	COOPERS S5 In-Vehicle Variable Speed Limit Information DRIVE/PREDRIVE C2X 3.2.2 Regulatory and contextual speed limit 3.2.11 In-vehicle signage CVIS Dynamic speed limit SAFESPOT Speed limitation and safety distance	Safety	7	5	9	5	6	32	
51.	45	Intelligent Speed Adaptation (ISA) With Infrastructure Links	Inform drivers of the current recommended speed limit and provide support to match their automatic speed control to prevailing traffic, weather and	COOPERS S7 ISA with infrastructure links	Comfort	1	2	2	2	4	11	

ODOT No.	No.	Name Of Service	Short Description	Reference	Category	EU Wide Implementation	Technical Maturity	Impact			Total	Remarks
								Safety	Efficiency	Comfort		
			road conditions.									
26. 34.	46	Adaptive Power Train Management	Infrastructure informs about road structure ahead (such as slope, curve) and possible dynamic road traffic information (for example, queue warning). The vehicle uses the information to prepare and optimize the power train performance (shift, throttle, brakes...).	PREDRIVE C2X 3.2.8 Adaptive drive train management	Efficiency	2	3	1	4	3	13	
53.	47	Cooperative Adaptive Cruise Control And Cooperative Vehicle Highway Automation System	Automated positional and velocity control of vehicles to operate as a platoon on a highway.	PREDRIVE C2X Co-operative adaptive cruise control Co-operative vehicle-highway automation system	Efficiency	2	3	3	5	3	16	
39.	48	Point Of Interest Notification	Drivers receive notifications informing about local peculiarities.	DRIVE/PREDRIVE C2X 3.3.1 Point of interest notification	Comfort	2	4	2	2	3	13	
35. 64.	49	Automatic Access Control / Parking Management Incl. ITP	Grants access to restricted areas automatically. This also includes Intelligent Truck Parking related service.	PREDRIVE C2X3.3.2 Automatic access control/ parking management CVIS Highway resting area	Efficiency	7	5	2	4	5	23	
43. 44. 45. 28.	50	Access Control Area Monitoring	Access control Area Monitoring" service allows local authorities to manage and monitor the access of vehicles into sensitive, critical or dangerous areas, based on local policies. This is to avoid the	CVIS Access control Area Monitoring CVIS Urban parking zones	Comfort	2	4	1	2	4	13	

ODOT No.	No.	Name Of Service	Short Description	Reference	Category	EU Wide Implementation	Technical Maturity	Impact			Total	Remarks
								Safety	Efficiency	Comfort		
			entrance of vehicles which are not allowed or suited to enter the area (e.g. dangerous goods load or height / weight regulations). Access authorization or denial is communicated by the local authority to the vehicle based on current situation, either after a remote monitoring of the vehicle status, or based on static policies (e.g. on Sundays access to a specific city area is forbidden). Areas managed by this kind of control are typically urban (e.g. city centers, city parks outskirts), but can be also suburban like tunnels or bridges.									
46.	51	Local Commerce	Vehicle drivers get in touch with local business and consume offered services.	PREDRIVE C2X 3.3.3 Local commerce DRIVE Local electronic commerce	Comfort	1	2	1	1	3	8	
60.	52	Car Rental/Sharing Assignment/ Reporting	A roadside unit, which has the capability to manage the booking of non-assigned vehicles and the release of returned vehicles.	PREDRIVE C2X 3.3.4 Car rental / sharing assignment / reporting	Comfort	1	2	1	1	3	8	
60.	53	Transparent Leasing	Use of data on vehicle usage and status to better adapt leasing contracts to lease's needs and habits and to improve processes at leasing companies	DRIVE Transparent leasing	Comfort	1	2	1	1	3	8	
43.	54	Electronic Toll	A vehicle pays the road toll	COOPERS S9 Road	Efficiency	1*	9	3	5	1	19	*Common

