# Rural Connected Vehicle Gap Analysis

## Factors Impeding Deployment and Recommendations for Moving Forward

**Intelligent Transportation Society of America**

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## Notice

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16. Abstract

The intent of the Rural Connected Vehicle Gap Analysis project was to identify any current gaps in the connected vehicle program that may result in a reduced deployment potential in the rural areas of the United States. Through a workshop conducted at the National Rural Intelligent Transportation System annual meeting and interviews with rural transportation experts, the project team identified the gaps or challenges that could limit rural connected vehicle technology deployments. Recommendations include ways to address the identified challenges of deployment of connected vehicle technologies in rural areas.

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We also appreciate the work of Patrick Son, Adam Hopps, and Carlos Alban in orchestrating the workshop referenced above, as well as Jennifer Carter for beginning this project.

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*List of Acronyms*

| | |
|---|---|
| 5G | Fifth Generation Mobile Network |
| AASHTO | American Association of State Highway and Transportation Officials |
| AID | Accelerated Innovation Deployment |
| ARC-IT | Architecture Reference for Connected and Intelligent Transportation |
| BAB | Build America Bonds |
| CITE | Consortium for ITS Training and Education |
| CRFC | Critical Rural Freight Corridor |
| CSW | Curve Speed Warning |
| CV | Connected Vehicle |
| CVRIA | Connected Vehicle Reference Implementation Architecture |
| DOT | Department of Transportation |
| DSRC | Dedicated Short Range Communications |
| FAST | Fixing America's Surface Transportation |
| FHWA | Federal Highway Administration |
| ITE | Institute of Transportation Engineers |
| ITS | Intelligent Transportation System |
| ITS America | Intelligent Transportation Society of America |
| JPO | Joint Programs Office |
| LTE | Long Term Evolution |
| NCHRP | National Cooperative Highway Research Program |
| NHTSA | National Highway Traffic Safety Administration |
| NRITS | National Rural ITS |
| NSFHP | Nationally Significant Freight and Highway Projects |
| PAB | Private Activity Bonds |
| PCB | Professional Capacity Building |
| PPP/P3 | Public Private Partnership |
| RESCUME | Response, Emergency Staging, Communications, Uniform Management, and Evacuation |
| SPaT | Signal Phase and Timing |
| TIFIA | Transportation Infrastructure Finance and Innovation Act |
| TMC | Transportation Management Center |
| TRB | Transportation Research Board |
| US | United States |
| USDOT | United States Department of Transportation |
| V2I | Vehicle to Infrastructure |
| V2V | Vehicle to Vehicle |
| V2X | Vehicle to Vehicle/Device/Infrastructure |
| VMT | Vehicle Miles Traveled |
| WTI | Western Transportation Institute |
| WYDOT | Wyoming Department of Transportation |

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# Executive Summary

The focus of the Rural Connected Vehicle Gap Analysis was to identify potential challenges pertaining to the deployment of connected vehicles across rural areas, and potential solutions that address the identified challenges. Decades of study regarding rural transportation needs indicate that rural areas share certain transportation hurdles that differ from those in urban areas. For instance, the relatively low population density in most rural areas means that not only are there fewer people traveling on local roads, but also that there is a lower tax base and hence less funding for transportation and other public services. Funding scarcity, in turn, restricts the money available for infrastructure repair, maintenance, personnel, and traditional resources for services such as emergency response and traffic management. Rural areas also have a higher occurrence of fatal road crashes than the urban roadways. The opportunity for improved safety and operating conditions that connected vehicles offers rural communities is great. This project aimed to identify any gap(s) restricting or hindering rural deployment of connected vehicle technologies.

Rural transportation leaders frequently assert that it is difficult to find funding to support everyday road maintenance, construction and operations. It is more difficult to justify allocating money for connected vehicle technologies. The research team found that there is some misunderstanding with regard to connected vehicle technologies that negatively impacts the decision-makers' willingness to deploy these technologies. Reoccurring perceptions or concerns regarding connected vehicles include:

- The perception that vehicle-to-infrastructure (V2I) technologies are targeted to address congestion issues

- That connected vehicle applications are not mature enough to base funding decisions

- Rural populations are generally skeptical of all technologies, including connected vehicles

- The cost of deploying connected vehicle technology and applications in rural areas is assumed to be particularly high

Recommended action items to address the rural connected vehicle deployment challenges include: rural communities to develop connected vehicle sustainability plans, support of rural connected vehicle deployment trials (to demonstrate benefits in a number of identified high need rural areas, include freight demonstrations), innovative approaches to funding, and to enact a sustainable outreach and benefit education effort.

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# Introduction

The transportation industry is undergoing a technological revolution that aims to use real-time data and communications to make transportation safer, more efficient, and more environmentally sustainable. The United States Department of Transportation (USDOT) has been at the forefront of this effort for several years, with a large research program devoted to connected vehicles. This program is intended to help vehicles, infrastructure, and other mobile devices communicate with each other, so as to reduce collisions, facilitate traffic movement, and reduce both idling time and air pollution, among other benefits.

The transportation challenges that get the most attention, from both policy makers and the general public, tend to be those in cities. Indeed, USDOT recently awarded a $40 million grant to the City of Columbus, Ohio under the Smart City Challenge, a competition designed to help cities "fully integrate innovative technologies – self-driving cars, connected vehicles, and smart sensors – into their transportation network."[1] While traffic congestion in cities routinely captures the headlines, vast stretches of the country's transportation network lie in rural areas. Rural highways form the backbone of the American economy, as they are essential for transporting agricultural and manufactured goods across the country. Rural areas are by definition remote, with relatively varied terrain, low populations, and few resources. Although traffic congestion is rare, rural America has its own specific transportation challenges—such as extreme weather,[2] severe vehicle crashes, and an overall lack of operational data about the roadways— for which connected vehicles can provide solutions.

As USDOT's Connected Vehicle Program shifts from the research phase into testing and deployment, the practical challenges of rolling out the technologies are coming to the fore. The evolution of this white paper began with a workshop held at the 2015 National Rural ITS (NRITS) conference in Snowbird, Utah, where participants from the rural transportation community were asked to identify gaps in rural connected vehicle research. The workshop results formed the foundation of this study, helping frame the questions asked during the interview stage, and aided in the selection of experts that were drawn from various rural transportation stakeholder groups for the in-depth interviews. While conducting interviews, the Intelligent Transportation Society of America (ITS America) research team followed a consistent protocol. Each interviewee was asked the same set of open-ended questions addressing rural transportation challenges, interviewee perspectives on the benefits and challenges of connected vehicles in the rural context, and an attempt to identify if there are any gaps in the connected vehicle program as related to rural areas. Each interview was conducted over the phone and lasted approximately one hour. A summary of the interviews and workshop proceedings, as well as a list of interview participants, is available in the appendix of this white paper. At the conclusion of the interviews, and after conducting research into

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[1] "Smart City Challenge." U.S. Department of Transportation. July 08, 2016. Accessed July 2016. https://www.transportation.gov/smartcity

[2] Steve Albert, "ITS ePrimer; Module 10: Rural and Regional ITS Applications," 5. Intelligent Transportation Systems Joint Programs Office, U.S. Department of Transportation. September 2003. Accessed August 2016. https://www.pcb.its.dot.gov/eprimer/documents/module10p.pdf

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various elements, the research team addressed gaps and challenges identified to develop a path forward with regard to rural connected vehicle applications.

This white paper is presented in three sections after this Introduction section. The first section identifies the current state of affairs in connected vehicles as compared to rural transportation challenges. The second section presents the research team findings (i.e., connected vehicle challenges and/or gaps) that were identified by the workshop participants and interviewees. This second section also documents any factors that could inhibit the deployment of connected vehicle technology in rural areas. The third (and last) section, Next Steps, identifies a path forward towards inclusion of rural transportation issues within the connected vehicle context. To the extent possible, the last section recommends how to overcome challenges and encourage rural jurisdictions to install connected vehicle applications in their areas.

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# Chapter 1. Connected Vehicles in the Rural Context

This section of the white paper sets the stage for the rest of the paper. In this section is an exploration of the current state of the USDOT Connected Vehicle Program and well documented rural transportation challenges that may be addressed by connected vehicle applications.

## Connected Vehicles

The USDOT's Connected Vehicle Program is focused on testing and deploying technologies that will "enable cars, buses, trucks, trains, roads, and other infrastructure, and our smartphones and other devices, to 'talk' to one another."[3]  The Program is divided into two major components: vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications. Both V2I and V2V use Dedicated Short Range Communications (DSRC) as well as other technologies and communications methods, such as cellular, Wi-Fi, and satellite communications. Connected vehicle applications include safety and collision avoidance, for which the high speed, secure connection, and reliability of DSRC is of paramount importance.

The connected vehicle applications conceptualized by USDOT are now in the pilot deployment stage and can be largely grouped into the following categories: safety, mobility, environment, agency data, road weather, and smart roadside.[4] By its very nature, connected vehicle technology generates and captures real-time transportation data, which can be used by DOTs and others to improve the safety, efficiency, and environmental impact of transportation. Many of the V2V and V2I applications are more cost effective than traditional intelligent transportation system (ITS) devices in that they do not require communications to a public agency to be effective.