ODOT No.	No.	Name Of Service	Short Description	Reference	Category	EU Wide Implementation	Technical Maturity	Impact			Total	Remarks
								Safety	Efficiency	Comfort		
		Collect	electronically and fully automatic by means of communication without stopping.	Charging to influence on demand; PREDRIVE C2X 3.3.5 Electronic toll collect								interest for EFC does not exist in EU
46.	55	High Speed Internet Access	Media download of multimedia content (audio, video) for entertainment. Map download and update Download of map updates from map servers Ecological drive Techniques focusing on safe, environment-friendly and economic driving style and behavior. Instant messaging Vehicle-to- vehicle instant messaging service (also known as chat system). Personal data synchronization Exchange of personal data for synchronization between devices of the vehicle driver/owner and components in the home infrastructure, e.g., a personal computer.	PREDRIVE C2X 3.3.6 Media downloading 3.3.7 Map download and update 3.3.8 Ecological drive 3.3.9 Instant messaging 3.3.10 Personal data synchronization (COOPERS S12 Map update)	Comfort	1	5	1	1	2	10	
39.	56	Stolen Vehicle Alert	The information about a stolen vehicle provided to relevant authorities	PREDRIVE C2X 3.3.12 Stolen Vehicle Alert	Comfort	2	9	1	1	4	17	
63.	57	Remote Diagnosis And Just In Time Notification	A vehicle exchanges information with a vehicle service center for a remote functional diagnosis.	PREDRIVE C2X 3.3.13 Remote diagnosis and just in time repair notification	Comfort	1	9	2	1	3	16	
--	58	Dealer Management	Provision of information on the	DRIVE Dealer	Comfort	1	9	2	1	3	16	

ODOT No.	No.	Name Of Service	Short Description	Reference	Category	EU Wide Implementation	Technical Maturity	Impact			Total	Remarks
								Safety	Efficiency	Comfort		
			actual vehicle status to service organization of OEMs; this improves processes in workshops and intensifies contact to customers.	management								
61. 62.	59	Fleet Management	Communication and data processing for assisted management of vehicle fleets, including vehicle maintenance and vehicle tracking. Driver management and transport logistics.	DRIVE/PREDRIVE C2X 3.3.18 Fleet management	Comfort	1	9	2	2	3	17	
--	60	Vehicle Software Provisioning And Update	A vehicle service station provides new software or software updates for vehicles.	DRIVE/PREDRIVE C2X 3.3.18 3.3.19 Vehicle software provisioning and update	Comfort	1	3	2	1	4	11	
55.	61	E-call	Automated transmission of emergency messages to a service centre in case of life- threatening emergency (in-vehicle detection).	PREDRIVE C2X 3.3.11 SOS service FOTSIS Emergency Management	Safety	8	9	3	1	2	23	
--	62	Vehicle Relationship Management	Connects vehicles to an IP-based backbone infrastructure. General objective is to establish a bi-directional information exchange in order to support commercial and business opportunities	PREDRIVE C2X 3.3.14 Vehicle relation management	Comfort	3	4	1	1	3	12	
--	63	Design Re-use and Change Management	Management of product design reuse and change in the automotive industry economical	PREDRIVE C2X 3.3.14 3.3.15 Design re-use and change	Comfort	1	3	1	1	3	9	

ODOT No.	No.	Name Of Service	Short Description	Reference	Category	EU Wide Implementation	Technical Maturity	Impact			Total	Remarks
								Safety	Efficiency	Comfort		
			system.	management								
--	64	Business Intelligence for High- Volume Service Parts Management	Optimization of service parts management in the automotive industry economical system.	PREDRIVE C2X 3.3.16 Business intelligence for high-volume service parts management	Comfort	1	3	1	1	3	9	OEM Related
--	65	Insurance and Financial Services	On-demand and real time interaction with financial and insurance coverage service providers.	DRIVE/PREDRIVE C2X 3.3.17 Insurance and financial services	Comfort	1	9	4	2	4	20	Different pricing models used in Europe
45.	66	Pay/Earn As You Drive (Congestion)	Reward (or punish) drivers when not driving (or when driving) in traffic-peak regions during traffic peak hours. A system in the car controls the time and route of the driver and communicates with a (de)central system.		Efficiency	1	5	2	7	1	16	

Sources:

- COMeSafety Deliverable D31 European ITS Communication Architecture
- EasyWay Proposal for first priority EasyWay cooperative services
- COOPERS Services Deliverable D13
- PREDRIVE C2X Deliverable D4.1
- FOTSIS (Data from “Cooperative Systems – List of services” – email Kerry 18.3.)
- CVIS Deliverable D.DEPN 5.1 Costs, benefits and business models, Version 31 (Comment ATE: Covers those services for which Conceptual Service Business Models have been provided)
- DRIVE (Data from “Cooperative Systems – List of services” – Email Kerry 18.3.)

APPENDIX C

CVRIA SUPPORT CORE SERVICES

APPENDIX C: CVRIA SUPPORT CORE SERVICES

Table C1: CVRIA Support Core Services

No.	Source	Group	Application Name	CVRIA Application Name
94.	CVRIA	**Support Core Services**	Connected Vehicle Map Management	Connected Vehicle Map Management
95.	CVRIA	**Support Core Services**	Core Authorization	Core Authorization
96.	CVRIA	**Support Core Services**	Data Distribution	Data Distribution
97.	CVRIA	**Support Core Services**	Infrastructure Management	Infrastructure Management
98.	CVRIA	**Support Core Services**	Location and Time	Location and Time
99.	CVRIA	**Support Core Services**	Object Registration and Discovery	Object Registration and Discovery
100.	CVRIA	**Support Core Services**	Privacy Protection	Privacy Protection
101.	CVRIA	**Support Core Services**	System Monitoring	System Monitoring
102.	CVRIA	**Support Security**	Security and Credentials Management	Security and Credentials Management

APPENDIX D

CVRIA APPLICATIONS

APPENDIX D: CVRIA APPLICATIONS

TABLE D-1: CVRIA Application Listing

This table contains the current Connected Vehicle Reference Implementation Architecture hierarchy of applications. The applications considered this study are highlighted and the fourth column in the table indicates the ODOT application number for reference.

Source: http://www.iteris.com/cvria/html/applications/applications.html

Type	Group	Application Name	ODOT No.
Environmental	AERIS/ Sustainable Travel	Connected Eco-Driving	26
		Dynamic Eco-Routing	36
		Eco-Approach and Departure at Signalized Intersections	23
		Eco-Cooperative Adaptive Cruise Control	30
		Eco-Freight Signal Priority	48
		Eco-Integrated Corridor Management Decision Support System	37
		Eco-Lanes Management	28
		Eco-Multimodal Real-Time Traveler Information	31
		Eco-Ramp Metering	32, 54
		Eco-Smart Parking	35, 63
		Eco-Speed Harmonization	29
		Eco-Traffic Signal Timing	24

		Eco-Transit Signal Priority	25
		Electric Charging Stations Management	27, 34
		Low Emissions Zone Management	33, 38
		Roadside Lighting	--
	Road Weather	Enhanced Maintenance Decision Support System	40
		Road Weather Information and Routing Support for Emergency Responders	42
		Road Weather Information for Freight Carriers	42
		Road Weather Information for Maintenance and Fleet Management Systems	42
		Road Weather Motorist Alert and Warning	39
		Variable Speed Limits for Weather-Responsive Traffic Management	51
Mobility	Border	Border Management Systems	--
	Commercial Vehicle Fleet Operations	Container Security	63
		Container/Chassis Operating Data	--
		Electronic Work Diaries	--
		Intelligent Access Program	--
		Intelligent Access Program - Mass Monitoring	--
	Commercial Vehicle Roadside Operations	Intelligent Speed Compliance	--
		Smart Roadside Initiative	63,

			64
	Electronic Payment	Electronic Toll Collection	43
		Road Use Charging	43
	Freight Advanced Traveler Information Systems	Freight Drayage Optimization	62
		Freight-Specific Dynamic Travel Planning	61
	Planning and Performance Monitoring	Performance Monitoring and Planning	19
	Public Safety	Advanced Automatic Crash Notification Relay	--
		Emergency Communications and Evacuation	57
		Incident Scene Pre-Arrival Staging Guidance for Emergency Responders	55
		Incident Scene Work Zone Alerts for Drivers and Workers	56
	Traffic Network	Cooperative Adaptive Cruise Control	53
		Queue Warning	52
		Speed Harmonization	51
		Vehicle Data for Traffic Operations	17, 20
	Traffic Signals	Emergency Vehicle Preemption	50
		Freight Signal Priority	48
		Intelligent Traffic Signal System	47
		Pedestrian Mobility	49
		Transit Signal Priority	48
	Transit	Dynamic Ridesharing	60