## Rural Transportation Challenges and the Promise of Connected Vehicle Benefits

The term "rural" has many different definitions, two of which are commonly used in the transportation field. For highway classification, anything outside of an area with a population of 5,000 people or more is considered rural; for planning purposes, areas outside of metropolitan areas with populations of 50,000

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[3] "Connected Vehicle – ITS Research 2015-2019." Intelligent Transportation Systems Joint Programs Office, U.S. Department of Transportation. Accessed August 2016. http://www.its.dot.gov/research_areas/connected_vehicle.htm

[4] "CV Pilot Deployment Program" Intelligent Transportation Systems Joint Programs Office, U.S. Department of Transportation. Accessed August 2016. http://www.its.dot.gov/pilots/

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people or more are considered rural.[5] While these are the official definitions, in speaking with practitioners for this white paper, several additional attributes that could define "rural" were mentioned, including areas outside of urban and suburban areas, roadways connecting urban areas, lower classification roadways in rural areas, and low volume roadways.

Decades of study regarding rural transportation needs clearly indicate that rural areas share certain transportation challenges with each other that differ from those in urban areas. These differences lead to the essence of this white paper: to specifically address rural transportation challenges via a unique approach when deploying advanced technologies, such as connected vehicles.

According to the ITS ePrimer chapter on rural and regional ITS applications, "rural areas have different technological infrastructure, fiscal resources, infrastructure usage, and travel patterns relative to urban areas."[6] Low population densities mean not only that there are fewer people traveling on roads, but that there is a lower tax base and hence less funding for transportation and other public goods in rural areas. The funding scarcity results not just in less money for infrastructure repair and maintenance, but also in fewer resources and personnel for services such as emergency response and traffic management. The remote and varied terrain found in rural areas leads to difficulties in deploying communications technology, and increases susceptibility to extreme weather events. The composition of travel changes in rural areas as well. While urban travel patterns tend to involve many people traveling shorter distances, rural travelers tend to be fewer but travel longer distances. The composition of rural traffic is also heavily skewed towards long-haul freight, as opposed to the commuter or local traffic generally found in cities.

The unique nature of rural transportation opens up a wide range of areas where connected vehicle technology could be of benefit, including opportunities for improving safety, information communication, and operational efficiency. Specifically, the interviewees and workshop participants highlighted reduced crash severity, better data collection (particularly regarding weather conditions), improved operational efficiency and freight movement, and an enhanced ability to manage incidents, emergency response, work zones, tourism, and other special events as core areas in which connected vehicle technology could positively impact rural areas. The following subsections provide additional information regarding the identified rural challenges.

## Rural Crashes

As rural America is disproportionately more affected by high severity crashes, it is not surprising that the primary anticipated benefit of connected vehicles mentioned in the interviews was the potential for improving rural road safety. Over half of all fatalities due to crashes occur on rural roadways while only 19% of Americans reside in rural areas and only 30% of all vehicle miles traveled occur on rural roadways.[7] Relatively high vehicle miles traveled (VMT) coupled with higher travel speeds and less-than-

[5] "Planning for Transportation in Rural Areas," 4. Office of Planning Environment and Realty, Federal Highway Administration. July 2001. Accessed July 2016. http://narc.org/uploads/File/Transportation/Library/ruralguide.pdf

[6] Steve Albert, "ITS ePrimer, Module 10: Rural and Regional ITS Applications," 2.

[7] "Roadway and Environment; Urban/Rural Comparison." IIHS. 2014. Accessed June 2016. http://www.iihs.org/iihs/topics/t/roadway-and-environment/fatalityfacts/roadway-and-environment/2014

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ideal road conditions (poor lighting, poorly maintained roads, etc.) contribute to frequent high-impact crashes. Indeed, in 2014, the fatality rate in rural areas per 100 million VMT was more than twice that in urban areas, with 1.18 rural fatalities per 100 million VMT versus 0.74 urban fatalities, as shown in Figure 1 which is a graph depicting the annual fatality rates per 100 million VMT for rural locations, urban locations, and all locations between 2005 and 2014.[8] Even in less severe cases, the long distances and limited communication capabilities mean that emergency response times can be 50% longer in rural areas, making safety a high priority issue in rural transportation.[9]
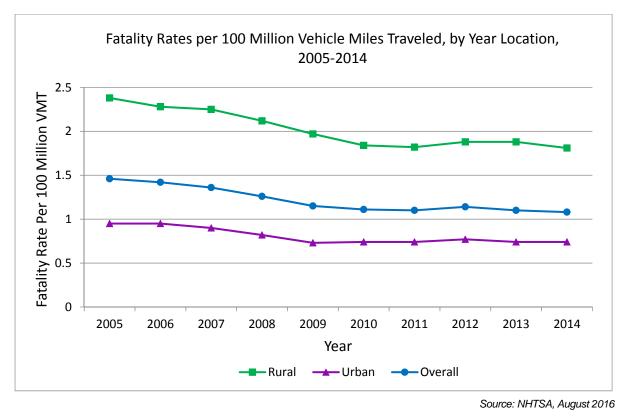


*Source: NHTSA, August 2016*

**Figure 1. Fatality Rates per 100 Million VMT**

There are several factors that contribute to the high incidence of crashes in rural areas, many of which can be directly addressed by connected vehicle technology:

1. High speed

2. Roadway curvature

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[8] "Traffic Safety Facts; Rural Urban Comparison" (2014 Data). NHTSA. July 2016. Accessed August 2016. http://www-nrd.nhtsa.dot.gov/Pubs/812301.pdf

[9] "Rural Emergency Medical Services." AASHTO. 2003. Accessed August 2016. http://safety.transportation.org/htmlguides/rural/section03.htm

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3.  Animals

4.  Weather

Regarding the impact of road speed on driving fatalities, data from the USDOT's Fatality Analysis Reporting System reveals that in 2014, "68% of crash deaths in rural areas occurred on roads with speed limits of 55 mph or higher. By comparison, as seen in Figure 2, below, 29% of crash deaths in urban areas occurred on these roads.[10] Figure 2 shows that the majority of rural crash fatalities occur where the posted speed limit is 55 mph and above, and that percentage of fatalities occurring on high speed roads is higher in rural areas than it is in urban areas. Vehicles travelling at higher speeds translate to a reduced field of vision for drivers and a need for greater stopping distances. Crashes are often the result of the driver being unable to assess and accommodate road conditions early enough to act in an appropriate and timely manner. Connected vehicle technology that could provide critical alerts to avoid high-impact crashes through applications include Curve Speed Warning (CSW), emergency electronic brake lights, various work zone warning systems, and Forward Collision Warning.

| Posted Speed Limit | Rural | | Urban | | Total Total includes other and/or unknowns | |
|---|---|---|---|---|---|---|
| | Deaths | % | Deaths | % | Deaths | % |
| ≤35 mph | 1,679 | 10 | 5,001 | 32 | 6,829 | 21 |
| 40-50 mph | 3,207 | 19 | 5,190 | 34 | 8,577 | 26 |
| 55+ mph | 11,412 | 68 | 4,474 | 29 | 15,996 | 49 |
| Total* | 16,710 | 100 | 15,487 | 100 | 32,675 | 100 |

*Source: IIHS, June 2016*

**Figure 2. Motor Vehicle Crash Deaths by Speed Limit and Land Use for 2014**

For rural roads with curves where crashes frequently occur, CSW could significantly reduce the frequency of lane and road departure.

As crashes involving large animals are a concern for rural areas, interviewees expressed interest in the potential for connected vehicle technology to assist in the reduction of these collisions through the deployment of advanced animal collision warning systems.

Lastly, interviewees indicated that weather and emergency response on the roadways are perceived as the public sector's responsibility. More robust and specific weather information obtained through connected vehicle applications would further enhance the public sector's ability to manage the roadways during impactful weather events, without endangering agency staff. The communication of road weather

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[10] "Roadway and Environment; Urban/Rural Comparison."

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conditions (and related warnings regarding treacherous driving locations) to vehicles will equip drivers with information necessary to make appropriate travel and routing decisions.

Better data, particularly regarding weather events (flooding, heavy rain, high winds, hurricanes, etc.) and road surface conditions (particularly wet, icy, or damaged pavement) increases the accuracy of the information disseminated to motorists (such as that communicated via 511 alerts, Spot Weather Impact Warnings, and Advanced Traveler Information notifications). Connected vehicle applications such as Motorist Advisories and Warnings and spot Weather Impact Warning aim to provide needed safety-related weather and roadway condition information to the motorist in a connected vehicle.

## Lack of Operational Data on Rural Roadways

Connected vehicles offer a means for acquiring critical road information in areas where data may otherwise not be available (particularly with respect to road and weather conditions) if the data is communicated to the operating agency. The total miles of roadways in rural America far exceed that in urban and suburban areas, which poses a challenge when it comes to operational knowledge of the rural roadways, even in the best of conditions.

Interviewees indicated that connected vehicle technology could provide a practical and more cost effective method to gather and communicate travel and road data, specifically real-time data. It was envisioned that equipped vehicles could serve as probes, better enabling road agencies to collect and monitor road and travel condition data and information. Improved rural roadway data would enable drivers to make better-informed decisions, and agencies to provide more efficient roadway maintenance. Consequently, agencies obtaining and using more robust roadway data will lead to an increased ability to create and maintain safer driving conditions.

In addition, a robust data stream would support and enable systematic decision-making and aid in demonstrating the effectiveness of road improvements through the ease of access to before and after data.