		Dynamic Transit Operations	59
		Integrated Multi-Modal Electronic Payment	
		Intermittent Bus Lanes	
		Route ID for the Visually Impaired	
		Smart Park and Ride System	35
		Transit Connection Protection	58
		Transit Stop Request	
	Traveler Information	Advanced Traveler Information Systems	46
		Traveler Information- Smart Parking	35, 63
Safety	Transit Safety	Transit Pedestrian Indication	
		Transit Vehicle at Station/Stop Warnings	
		Vehicle Turning Right in Front of a Transit Vehicle	15
	V2I Safety	Curve Speed Warning	3
		In-Vehicle Signage	
		Oversize Vehicle Warning	8
		Pedestrian in Signalized Crosswalk Warning	6
		Railroad Crossing Violation Warning	7
		Red Light Violation Warning	2
		Reduced Speed Zone Warning / Lane Closure	56
		Restricted Lane Warnings	56

		Spot Weather Impact Warning	5
		Stop Sign Gap Assist	4
		Stop Sign Violation Warning	4
		Warnings about Hazards in a Work Zone	22
		Warnings about Upcoming Work Zone	22
	V2V Safety	Blind Spot Warning + Lane Change Warning	13
		Control Loss Warning	
		Do Not Pass Warning	14
		Emergency Electronic Brake Light	9
		Emergency Vehicle Alert	
		Forward Collision Warning	10
		Intersection Movement Assist	11, 12
		Motorcycle Approaching Indication	
		Pre-crash Actions	
		Situational Awareness	
		Slow Vehicle Warning	
		Stationary Vehicle Warning	
		Tailgating Advisory	
		Vehicle Emergency Response	
Support	Core Services	Connected Vehicle Map Management	

		Core Authorization	
		Data Distribution	
		Infrastructure Management	
		Location and Time	
		Object Registration and Discovery	
		Privacy Protection	
		System Monitoring	
	Security	Security and Credentials Management	
	Signal Phase & Timing	Signal Phase and Timing	1

APPENDIX E

AASHTO BENEFIT COST TOOLS APPLICATIONS

APPENDIX E: AASHTO BENEFIT COST TOOLS APPLICATIONS

Table E. 1: Applications Used for AASHTO CV Benefit Cost Tools

AASHTO and the U.S. DOT have begun developing connected vehicle cost benefit analysis tools. Below is a current listing of the applications included in that system, along with numbers referencing the ODOT connected vehicle application analysis.

ODOT No.	Application	Application Description
--	Advanced Automatic Crash Notification Relay - DSRC (AACNR)	Provides the capability for a vehicle to automatically transmit an emergency message when the vehicle has been involved in a crash or other distress situation
--	Border Management Systems - DSRC (BMS)	Provides international border registration, pre-processing and border inspection capabilities
26.	Connected Eco-Driving - Cellular (CED)	Provides drivers customized real-time driving advice, such as recommended driving speeds, optimal acceleration, and optimal deceleration profiles based on prevailing traffic conditions, interactions with nearby vehicles, and upcoming road grades so that they can adjust their driving behavior to save fuel and reduce emissions
63.	Container Security - Cellular (CS)	Uses container to infrastructure communications to allow security and public safety agencies to interrogate a container relative to its contents, enabling law enforcement and security agencies to identify container contents in support of security and incident response functions
63	Container Security - DSRC (CS)	Uses container to infrastructure communications to allow security and public safety agencies to interrogate a container relative to its contents, enabling law enforcement and security agencies to identify container contents in support of security and incident response functions
53.	Cooperative Adaptive Cruise Control - DSRC (CACC)	Represents an evolutionary advancement of conventional cruise control (CCC) systems and adaptive cruise control (ACC) systems by utilizing Vehicle to Vehicle (V2V) communication to automatically synchronize the movements of many vehicles within a platoon
3.	Curve Speed Warning - Cellular (CSW)	Allows connected vehicles to receive information that it is approaching a curve along with the recommended speed for the curve
3.	Curve Speed Warning - DSRC (CSW)	Allows connected vehicles to receive information that it is approaching a curve along with the recommended speed for the curve
36.	Dynamic Eco-Routing - Cellular (DER)	Determines the most eco-friendly route, in terms of minimum fuel consumption or emissions, for individual travelers

ODOT No.	Application	Application Description
51.	Dynamic Speed Harmonization - Cellular (SPD-HARM)	Determines regulatory (e.g. variable speed limits) or advisory speed recommendations based on traffic conditions and weather information
51.	Dynamic Speed Harmonization - DSRC (SPD-HARM)	Determines regulatory (e.g. variable speed limits) or advisory speed recommendations based on traffic conditions and weather information
59.	Dynamic Transit Operations - Cellular (T-DISP)	Allows a transit passenger to send a stop request to an approaching transit vehicle
59	Dynamic Transit Operations - DSRC (T-DISP)	Allows a transit passenger to send a stop request to an approaching transit vehicle
23.	Eco-Approach and Departure at Signalized Intersections - DSRC (EADSI)	Encourages "green" approaches to and departures from signalized intersections by collecting intersection geometry information and signal phase movement information and performing calculations to provide speed advice to the driver of the vehicle allowing the driver to adapt the vehicle's speed to pass the next traffic signal on green or to decelerate to a stop in the most eco-friendly manner
30.	Eco-Cooperative Adaptive Cruise Control - DSRC (ECACC)	Is an extension to the adaptive cruise control (ACC) concept. ECACC includes longitudinal automated vehicle control while considering eco-driving strategies
28.	Eco-Lanes Management - DSRC (ELMD)	Supports the operations of eco-lanes (dedicated lanes similar to high-occupancy vehicle (HOV) or high-occupancy toll (HOT) lanes, but optimized for the environment) by gathering real-time traffic and environmental information from multiple sources including infrastructure, vehicles, and other systems and then processing these data to determine whether an eco-lane should be created or decommissioned along a roadway
28.	Eco-Lanes Management - Cellular (ELMC)	Supports the operations of eco-lanes (dedicated lanes similar to high-occupancy vehicle (HOV) or high-occupancy toll (HOT) lanes, but optimized for the environment) by gathering real-time traffic and environmental information from multiple sources including infrastructure, vehicles, and other systems and then processing these data to determine whether an eco-lane should be created or decommissioned along a roadway
32.	Eco-Ramp Metering - DSRC (ERM)	Determines the most environmentally efficient operation of traffic signals at freeway on-ramps to manage the rate of entering automobiles by collecting traffic and environmental data from connected vehicles to allow on-ramp merge operations that minimize overall emissions, including traffic and environmental conditions on the ramp and on the

ODOT No.	Application	Application Description
		freeway upstream and downstream of the ramp
32.	Eco-Smart Parking - DSRC (ESP)	Provides users with real-time location, availability, type (e.g., street, garage, AFV only), and the price of parking. The parking information can be provided via DSRC or wide area communications. The application reduces time required for drivers to search for a parking space, which can have eco benefits such as reducing emissions
29.	Eco-Speed Harmonization - DSRC (ESH)	Determines eco-speed limits based on traffic conditions, weather information, greenhouse gas emissions, and criteria pollutant information
25.	Eco-Traffic Signal Priority - DSRC (ETSP)	Allows a transit vehicle approaching a signalized intersection to request signal priority based upon the vehicle's location, speed, vehicle powertrain type, mass, grade, and associated modal GHG, criteria air pollutant emissions, adherence to its schedule or the number of passengers on the transit vehicle, as well as information from other vehicles approaching the intersection
24.	Eco-Traffic Signal Timing - DSRC (ETST)	Optimizes traffic signals for the environment rather than the current adaptive systems' objective, which is to enhance the intersection level of service or throughput, which might improve the intersection's environmental performance
50.	Emergency Vehicle Preemption - DSRC (PREEMPT)	Provides traffic signal priority for emergency vehicles traveling in a signalized network
40.	Enhanced MDSS - Cellular (EMDSS)	Incorporates the additional information that can come from collecting road weather data from connected vehicles into the existing Maintenance Decision Support System (MDSS) capabilities
62.	Freight Drayage Optimization - Cellular (FDO)	Covers the information exchanges between all intermodal parties to provide current drayage truck load matching and container availability and appointment scheduling at railroad and steamship line terminals
62.	Freight Drayage Optimization - DSRC (FDO)	Covers the information exchanges between all intermodal parties to provide current drayage truck load matching and container availability and appointment scheduling at railroad and steamship line terminals
48.	Freight Signal Priority - DSRC (FSP)	Provides traffic signal priority for freight and commercial vehicles traveling in a signalized network