Furthermore, rural transit is often an on-demand service, which could greatly benefit from real-time traffic information. Connected vehicle technology holds the promise of providing an efficient means of communicating more robust roadway data. The connected vehicle suite of Agency Data Applications will aid in addressing the lack of operational data on rural roadways.

## Operational Inefficiencies

Though relatively infrequent compared to urban areas, congestion in rural areas is often the result of crashes, stalled vehicles, road construction, weather, tourism, and special events. Unlike urban recurring congestion which generally reflects commuting patterns, rural congestion is more challenging to predict due to the lack of situational awareness on the roadways and the length of time it takes for the source of the congestion to clear. In rural environments, it takes longer to clear a source of congestion due to limited and unsuitable alternate routes and/or the wide-spread nature of the cause of the congestion (such as in the case of weather events). The time it takes to clear congestion impacts freight movement and at times can lead to fatal situations, due to the ability (or lack thereof) of drivers to detect and respond to the event in a timely manner.

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Connected vehicle applications that could aid in improving operational efficiency on rural roadways are numerous and include: Advanced Traveler Information Systems (Disaster Traveler Information, Broadcast Traveler Information, and Personalized Traveler Information), Enhanced Maintenance Decision Support System (Winter Maintenance), road weather information applications, Advanced Automatic Crash Notification Relay (Mayday Notification), incident notification applications, Speed Harmonization (Speed Harmonization), Queue Warning (Queue Warning), Emergency Communications and Evacuation (Wide-Area Alert, Early Warning System, Disaster Response and Recovery, Evacuation and Reentry Management, and Disaster Traveler Information), Freight-Specific Dynamic Travel Planning (Freight-Specific Dynamic Travel Planning), and many other applications.[11]

## Challenging Incident and Emergency Response

Rural areas are vulnerable to long incident and emergency response times. This is due to a lack of situational awareness across the rural roadway network and limited resources for emergency response, combined with longer travel distances and sometimes unforgiving roadways. According to the National Highway Traffic Safety Administration (NHTSA), 38% of rural fatal crashes in 2014 involved a total response time exceeding one hour, whereas in urban areas, less than 10% of fatal crashes required this amount of time.[12] This delay reflects gaps in both emergency notification and the response time required once notified, and may contribute to higher dead-at-scene and death en-route rates in rural areas. In 2013, the Federal Highway Administration (FHWA) reported that 63% of drivers involved in fatal crashes died en-route to hospitals in rural areas, compared to 38% in urban areas.[13] Therefore, reducing this gap is particularly important.

The application of safety-related connected vehicle technology could reduce the frequency and severity of crashes, which could improve operational efficiency. For example, secondary crashes could be avoided through application of Incident Scene Work Zone Alerts for Drivers and Workers (Incident Scene Safety Monitoring)[14]. Furthermore, connected vehicle technologies could be applied to effectively communicate road condition data to local authorities, resulting in more responsive and timely response efforts.

Connected vehicle technologies could facilitate incident response and management by helping to identify optimal or alternate routing options, alert drivers coming around turns upon a scene, and provide additional communication infrastructure and roadway data. Response, Emergency Staging, Communications, Uniform Management, and Evacuation (R.E.S.C.U.M.E.) is a USDOT program that

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[11] "CVRIA 2.2 Heritage." U.S. Department of Transportation. June 27, 2017. Accessed July 2017. http://local.iteris.com/arc-it/html/servicepackages/spsheritagecvria.html [Note: the first application name is from CVRIA (Connected Vehicle Reference Implementation Architecture) and the applications in parentheses are the current ARC-IT (Architecture Reference for Connected and Intelligent Transportation) v. 8.0 application names.]

[12] "Traffic Safety Facts 2014; A Compilation of Motor Vehicle Crash Data from the Fatality Analysis Reporting System and the General Estimates System." NHTSA. 2014. Accessed June 2016. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812261

[13] "Traffic Safety Facts; Rural Urban Comparison."

[14] "CVRIA 2.2 Heritage."

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promotes connected vehicle applications for first responders. In addition, connected vehicle technologies have the potential to expedite incident and emergency response through applications such as Incident Scene Pre-Arrival Staging Guidance for Emergency and Incident Scene Work Zone Alerts for Drivers and Workers.

## Freight Challenges

Freight represents a large percentage of traffic on rural highways, transporting agricultural and other goods across the country. Connected vehicle technology has the potential to help freight carriers operate more efficiently – via smart truck parking, platooning, and other applications – and enhance travel safety. Large, commercial vehicles have maneuverability constraints due to their size, and are particularly vulnerable to adverse conditions. In 2014, more than 70% of fatal crashes involving vehicles carrying hazardous cargo occurred in rural areas.[15] These crashes not only create delays and safety risks for drivers, they can lead to expensive or dangerous loss of cargo. Freight haulers are traveling on roads where weather information is badly needed, and putting sensing and communicating devices on those trucks would help freight companies and others both better understand road conditions in real time and reduce unnecessary travel risks.

One of the three USDOT Connected Vehicle Deployment Pilot Sites is focused on a rural freight corridor in Wyoming. According to the Wyoming DOT (WYDOT), the pilot "hopes to improve safety and freight mobility along the corridor through a reduction in the number of truck blow-over incidents, secondary incidents, and road closures,"[16] thus providing a platform to evaluate several of the potential benefits of connected vehicles that are specific to rural environments. The Wyoming pilot is being conducted on a section of Interstate 80 (I-80), which is a heavy freight corridor prone to severe weather events. Freight traffic makes up between 30-55% of traffic volume in this corridor, rising to as high as 70% during certain seasons.[17] This high elevation route may also suffers from strong winds and heavy snow, as well as fires and reduced visibility. Together, these conditions result in a high number of incidents and a large impact on the economy of the region. For instance, in the 5-year period between 2007 and 2012, the road was closed 86 times due to severe weather, with each closure averaging around 8 hours in duration and resulting in an estimated economic cost of $11.7 million.[18] The pilot envisages the use of several connected vehicle components based on a combination of cellular, DSRC, and other communication technologies, such as the dedicated backhaul network employed in WyoLink (their statewide public safety communication system). Snowplows, freight carriers, roadside units, connected vehicle-equipped trucks,

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[15] "Traffic Safety Facts 2014; A Compilation of Motor Vehicle Crash Data from the Fatality Analysis Reporting System and the General Estimates System."

[16] "Wyoming Project will Connect Snowplows, Trucks, Fleet, Management Centers." WYDOT. October 07, 2015. Accessed August 2016. http://www.dot.state.wy.us/news/wyoming-project-will-connect-snowplows-trucks-fleet-management-centers-1

[17] "Wyoming DOT Connected Vehicle Pilot Program" 10. U.S. Department of Transportation. September 30, 2015. Accessed July 2016. http://www.its.dot.gov/pilots/pdf/04_CVPilots_Wyoming.pdf

[18] "Wyoming Project will Connect Snowplows, Trucks, Fleet, Management Centers."

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and more will be integrated into WYDOT and other fleet management centers as part of this pilot program.

Connected vehicle applications such as Blind Spot Warning and Lane Change Warning (V2V basic safety applications)[19], weather-related alerts, and road-specific restriction warnings – such as those pertaining to height, weight, width, and time of day – would be especially valuable for truck drivers. Other applications, such as the ones piloted in the Wyoming Connected Vehicle Pilot also present potential benefits with respect to addressing specific rural freight challenges. Connected vehicle technologies can also help improve communication and coordination between port transport departments and state DOTs, and optimize both supply chain and logistics management.

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[19] "CVRIA 2.2 Heritage."

# Chapter 2. Preliminary Findings

This section presents the ITS America research team findings (i.e., connected vehicle challenges and/or gaps) that were identified by the workshop participants and interviewees. It also documents any factors that could inhibit the deployment of connected vehicle technology in rural areas.

Technology is an invaluable tool for addressing transportation challenges in rural areas, where resources are scarce, information about vast areas is difficult if not impossible to collect, and maintenance and operation of transportation systems is a costly. Given that rural areas stand to benefit significantly from the deployment and use of connected vehicle technology, the research team sought to explore what barriers might prevent adoption of this connected vehicle technology in rural areas. Drawing on the workshop, interviews with subject matter experts, and literature reviews, the team synthesized the biggest challenges – as seen by current practitioners – to successful deployment of connected vehicle technology in rural areas.

The challenges and gaps addressed in this section include understanding connected vehicle technologies, lack of resources, rural infrastructure challenges, and cultural challenges experienced in rural areas.

## Confusion Regarding Connected Vehicle Technologies

State DOT officials and others who were interviewed overwhelmingly asserted that it was difficult to justify allocating money for connected vehicle technology based on their current understanding of the technologies, in an era of limited transportation funding.

Four themes regarding understanding connected vehicle technologies (resulting in a reluctance to fund these technologies) were presented to the ITS America research team and are addressed in this section of the white paper:

- Respondents and decision makers perceive V2I technologies as largely utilized to address congestion issues.

- Connected vehicle applications are not mature enough for decision makers to base funding decisions around them.

- There is skepticism regarding connected vehicle technologies and what is involved in ensuring that they function properly.

- The cost of deploying connected vehicle technology and applications in rural areas is assumed to be particularly high.