ODOT No.	Application	Application Description
55.	Incident Scene Pre-Arrival Staging Guidance for Emergency Responders - DSRC (RESP-STG)	Provides situational awareness to and coordination among emergency responders- upon dispatch, while en route to establish incident scene work zones, upon initial arrival and staging of assets, and afterware if circumstances require additional dispatch and staging
56.	Incident Scene Work Zone Alerts for Drivers and Workers - Cellular (INC-ZONE)	Employs communications technologies to provide warnings and alerts relating to incident zone operations
56.	Incident Scene Work Zone Alerts for Drivers and Workers - DSRC (INC-ZONE)	Employs communications technologies to provide warnings and alerts relating to incident zone operations
43.	Integrated Multi-Modal Electronic Payment - Cellular (IMMEP)	Uses connected vehicle roadside and vehicle systems to provide the electronic payment capability for toll systems, parking systems, and other areas requiring electronic payments
43.	Integrated Multi-Modal Electronic Payment - DSRC (IMMEP)	Uses connected vehicle roadside and vehicle systems to provide the electronic payment capability for toll systems, parking systems, and other areas requiring electronic payments
47.	Intelligent Traffic Signal System - DSRC (I-SIG)	Uses both vehicle location and movement information from connected vehicles as well as infrastructure measurement of non-equipped vehicles to improve the operations of traffic signal control systems
44.	Intemittent Bus Lanes - Cellular (IBL)	Provides dedicated bus lanes during peak demand times to enhance transit operations mobility
44.	Intermittent Bus Lanes - DSRC (IBL)	Provides dedicated bus lanes during peak demand times to enhance transit operations mobility
39.	Motorist Advisories and Warnings - Cellular (MAW)	Provides the capability of collecting road weather data from connected vehicles and using that data to develop short term warnings or advisories that can be provided to individual motorists
8.	Oversize Vehicle Warning - Cellular (OVW)	Uses external measurements taken by the roadside infrastructure, and transmitted to the vehicle, to support in-vehicle determination of whether an alert/warning is necessary
8.	Oversize Vehicle Warning - DSRC (OVW)	Uses external measurements taken by the roadside infrastructure, and transmitted to the vehicle, to support in-vehicle determination of whether an alert/warning is necessary
6.	Pedestrian in Signalized Crosswalk Warning - DSRC (PSCW)	Provides to the connected vehicle information from the infrastructure that indicates the possible presence of pedestrians in a crosswalk at a signalized intersection

ODOT No.	Application	Application Description
52.	Queue Warning - Cellular (Q-WARN)	Enables vehicles within the queue event to automatically broadcast their queued status information (e.g., rapid deceleration, disabled status, lane location) to nearby upstream vehicles and to infrastructure-based central entities (such as the TMC) in order to minimize or prevent rear-end or other secondary collisions
52.	Queue Warning - DSRC (Q-WARN)	Enables vehicles within the queue event to automatically broadcast their queued status information (e.g., rapid deceleration, disabled status, lane location) to nearby upstream vehicles and to infrastructure-based central entities (such as the TMC) in order to minimize or prevent rear-end or other secondary collisions
7.	Railroad Crossing Warning - Cellular (RCW)	Alerts and/or warn drivers who are approaching an at-grade railroad crossing if they are on a crash-imminent trajectory to collide with a crossing or approaching train
7.	Railroad Crossing Warning - DSRC (RCW)	Alerts and/or warn drivers who are approaching an at-grade railroad crossing if they are on a crash-imminent trajectory to collide with a crossing or approaching train
2.	Red Light Violation Warning - DSRC (RLW)	Enables a connected vehicle approaching an instrumented signalized intersection to receive information from the infrastructure regarding the signal timing and the geometry of the intersection
22.	Reduced Speed-Work Zone Warning - DSRC (RSWZW)	Provides connected vehicles which are approaching a reduced speed zone with information on the zone's posted speed limit and/or if the configuration of the roadway is altered (e.g., lane closures, lane shifts)
44.	Restricted Lane Warnings - Cellular (RLW)	Provides the connected vehicle with restriction information about the travel lanes, such as if the lane is restricted to high occupancy vehicles (HOV), transit, or public safety vehicles only or has defined eco-lane criteria
44.	Restricted Lane Warnings - DSRC (RLW)	Provides the connected vehicle with restriction information about the travel lanes, such as if the lane is restricted to high occupancy vehicles (HOV), transit, or public safety vehicles only or has defined eco-lane criteria
42.	Road Weather Information and Routing Support for Emergency Responders - Cellular (RWIRSER)	Provides the capability of collecting road weather data from connected vehicles and other sources and using that data to develop short term warnings or advisories that can be provided to individual emergency response vehicles or to emergency response dispatchers
42.	Road Weather Information and Routing Support for Emergency Responders - DSRC (RWIRSER)	Provides the capability of collecting road weather data from connected vehicles and other sources and using that data to develop short term warnings or advisories that can be provided to individual emergency response vehicles or to emergency response dispatchers