The interviews demonstrated that V2I technologies are commonly perceived to be mainly for congestion mitigation while V2V is more useful to address safety challenges. This perception of V2I as a tool to primarily address congestion, a problem that is less common in rural areas, discounts the other ways in which V2I could be helpful. For example, equipping the road network with DSRC radios could

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dramatically improve safety through features such as warnings for curve speed, spot weather impact, reduced speed zones, and work zones. Further, it is expected that roadside V2I units would also enable improved collection and dissemination of useful traveler information, and enhance data collection of road and weather conditions, providing a large variety of benefits for tourism, operations, maintenance, and safety.

This perception of V2I technologies specifically, and connected vehicles as a whole, being mainly for congestion mitigation came up repeatedly and reflects an incomplete understanding of connected vehicle technology among a section of the rural transportation community. This misunderstanding was cited as one of many reasons to avoid spending scarce rural resources on technology to fight a problem (congestion) that was either rare or nonexistent. Several interviewees expressed that it was difficult to justify spending on connected vehicle technology when dealing with areas of low traffic density. The mindset that connected vehicles are for higher volume roadways and congested areas would need to be overcome in order to accelerate deployment in rural areas. At the same time, safety was the single biggest need brought up by practitioners that connected vehicle technologies can address; therefore, spreading awareness of the safety benefits of connected vehicle technologies would go a long way towards changing decision maker attitudes and encouraging DOT spending on these technologies.

## No Clear Demonstration of Benefits

Another major reason provided for the reluctance to dedicate funding to connected vehicle technology deployments is that it is difficult to convince those making financial and project decisions at this point because the program is largely theoretical. There is currently little or no proof of concept to which decision makers can refer. The Connected Vehicle Pilot Deployment Program is addressing this gap, with three pilot deployment sites in New York City, Wyoming, and Tampa. While the Wyoming Connected Vehicle Pilot site is a rural freight corridor on I-80 and is faced with some of the most difficult rural challenges (such as aiming to reduce incidents caused by extreme weather),[20] some interviewees suggested that further pilot projects are needed to address areas other than major freight corridors/interstates to be helpful.

The question of return on investment was also brought up by the interviewees. Because rural roads tend to have low traffic volumes, there may not be enough users to achieve a sufficient return on investment, especially in the initial stages. This results in a chicken and egg situation: the benefits of connected vehicles will only be realized once there is sufficient technology penetration, both in terms of roadside infrastructure and vehicles, but the DOTs may not have the incentive to deploy infrastructure until vehicles have the technology. Furthermore, vehicle manufacturers may not have the incentive to include DSRC in vehicles (and consumers might not spend extra to buy those vehicles) unless the infrastructure is more commonplace (or a mandate requires the technologies). For the DOTs, the issue is that they are not able to fully operate and control V2I deployments unless there are equipped vehicles on the roadways and unless the car and the driver act on the data. The rulemaking currently under consideration by NHTSA to mandate the inclusion of DSRC in light-duty passenger vehicles would help incentivize (or require that) both vehicle manufacturers to deploy DSRC and other connected communications technologies in the vehicles. However, it appears that it will likely take longer for connected vehicle benefits to be realized in rural areas as opposed to urban areas, and the perception currently is that these

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[20] "CV Pilot Deployment Program."

benefits do not appear—at least on the surface—to outweigh the deployment, operations, and maintenance costs.

## General Skepticism about Connected Vehicle Benefits

While there is a lot of enthusiasm in the rural transportation community for the potential benefits of connected vehicle technologies, deeper discussions reveal that many individuals have some degree of ambivalence about the use of DSRC and V2I infrastructure, due to the associated expense and the lack of telecommunications infrastructure. However, the interviewees consistently mentioned using other technology, specifically cellular connection and autonomous vehicles, in addition to DSRC. Interviewees gave specific examples of how technology was proving beneficial when other technology and communications mechanisms (besides DSRC) were used.

One interviewee, who thought animal detection warning systems would be a big benefit of connected vehicles, described a system they already had in place using radar and thermal imaging combined with activated signs indicating that animals were present in the road corridor. This system has been successful in reducing travel speeds during animal detection events, resulting in animal-vehicle collisions dropping by 80%. In this case, the addition of DSRC-based V2I systems may add only incremental value, and may therefore not provide a sufficiently large enough benefit to justify the cost.

Another interviewee described how his department was currently using drivers to collect road, thermal, and grip-mapping data using a fleet of vehicles equipped with sensors. Most drivers return to the agency and then upload the data (which is posted to the agency website to inform drivers who access this information pre-trip), while some are able to upload using cellular connection. However, the fact that the road network has to be driven to collect the data can be dangerous during inclement weather conditions. Further integration of advanced technologies will aid in automatically collecting and uploading the information to the website, as well as in sending out timely alerts to the public when required – without risk to life. Connected vehicle technologies are envisioned to assist in this scenario through the collection and distribution of road condition data and traveler information (decreasing the risk to agency staff over the current process).

These two examples show how a combination of non-connected vehicle technologies (vehicle sensors, radar, thermal imaging, and integration of systems) are currently performing and how the addition of connected vehicle technologies (in the second example) may improve safety, road, and weather data collection in the rural context.

Autonomous vehicles were frequently mentioned as an example of an advanced transportation technology that was envisioned by the interviewees to provide many of the safety-related benefits of connected vehicles, without the extensive infrastructure costs. Current connected vehicle applications make use of real-time data to provide warnings to drivers; however, autonomous vehicles go beyond warnings to actually taking action when obstacles are detected. Vehicles that have built-in routing would reduce the need for building extensive V2I traveler information systems. Autonomous vehicles could provide Americans with Disabilities Act -compliant mobility opportunities for rural residents who traditionally experience limited mobility, such as the elderly and individuals with disabilities. Autonomous vehicles could further address some of the difficulties that public transit agencies have operating in low-density areas. Autonomous vehicles could be used in national parks and tourist attractions to help limit both extraneous vehicular traffic and the number of tourists traversing restricted areas. Thus, the benefits of autonomous vehicle deployment were perceived by some interviewees to potentially exceed those of

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connected vehicle deployments, which may prove a disincentive to rural agencies and DOTs to deploy DSRC in the short term. Autonomous vehicles are making their commercial debut in a number of areas, such as with nuTonomy's launch of self-driving taxis in Singapore and Uber's announcement of a pilot program in Pittsburgh. Ford, Volvo, and many other automakers have also committed to rolling out fleets of autonomous vehicles in the next few years. The timeline for autonomous vehicles coincides with interviewee estimates of how long it will take for connected vehicle technology to be deployed in rural areas.

## Lack of Resources

The lack of resources in rural areas includes a lack of funding, as well as a lack of skilled workers, information, and equipment/technology resources.

The interviewees' perception was that deploying V2I infrastructure would be "too expensive." In contrast, V2V applications and autonomous vehicles were identified as more likely channels by which connected vehicle technology could enter the rural environment, because the costs would be borne by consumers and vehicle manufacturers rather than state DOTs. Even if the safety benefits of connected vehicles were well understood, and the benefits were proven (for example, proven through pilot deployments), the perceived high cost of deploying connected vehicle technology still stands out as an overwhelming obstacle in the rural context. Due to the small tax base and the fact that rural roadways typically have less traffic flow than urban roadways, there are fewer funds available for transportation in rural areas in general.

A 2014 study conducted jointly by USDOT and the American Association of State Highway and Transportation Officials (AASHTO) found that the total potential DSRC deployment cost for a non-signalized intersection could average as much as $48,400.[21] One interviewee said that the "unimaginably severe resource constraints" in rural areas are not understood by officials at the state, metropolitan, and possibly even national level. These resource constraints are expected to worsen as a result of any transportation funding reductions. Rural officials do not expect the situation to improve, and in fact one interviewee expressed that being asked to plan for deployment under the assumption that there will be a time "when you get more money" results in a loss of credibility because there is "no reasonable expectation of funding" or of when increased funding will be made available.

The combined resource shortcomings (including skilled staff, equipment/technology, etc.) make managing and maintaining assets, such as roadside infrastructure, challenging. The difficulty of maintaining connected vehicle infrastructure, particularly roadside units, was a common recurring theme in interviews. Even under normal circumstances, rural roadways are typically not maintained to the same standard as urban highways, due to funding prioritizations or constraints by state DOTs that favor urban roadways over rural roadways. In the rural environment, adding the cost of maintaining technological infrastructure in remote areas strikes many practitioners as being unrealistic. This perception threatens the functionality

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[21] "AASHTO Connected Vehicle Field Infrastructure Footprint Analysis; Preparing to Implement a Connected Vehicle Future." U.S. Department of Transportation. FHWA-JPO-14-125. 2014. Table 19. Accessed August 2016. http://www.its.dot.gov/itspac/Dec2014/AASHTO_FootprintAnalysis.pdf

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of connected and autonomous technologies which rely on pavement markings, physical barriers, or operational ITS devices.

In addition, many rural areas lack staff who are sufficiently trained in maintenance of technological infrastructure, with one interviewee pointing out that cities tend to have entire ITS teams, whereas a rural area would be lucky to have even one person knowledgeable about ITS. Finally, one of the defining characteristics of the rural environment is the difficulty in obtaining information about roadway conditions, which is likely to also impede the deployment of advanced technology. In some remote areas, GIS or mapping technology may not recognize all existing roadways,[22] which will particularly impact autonomous vehicles and driver-assist technologies.

## Challenges in Infrastructure Implementation

In addition to potentially rugged terrain, extreme weather, and other environmental conditions, the lack of reliable communications and power infrastructure in many stretches of rural America is anticipated to be a significant compounding obstacle to the successful deployment of connected vehicle technology. Connected vehicle applications not only involve V2V and V2I communication, but also communication between mobile devices, transportation management centers (TMCs), and other information systems, such as the internet and traveler information systems (like 511). For connected vehicle technology to be successful, all components in the system must be powered and able to communicate, whether it be through DSRC, cellular, or any wireless communications technology.

The choice of communications technology depends on the application, but DSRC (or other communications mode with similar capabilities), cellular, and broadband communications are recommended for a robust connected vehicle system. For example, safety applications designed to prevent crashes require high-speed, low-latency, and secure connectivity that is currently achieved only by DSRC. Other applications that address non-crash imminent situations and are expected to be useful in the rural context include road weather and traveler information or work zone applications. These non-crash applications are expected to make use of the wireless connections that are increasingly available on vehicles.[23] Infrastructure-based connected vehicle applications (many of which are expected to prevent crashes or are safety critical) will require power and a dedicated (or low latency) network communications system (also possibly including backhaul). Cellular applications, while reducing the need for infrastructure deployment on the part of the DOTs, could result in safety critical communication delays[24] that may impact how a given application functions. As the Footprint Analysis by AASHTO points out, "DRSC is the more demanding case from the standpoint of infrastructure deployment by an

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[22] Intelligent Transportation Systems; Urban and Rural Transit Providers Reported Benefits but Face Deployment Challenges," 42-43. GAO. June 2016. Accessed June 2016. http://www.gao.gov/products/GAO-16-638

[23] "AASHTO Connected Vehicle Field Infrastructure Footprint Analysis; Preparing to Implement a Connected Vehicle Future."

[24] "National Connected Vehicle Field Infrastructure Footprint Analysis," 66. U.S. Department of Transportation. May2, 2014. Accessed August 2016.

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agency,"[25] and thus represents a bigger challenge to deploy and operate in rural environments than a cellular network does. However, DSRC (or a communications network with similar capabilities) is required for crash-preventative applications. When addressing which types of communication is required, it is best to consider a network that includes both DSRC and cellular.

Interviewees note that existing network backhaul capacity is not adequate to support connected vehicle technology in rural areas. Backhaul refers to the communications connection between a node (vehicle or roadside unit) and a larger network. A backhaul network could be limited to the DOT communications network, the network only connected to the TMC or certain data aggregators, or open to the entire internet. In addition, backhaul capacity can be provided by fiber, cellular, satellite, or any combination of these. In a world of connected vehicles, backhaul is what enables vehicles and roadside units to obtain information from TMCs and transmit data back to the operating agencies (i.e., DOTs). Backhaul is particularly important to connected vehicle communication technologies (such as DSRC) because it is necessary to verify the security certificates that form the basis of the technology. While there are some applications that may not require backhaul (such as V2V and location-specific V2I applications), as well as those that are self-contained (such as an animal collision warning system that detects animals and broadcasts warnings to nearby vehicles), the lack of backhaul will severely limit both the functionality of a system of connected vehicle applications and the system's ability to capture and aggregate real-time data.

In addition to backhaul, cellular coverage is an issue. Rural areas, especially those with extreme terrain, tend to have sporadic cellular coverage. Cellular coverage is needed from the roadside to the local DOT (or agency TMC) in order to communicate emergency situations, roadway conditions, and other data or information collected by the connected vehicle applications. The reasons behind the lack of broadband and cellular connectivity in rural areas are mostly financial. The terrain and remote conditions can increase construction costs and the low population density in rural areas translates to lower cellular usage. This means that it is difficult for telecommunications companies to make a financial business case justifying deployment in rural areas, as it is difficult to earn enough of a return on their infrastructure investments.[26] In fact, certain wireless carriers have decided not to deploy cellular infrastructure in certain rural areas because they estimate that it does not generate sufficient profit, due to the low population densities. However, other carriers have committed to rolling out coverage in rural areas, so cellular coverage may not be an issue by the time connected vehicle technology is in common use.[27]

## 5G vs. DSRC

Current cellular technology suffers from latency challenges, namely that the latency provided by cellular networks is too high to be used in safety-critical applications. DSRC is able to transmit data at a faster

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[25] "National Connected Vehicle Field Infrastructure Footprint Analysis," 45.

[26] "Intelligent Transportation Systems; Urban and Rural Transit Providers Reported Benefits but Face Deployment Challenges."

[27] Diana Smith. "The Truth About Spectrum Deployment in Rural America," 2-3, 8. Mobile Future. March 2015. Accessed June 2016.
http://mobilefuture.org/wp-content/uploads/2015/03/031615-MF-Rural-Paper-FINAL.pdf

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speed than 3G and 4G/LTE networks. In the future, the advent of 5G technology might be able to match DSRC transmission speeds and possibly further reduce latency, but this network may face capacity issues that are not present on the dedicated DSRC network. While the specifications for 5G have not yet been established, 5G Infrastructure Public Private Partnership (5G PPP), a research program organized by the European Commission, listed latency of under 5ms and mobility support at speeds of up to 500 km/hour as being some of the most important requirements of 5G if it is to support emerging technology in sectors such as transportation, energy, health, and so on.[28] DSRC equipment (radios, on-board devices, etc.) are currently being rolled out; however, there is discussion in the industry that DSRC may be overtaken by 5G, if a 5G network can be deployed in rural areas. This could lead to challenges with the connected vehicle infrastructure deployment and may further curb investment, as agencies want to ensure that their infrastructure investment will be operational long into the future with minimal need to replace or supplement the initial investment. 5G (as well as 4G, 3G, etc.) could be quite useful to provide a backhaul channel for connected vehicle technology in rural environments; in fact, Verizon is already providing wireless backhaul to several state DOTs. The challenge is to get the telecommunication providers to deploy their technologies so that it reaches all roads.

# Rural Culture and Demographic Barriers to Technology Adoption

Another finding related to rural culture with regard to advanced technologies. In this section, the white paper presents rural barriers such as the lack of uptake of technology, reluctance to upgrade to newer generations of technology, and a generalized rural perception regarding government programs and privacy (and safety) issues related to technology that may present challenges.

## Technology Adoption in Rural Areas

Technology adoption (or the lack thereof) in rural America presents a significant challenge to connected vehicle deployment. Studies confirm that there is less digital literacy and lower penetration of connected devices among adults living in rural areas, compared to their counterparts living in urban and suburban areas. In 2011, the Pew Research Center reported that urban and suburban residents were roughly twice as likely to own a smartphone as were those living in rural areas.[29] Though the gap in technology acquisition between these communities is lessening with time (with 43% of rural adults owning a smartphone in 2014, as opposed to 64% of urban adults), the difference is still significant. Figure 3 depicts internet and smartphone penetration in the United States by population demographic for 2014.

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[28] "5G Empowering Vertical Industries" 5G PPP. February 2016. Accessed August 2016. https://5g-ppp.eu/wp-content/uploads/2016/02/BROCHURE_5PPP_BAT2_PL.pdf

[29] Aaron Smith. "Smartphone Adoption and Use," 3. Pew Research Center. July 11, 2011. Accessed June 2016. http://www.pewinternet.org/2011/07/11/smartphone-adoption-and-usage/

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Figure 3 breaks down the percentage of internet and smartphone users by age group, education level, household income, and community type (urban, suburban, or rural).[30]

| Demographic | Smartphone owners in 2014 *Among adults, the % who have a smartphone* | Internet users in 2014 *Among adults, the % who use the internet, email, or access the internet via a mobile device* |
|---|---|---|
| **All Adults** | 58% | 87% |
| **Age group** | | |
| a) 18-39 | 83 | 97 |
| b) 30-49 | 74 | 93 |
| c) 50-64 | 49 | 88 |
| d) 65+ | 19 | 57 |
| **Educational Level** | | |
| a) High school grad or less | 44 | 76 |
| b) Some college | 67 | 91 |
| c) College+ | 71 | 97 |
| **Household Income (per year)** | | |
| a) Less than $30,000 | 47 | 77 |
| b) $30,000-$49,999 | 53 | 85 |
| c) $50,000-$74,999 | 61 | 93 |
| d) $75,000+ | 81 | 99 |
| **Community Type** | | |
| a) Urban | 64 | 88 |
| b) Suburban | 60 | 87 |
| c) Rural | 43 | 83 |

*Source: Pew Research Center, June 2016*

**Figure 3. Smartphone Ownership and Internet Usage**

The disparity in technology penetration is consistent across various areas of technology ownership and use, from smartphones to broadband service to Internet usage, and is correlated with demographic factors such as age, income, and education.

As rural areas tend to have a higher percentage of older and lower income residents who have lower education completion levels, the general public's knowledge of connected vehicle technology and acceptance of these vehicles and technologies could take longer than in urban and suburban areas.