ODOT No.	Application	Application Description
42.	Road Weather Information for Freight Carriers - Cellular (RWIFC)	Provides the capability of collecting road weather data from connected vehicles and using that data to develop short term warnings or advisories that can be provided to individual commercial vehicles or to commercial vehicle dispatchers
42.	Road Weather Information for Freight Carriers - DSRC (RWIFC)	Provides the capability of collecting road weather data from connected vehicles and using that data to develop short term warnings or advisories that can be provided to individual commercial vehicles or to commercial vehicle dispatchers
102.	Security and Credentials Management - Cellular (SCM)	A set of support applications that are used to ensure the trusted communications between mobile devices and other mobile devices or roadside devices and protect data they handle from unauthorized access
102.	Security and Credentials Management - DSRC (SCM)	A set of support applications that are used to ensure the trusted communications between mobile devices and other mobile devices or roadside devices and protect data they handle from unauthorized access
1.	Signal Phase and Timing - DSRC (SPaT)	Provides the current intersection signal light phases, current state of all lanes at a single intersection, as well as any preemption or priority
35.	Smart Park and Ride System - Cellular (SPRS)	Provides real-time information on Park and Ride capacity and supports traveler's decision-making on where best to park and make use of transit alternatives
35.	Smart Park and Ride System - DSRC (SPRS)	Provides real-time information on Park and Ride capacity and supports traveler's decision-making on where best to park and make use of transit alternatives
39.	Spot Weather Impact Warning - Cellular (SWIW)	Alerts drivers to unsafe conditions at specific points on the downstream roadway as a result of weather-related impacts, which include, but are not limited to high winds, flood conditions, ice, or fog
39.	Spot Weather Impact Warning - DSRC (SWIW)	Alerts drivers to unsafe conditions at specific points on the downstream roadway as a result of weather-related impacts, which include, but are not limited to high winds, flood conditions, ice, or fog
4.	Stop Sign Gap Assist - DSRC (SSGA)	Improves safety at non-signalized intersections where only the minor road has posted stop signs
4.	Stop Sign Violation Warning - Cellular (SSVW)	Improves safety at unsignalized intersections with posted stop signs by providing warnings to the driver approaching an unsignalized intersection
4.	Stop Sign Violation Warning - DSRC (SSVW)	Improves safety at unsignalized intersections with posted stop signs by providing warnings to the driver approaching an unsignalized intersection
48.	Transit Signal Prioritiy - DSRC (TSP)	Uses transit vehicle to infrastructure communications to allow a transit vehicle to request a priority at one or a series of intersections

ODOT No.	Application	Application Description
58.	Transit Vehicle at Station/Stop Warnings - DSRC (TVSSW)	Informs nearby vehicles of the presence of a transit vehicle at a station or stop
17.	Vehicle Data for Traffic Operations - Cellular (VDTO)	Uses probe data information obtained from vehicles in the network to support traffic operations, including incident detection and the implementation of localized operational strategies
17.	Vehicle Data for Traffic Operations - DSRC (VDTO)	Uses probe data information obtained from vehicles in the network to support traffic operations, including incident detection and the implementation of localized operational strategies
22.	Warnings about Upcoming Work Zone - Cellular (WUWZ)	Provides information about the conditions that exist in a work zone to vehicles that are approaching the work zone
22.	Warnings about Upcoming Work Zone - DSRC (WUWZ)	Provides information about the conditions that exist in a work zone to vehicles that are approaching the work zone
42.	Weather Response Traffic Information - Cellular (WxTINFO)	Uses road weather information from connected vehicles as well as current and historical data from multiple sources to determine the appropriate current safe speed and warn drivers of coming road conditions
42.	Weather Response Traffic Information - DSRC (WxTINFO)	Uses road weather information from connected vehicles as well as current and historical data from multiple sources to determine the appropriate current safe speed and warn drivers of coming road conditions
22.	Work Zone Traveler Information - Cellular (WZTI)	Provides warnings to maintenance personnel within a work zone about potential hazards within the work zone
22.	Work Zone Traveler Information - DSRC (WZTI)	Provides warnings to maintenance personnel within a work zone about potential hazards within the work zone