It is important to develop a public education program to explain the importance and benefits of connected vehicles, and how individual drivers in rural communities may benefit from the use of these technologies. According to the 2012 Census Bureau, nearly 53% of United States (US) households without internet

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[30] "The Web at 25 in the U.S." Pew Research Center. February 27, 2014. Accessed June 2016. http://www.pewinternet.org/files/2014/02/PIP_25th-anniversary-of-the-Web_022714_pdf.pdf

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service of any kind cited a lack of interest or need as the main reason for non-adoption.[31] This demonstrates the importance of investment in outreach to rural areas regarding the benefits of connected vehicle technology to minimize the rural adoption gap.

## Technology Turnover

Another factor to consider when assessing connected vehicle deployment is technology turnover rate. Promoting a new technology is not always enough to make it commonplace. In 2015, for instance, a mere 2% of Americans said they upgrade their smartphone when a new model is released, citing that they preferred to wait until their existing phones stop working or become obsolete.[32] In the case of connected vehicles, in order to get people in rural communities to update the technology in the vehicles they drive, concerted efforts will have to be made to incentivize upgrades. Growth of the refurbishment market and/or discounts on the price of switching to a connected vehicle could help facilitate connected vehicle integration.

## The Impact of Culture

Research has shown that rural residents tend to be more skeptical of government initiatives. Workshop attendees stressed the importance of this difference in cultural attitudes, saying that any program promoting connected vehicle technologies needed to be explained to the rural community in a way that addresses their concerns, rather than simply being mandated from the top, in order to increase the chances that the technology is actually accepted and used.

In addition, researchers at the University of Minnesota studied driver attitudes and found that rural drivers were more distrustful of government interventions and tended to have lower perceptions of the risk of certain driving behavior, such as not wearing seatbelts, than urban drivers.[33]

These factors may be important to keep in mind for effective deployment of new technologies in rural areas.

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[31] Mike Maciag. "Broadband Expands into Rural America, But How Many Will Adopt?" Governing. November 2014. Accessed June 2016.
http://www.governing.com/topics/transportation-infrastructure/gov-broadband-rural-expansion.html

[32] Art Swift. "Americans Split on How Often They Upgrade Their Smartphones." Gallup. July 8, 2015. Accessed July 2016. http://www.gallup.com/poll/184043/americans-split-often-upgrade-smartphones.aspx

[33] Michael E. Rakauskas, Nicholas J. Ward, and Susan Gerberich. "Identification of Differences between Rural and Urban Safety Cultures," in Accident Analysis & Prevention 41 (2009): 3. PubMed. Accessed July 2016. https://www.researchgate.net/profile/Michael_Rakauskas/publication/26726311_Identification_of_differences_between_n_rural_and_urban_safety_cultures/links/55d3edd308ae0a3417226f26.pdf

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# Chapter 3. Next Steps

In this section the ITS America research team begins to address the question of what can be done to improve the chances of successful connected vehicle deployment and subsequently, what can aid in increasing the benefits of these technologies in rural areas. These recommendations are intended to address some of the challenges identified above and help promote effective deployment of connected vehicle technology on rural roadways. There are a number of references in this section that will allow the rural communities to self-start the recommendations.

The near-term action items for promoting connected vehicle deployment in rural areas are varied and are envisioned to begin at once, and then build over the next three to five years. The near-term areas further defined as action items are:

1. Develop connected vehicle sustainability plan
2. Support freight supply chain deployments
3. Innovative approaches to funding
4. Enact benefits and outreach program

## Develop Connected Vehicle Sustainability Plan

Even though connected and automated vehicle technology deployments appear to be a few years off, there are additional steps that are recommended for rural agencies to take to ensure their readiness and the sustainability of these recommended action items. Development of sustainability plans is also a relatively inexpensive action item that will aid in setting a vision for connected and automated vehicle technologies.

It is recommended that rural communities develop connected vehicle sustainability plans. The sustainability plans are recommended to also address automated vehicles and address sustainable funding, a communications plans for connected and automated vehicles, steps leading to the creation and fulfillment of a sustainable outreach effort (which includes dissemination of the outcome of rural trials and pilots), necessary staffing KSAs required to support connected and autonomous vehicle technologies, data management and use needs, and support for deployment of freight supply chain trials and pilots.

The opportunity for connected vehicles to aid in improved data collection on rural roadways may not readily seem like a benefit worthy of funding, especially when compared to investing in safety improvements. However, it is important to note that a more robust data stream indicating roadway conditions and how rural roadways are operating will aid in supporting systematic decision-making and in demonstrating the effectiveness of any road improvement. Enhancing the organizations' ability to easily quantify improvements by having data readily available will aid in keeping the cost of the trials down and allow the agencies to easily demonstrate benefits. To take advantage of this opportunity, the local

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transportation agency is recommended to internally assess their ability to receive the data. Assessment will include current systems, communications, roadside infrastructure, and appropriately trained staff.

With regard to staff, managing new technology will require new skills, such as data analysis and cybersecurity, where state or local DOTs may not have staff with adequate knowledge and training. Agencies are recommended to assess current staff KSAs and determine what additional skillsets may be required. This assessment can be done through discussions with other rural communities that have deployed these technologies, as well as through various ongoing ITS/connected vehicles/AV workforce challenges. Once the educational needs are identified, staff can be trained using online course offerings such as USDOT's ITS Joint Program Office's (JPO's) Professional Capacity Building (PCB) Program[34] and Consortium for ITS Training and Education (CITE)[35] courses (many of which are free), or by cultivating relationships with local universities and/or private entities that could provide the necessary training. This white paper recommends that agencies start early to explore what skills are required and how best to ensure that staff is equipped with these skills to prepare for the future of connected vehicles.

In addition to workforce skills, it may be necessary to perform an assessment of equipment currently in use to determine if the existing equipment is scalable, adaptable, and capable of accommodating the currently known and recognized connected vehicle technologies and ancillary components.

## Support Trial Deployments

Trial deployments are effective in demonstrating the effectiveness of connected vehicle technologies on rural roadways and can be deployed using a number of means. It is important to note that for rural applications the trials are less a test of IF the connected vehicle technology functions properly, but rather will demonstrate the benefits of and how well the tried-and-true connected vehicle technology works in the rural environment.

Trial deployments can be funded through national competitive procurement efforts and/or may be a form of a public-private partnership (P3) between the rural agency and the vendor.

The research team recommends that trials and/or demonstrations of connected vehicle technology focus on the following locations and problem areas. These recommendations are based on information gathered from rural practitioners providing input into this project. These trial locations and issue areas are envisioned to have the highest potential to benefit from connected vehicle technology:

- Remote and high speed curves with a high frequency of crashes, high number of fatal or severe crashes, likely without access to traditional power and telecommunications sources

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[34] "ITS Professional Capacity Building Program / Advancing ITS Education." Intelligent Transportation Systems Joint Programs Office, U.S. Department of Transportation. Accessed August 2016. http://www.its.dot.gov/research_areas/connected_vehicle.htm

[35] "Online Interactive Advanced Transportation Training and Education." CITE. 2017. Accessed July 2017. http://www.citeconsortium.org/

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- Turns across non-signalized, high-speed intersections with curve and/or horizontal alignment challenges, where there is a high frequency of crashes

- Rural signalized intersections

- Rural interstates, building on the Wyoming Connected Vehicle Pilot

- Freight routes which connect hubs, such as a port or a freight depot or rail facility, to help identify larger benefits including those that impact global agricultural or manufacturing supply chains

- Remote rural roadways prone to extreme winter weather, where weather data is being collected manually using fleet vehicles, in order to compare the results of such a system with one running on advanced vehicle technologies

- High animal collision areas, including in areas with warning systems currently in place, so that the added value of a connected vehicle deployment can be assessed

Due to low traffic volumes on rural roadways, any trial intended to quantify the benefits of a particular connected vehicle technology or application will require a longer timeframe than a corresponding trial in an urban area, in order to allow a sufficient number of vehicles to use or take advantage of the technology. State and local road agencies should take this into account when evaluating the results of trial deployments and making decisions on where to deploy these technologies.

## Freight Supply Chain Deployment Trials

The Fixing America's Surface Transportation (FAST) Act enables trial deployments located on Critical Rural Freight Corridors[36] (CRFCs) which are an integral part of the National Highway Freight Networks.[37] A more compelling case is recommended to be made to federal, state, and local entities to facilitate rural freight connected vehicle trial deployments on CRFCs. Significant returns on investment can be realized by investing in rural technology projects that are much less expensive and quicker to deliver when compared to traditional highway capacity building and/or expansion projects.

The rural freight trial deployment locations will have added value by supporting the freight supply chain in addition to tackling the challenges of traffic operations in rural areas.

It is also recommended to develop freight supply chain Use Cases and Deployment Strategies as a continuation to this effort. Resources related to funding opportunities and channels for advancing new technology deployment projects that are freight focused are available at:

- Infrastructure for Rebuilding America Grants: https://www.transportation.gov/buildamerica/FASTLANEgrants

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[36] "FAST Act, Section 1116 National Highway Freight Program (NHFP) Guidance: Designating and Certifying Critical Rural Freight Corridors and Critical Urban Freight Corridors." Federal Highway Administration, U.S. Department of Transportation. Accessed July 2017. https://ops.fhwa.dot.gov/fastact/crfc/sec_1116_gdnce.htm

[37] "National Highway Freight Network." Federal Highway Administration, U.S. Department of Transportation. Accessed July 2017. https://ops.fhwa.dot.gov/freight/infrastructure/nfn/index.htm

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- Nationally Significant Freight and Highway Projects (NSFHP) program under the FAST Act: https://www.transportation.gov/sites/dot.gov/files/docs/NSFHP%20Fact%20Sheets%20with%20Letterhead_v2.pdf
- Accelerated Innovation Deployment (AID) Demonstration notice of funding availability: https://www.fhwa.dot.gov/innovation/grants/

# Innovative Approaches to Funding

There are several instruments that agencies can use to fund deployment of innovative transportation projects such as connected vehicles. Keeping in mind that sustainable outreach and education efforts may also require funding, rural agencies are strongly encouraged to review resources and funding opportunities available in order to develop innovative financing mechanisms, and stresses inclusion of private sector opportunities where applicable. The deployment of connected vehicle technology will by definition include several private sector partners (telecom providers, technology vendors, and others) and therefore provides a prime opportunity for public-private partnerships.

## Grants, Bonds, and Project Finance

While most states are familiar with the more traditional grants and funding opportunities, there has been a recent addition to the grant pool – FAST Act Technology grants.[38][39] These grants have been funded at approximately $60 million per year for the years 2016 to 2020, inclusive. As the FAST Act technology grants are specifically tailored to deploying advanced technologies, this grant opportunity is uniquely suited for connected vehicle deployments and can be applied for at the state or local level, or by universities, transit agencies, or research organizations.

Other project finance vehicles that communities can look to include Section 129 Loans, State Infrastructure Banks, Grant Anticipation Revenue Vehicles, Transportation Infrastructure Finance and Innovation Act (TIFIA)[40] Credit Assistance, Private Activity Bonds (PAB), and Build America Bonds (BAB).

Links to funding information can be found in Appendix C.

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[38] "FAST Act; Advanced Transportation and Congestion Management Technologies Deployment," Report 114, Section 6004, 671. House of Representatives. 2015. Accessed August 2016. http://transportation.house.gov/uploadedfiles/crpt-114hrpt-hr22.pdf

[39] "Fixing America's Surface Transportation Act or "FAST Act." Federal Highway Administration, U.S. Department of Transportation. Accessed July 2017. https://www.fhwa.dot.gov/fastact/funding.cfm

[40] "Fact Sheets on Highway Provisions." Federal Highway Administration, U.S. Department of Transportation. Accessed July 2017. https://www.fhwa.dot.gov/safetealu/factsheets/tifia.htm

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## Public-Private Partnerships

Financing mechanisms adopted in expanding highway infrastructure such as P3s and innovative project financing should be considered for funding and expanding telecommunications infrastructure. FHWA encourages the use of P3s in the development of transportation improvements and has created several resources designed to help communities create innovative funding mechanisms.

USDOT's Build America Bureau[41] has been created specifically in order to expand, innovate, and deliver transportation facilities and services, and combined with the Center for Innovative Finance Support,[42] provides information and expertise in the use of different P3 approaches. Assistance includes using the Special Experimental Project 15[43] program, Section 129 Loans[44], State Infrastructure Banks, Grant Anticipation Revenue Vehicles, TIFIA Credit Assistance, PAB and BAB.

In the case of connected vehicle deployments in rural areas, local agencies should consider the use of P3s for expanding telecommunications infrastructure. Specific efforts should be made to involve the freight and telecommunications industry in the financing of these projects, as commercial freight players will reap benefits from connected vehicle technology in the form of improved logistics and early warning about weather events that can prevent delays and economic loss. Similarly, telecommunications providers stand to earn revenue from new customers and increased bandwidth usage by the connected vehicles and infrastructure. More information on federal resources for public-private partnerships can be found in the appendix.

## Other Funding Opportunities

Other recommended funding opportunities that are worth exploring include:

- Encouraging the establishment of a set-aside fund specifically for rural connected vehicles deployments. This set-aside could come from a number sources (including private sector sources). Set asides may be instrumental in creating funding for freight organizations (funding

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[41] "About The Build America Bureau." Build America Bureau, U.S. Department of Transportation. Accessed July 2017. https://www.transportation.gov/buildamerica/about

[42] "Public Private Partnerships (P3s)." Federal Highway Administration, U.S. Department of Transportation. Accessed July 2017. https://www.fhwa.dot.gov/ipd/p3/

[43] "E-Alerts: FHWA Initiates SEP-15 to Promote Public-Private Partnerships and Other Innovations in Project Development and Finance." Nossaman LLP. Accessed July 2017. http://www.nossaman.com/fhwa-initiates-sep15-promote-publicprivate-partnerships-other

[44] "Section 129 Loan Program Guidance." Federal Highway Administration, U.S. Department of Transportation. May 2014. Accessed July 2017. https://www.fhwa.dot.gov/ipd/pdfs/finance/Section_129_Loan_Guidance_051514.pdf

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special grants or trials such as was done with the Smart City Challenge are envisioned for freight).[45] An organized approach will need to occur for this recommendation to be realized.

- Creating business models that are attractive to third parties; encouraging use of rural roadways as a test bed; create any necessary laws and regulations to allow third parties to deploy technologies on the roadways. The state offer use of the rural roadways and the third parties provide the cost of the deployments.

- Phase 1 V2I Deployment Coalition Technical Working Group #1: Deployment Initiatives – has been developing a "bold plan" to encourage the deployment of DSRC infrastructure with Signal Phase and Timing (SPaT) broadcast at a minimum of 20 intersections in each state in the coming three years, and for the states to commit to operating these SPaT broadcasts for at least ten years.[46] As of April 2017, funding for the bold plan was still under discussion.[47] Encouragement of such options could benefit rural communities where traffic signals are present. This type of early deployment with anticipated positive safety results could greatly benefit rural connected vehicle deployments as a whole.

# Enact Benefits and Outreach Campaign

A well thought out outreach and building awareness of technology benefits impacting roadway operations as well as regional economies will be key to get the support of transportation agencies, elected officials, and communities in rural areas. A more aggressive and dedicated approach should be developed to engage all entities involved to gain their confidence and acceptance of embracing new technologies by imparting messages in clear terms.[48]

As discussed in the Rural Culture section, there is skepticism in the rural transportation community about connected vehicle technology as a whole, especially as there are some industry-wide perceptions that technologies other than DSRC might be better suited. Furthermore, most interviewees shared the perception that connected vehicle applications are a tool to mitigate congestion and therefore are not particularly necessary in rural communities with low vehicular density. This white paper recommends that USDOT assist rural transportation providers in clearly educating and spreading awareness about how connected vehicle technology works, how it can be implemented in rural areas, and how rural communities could benefit from the enhanced safety and mobility features it can provide.

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[45] "Smart City Challenge: Interested Organizations." U.S. Department of Transportation. August 16, 2016. Accessed August 2016. https://www.transportation.gov/smartcity/interested-organizations/list

[46] "TWG I: Deployment Initiatives." NOCoE. 2016. Accessed August 2016. http://www.transportationops.org/twg-1-deployment-initiatives

[47] "SPaT Challenge Overview." NOCoE. Accessed July 2017. https://www.transportationops.org/spatchallenge

[48] Mike Pina, "How to Communicate Complex Ideas to the General Public." U.S. Department of Transportation. June 2017. Accessed July 2017. https://www.its.dot.gov/presentations/2017/NAGC%202017.v3.pdf

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The first step is education and promotion. Promotion includes developing an outreach and awareness program that:

- Raises awareness about rural transportation needs that are best served by connected vehicle technology

- Promotes and educates the transportation providers on the utility of rural connected vehicle technology

- Creates opportunities for rural communities to deploy connected vehicle technology that minimizes obstacles to deployment and addresses sustainability measures early in the planning process

To facilitate the outreach and education effort, it is important to have a champion to lead the effort and be the focal point for the organization and possibly for the region. Identifying a "champion" organization (at first) and then an individual or team of individuals within the organization will help in addressing issues, concerns, and any miscommunications or misperceptions that are likely to occur when introducing connected vehicles. Early and effective communications of what is planned and how the motoring public may encounter or benefit from the new technologies will be a common theme in the role of the lead agency. The interviewees indicated that a state DOT or agency should be in the lead role to coordinate the connected vehicle program for the state or region.

USDOT provides a number of resources on public engagement and related topics that will aid the "champion" and lead organization.[49][50] Outreach should be initially targeted at rural transportation decision makers, as transportation leadership must recognize the potential of connected vehicles in order to facilitate deployment. However, as pointed out by one interviewee, the use of this type of pervasive technology in transportation is a dramatic change from the past, and will require a cultural change that might take some time to evolve and become commonplace.

One recommendation that can happen immediately is to share information from this white paper, the NRITS presentation, previous webinars, and other informational materials among the local authority leadership. As connected vehicle benefits are quantified, this white paper recommends conducting further outreach and education among the leadership and other decision makers in rural communities.

While it would be advantageous to share information in one-on-one discussions between rural transportation decision makers and those that have already deployed and operated connected vehicle systems, the cost and time required for travel is often prohibitive. Webinars and web-based teleconferences are recommended to increase information sharing as these tools allow two-way

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[49] "Public Involvement Techniques for Transportation Decisionmaking." Federal Highway Administration, U.S. Department of Transportation. 2015. Accessed July 2017. https://www.fhwa.dot.gov/planning/public_involvement/publications/pi_techniques/fhwahep15044.pdf

[50] "Regional Models of Cooperation." Center for Accelerating Innovation, Federal Highway Administration, U.S. Department of Transportation. November 7, 2016. Accessed July 2017. https://www.fhwa.dot.gov/innovation/everydaycounts/edc-3/regional.cfm

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communications among presenters and participants. This recommendation can begin immediately, and is expected to continue to grow in utility as more rural connected vehicle deployments occur.

For rural communities, the ability to share information regarding what other rural communities are doing and have encountered is critical. Several interviewees suggested that case studies about tests, trials, and pilots be deployed and documented to assist rural decision makers with deployment consideration. As rural areas implement connected vehicle technology, a broad dissemination of their experiences and lessons learned—including design guidance, baseline conditions, necessary staff/workforce skills, before and after metrics, cost to deploy, cost to operate, and additional information—will help other rural communities begin their connected vehicle deployments.

While national deployment guidance has yet to be published, one current source for useful institutional information is the Transportation Research Board's (TRB's) National Cooperative Highway Research Program (NCHRP) 20-102 series of research projects.[51] The objectives of NCHRP 20-102 are to

1. Identify critical issues associated with connected vehicles and automated vehicles that state and local transportation agencies and AASHTO will face,

2. Conduct research to address those issues, and

3. Conduct related technology transfer and information exchange activities.

It is important to commend rural communities, as they have long known the value of sharing information and working together in partnerships toward common goals. As advancements continue, the recommendations in this white paper will thrive as rural transportation providers continue to collaborate and mentor each other in the evolving organizational philosophy and technology deployments in support of the next generation of operations and connected vehicle technology. Agencies should establish or enhance a wide variety of relationships, such as with rural communities currently active with connected vehicle deployments, abutting state transportation agency relationships, federal-state, cross-modes, and relationships with third parties that are involved with connected and automated technologies. A strong institutional layer is the foundation for effective deployment and sustainability.

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[51] "Impacts of Connected Vehicles and Automated Vehicles on State and Local Transportation Agencies." The National Academy of Sciences; NCHRP 20-10. 2016. Accessed August 2016. http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3824

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# Appendix A. Interviews

## Individuals Interviewed

The research team chose to interview rural subject matter experts from among those identified in the workshop, as well as those recommended by the Rural Special Interest Group, the Transportation Safety Advancement Group, and other ITS practitioners.

The individuals interviewed as shown in Table 1 aligned with the targeted areas identified during the Workshop:  Safety, Freight, Work Zone Management, Incident Management, and Tourism/Event Management.

**Table 1. Rural CV Gap Analysis Interviewees**

| Interviewee | Organization | Workshop area(s): | | | | |
|---|---|---|---|---|---|---|
| | | **Safety** | **Freight** | **WZs** | **IM** | **Tourism** |
| Steve Albert | Western Transportation Institute (WTI) at Montana State University | ✔ | ✔ | ✔ | ✔ | ✔ |
| John Corbin | FHWA | | | | | |
| Dean Deeter | Athey Creek Consultants | ✔ | ✔ | ✔ | ✔ | ✔ |
| Bob Koeberlein | Idaho Transportation Department | ✔ | | ✔ | ✔ | ✔ |
| Bill Legg | Washington State DOT | ✔ | ✔ | ✔ | ✔ | ✔ |
| Blaine Leonard | Utah DOT | ✔ | | | | |
| Galen McGill | Oregon Department of Transportation | ✔ | | ✔ | ✔ | |
| Paul Pisano | FHWA – Road Weather Information Systems & Work Zone Team Leader | | | ✔ | ✔ | |
| Acey Roberts | Mississippi Department of Transportation | ✔ | | | | ✔ |
| Eric Rensel | Gannett Fleming | | ✔ | | | |
| Tim Simodynes | Iowa Department of Transportation | ✔ | | ✔ | ✔ | |

*Source: ITS America*

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# Interview Questions

The majority of the interviewees were asked a similar set of base interview questions as well as follow up questions as needed.

1. Rural roadways/environments can mean many different things – roads with low VMT, roads in low population areas, recreational areas (such as state/national parks), roads that may seem somewhat suburban/urban but only serve a transient set of drivers (such as in Branson, MO). Can you please define (or point us to literature that defines) the rural environment?

2. Transportation challenges for rural roadways have been characterized as: severe weather, jurisdictional issues, decreased funding, non-system-wide technology deployments (hot spots only), safety/more severe crashes, power, communications, lack of backhaul, etc. Are there any others? Which types of challenges are most important?

3. Connected Vehicles (CV) and their applications have been described as vehicle, mobile devices, and infrastructure equipped with communications and processing capabilities that exchange pertinent data and information wirelessly (over cellular, satellite, DSRC, etc.) to fulfill a specific (application) need; do you agree? What are the top rural issues/applications that may benefit from connected vehicle technology? Specifically, what about:

    i. Tourism and Event Management

    ii. Safety & Work Zone Management

    iii. Freight

    iv. Transit

    v. Other – funding, institutional acceptance, staff KSAs

4. If/when CVs technologies have been deployed, what benefits do you hope that CV apps can address in rural settings?  How will success be defined?

5. When do you see CV applications being deployed in rural settings? In your setting? (Any answer will do – timeline, contingencies, etc.)

6. What are the challenges to deploying CV technologies in rural settings?
Are these challenges different from deploying (or trying to deploy) other technologies in rural environments?

7. Is the value (or benefits) that CV can provide for rural settings different from other technological deployments?
If so, what is it/are they? Additionally, are they different from urban or suburban settings?

8. In your opinion, has there been sufficient focus on rural CV applications?
If not, what other elements would you like developed?

9. What roles do you see the DOTs being responsible for with regard to CV technologies?
Does DOT (or the public sector) have appropriately trained staff for this role?

10. What types of vendor – or private sector partners – do you envision in the CV marketplace?
Do these types of partnerships (DOTs and private CV players) readily exist?

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11. Have you or your region taken action toward deployment of CV technologies?
     If so, what actions have occurred so far?

Each interview was concluded with an open-ended question such as: "Anything else?" "What do you think are the rural connected vehicle gaps?" "Did we miss anything?"

# Synthesis of Interview Notes

The bullet points below provide some preliminary themes that appear across multiple interviews. This section is not meant to be a thorough or final analysis of the interview notes; rather, it is intended to provide a preliminary, informal glimpse at some of the thoughts that may be expanded upon in this project's final report.

- There are many definitions of "rural," but the defining characteristics seem to be areas with low traffic volumes, high speeds, and fewer resources (especially transportation funding) and other types of public services.

- The term "connected vehicles" is seen as a broad category encompassing vehicles connected to the internet in some way; it does not seem to be specifically limited to DSRC technology. Many SMEs believed that cellular connectivity was a more realistic solution for rural areas, at least in the short term.

- There were five major rural ITS challenges that were consistently cited by interviewees. The difficulty of establishing communications and connectivity in rural areas was a strong theme, and related to that, a general lack of information, whether it is general traveler information, updates for emergency response or incident management, or road weather data. A lack of funding and severe resource constraints were considered to be one of the most serious challenges in deploying rural ITS solutions. Other challenges mentioned include the cost and difficulty of maintaining rural roads, with a general feeling that rural roads tend to be neglected or have low priority at the state DOT level, and the impact of extreme weather events and related incident management.

- Safety topped the list of rural concerns that could be addressed with connected vehicle applications, although the solutions covered a wide variety of areas. Many interviewees mentioned that secondary crashes, where vehicles rear-end other vehicles that have stopped on the road, tend to be a big issue, and these could be avoided with applications that alert drivers to work zones or other incidents on the roadway. Using connected vehicles to collect more granular data on road and weather conditions was listed as being very beneficial, as were animal collision warning systems. Connected vehicles were also seen to be potential helpful in improving operational efficiency, especially with regards to determining when and where road maintenance was required. Finally, applications to help with event management (especially sudden surges associated with sporting events or tourism) and improving freight logistics were cited as areas of interest.

- When asked what would constitute successful deployment of connected vehicle technology, most experts mentioned a reduction in the number and severity of crashes as being the main metric by which they would define success. Improvements in safety were also cited as something that would grab the attention of rural decision makers, who tend to think of connected vehicle technology more as a congestion-mitigation strategy that is perhaps not as applicable in the rural

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areas. The second major metric was the increase in data availability resulting in operational improvements, which could be measured in maintenance cost savings, reduced travel time around events or work zones, and a decrease in road closures.

- None of the experts interviewed envision CV deployments in rural settings in the short term. Most opinions ranged from as early as 2018-2020 to 10 or 15 years from now. Among the reasons cited for the slow deployment were slower fleet turnover rates in rural areas and a lack of funding and buy-in from senior decision makers. However, some experts noted that a change in legislation or the introduction of CV technology on fleets, especially freight vehicles, could cause quicker adoption.

- In general, the challenges of deploying CV technology seem to be similar to general rural ITS challenges in terms of resource constraints, communications, etc. However, there were a few differences worth noting. The timeline of deployment might be longer because it is a new and dramatic change that will require buy-in from decision makers, and the lack of proven benefits or case studies may make that difficult. Further, the fact that the benefits will not be seen until a substantial number of vehicles are equipped with the technology makes justification difficult, especially in the face of severe resource constraints. Finally, CV deployments are different from traditional ITS deployments because it is not fully under the control of state DOTs. They can deploy the infrastructure but vehicles need to be equipped to use the data, which requires either vehicle manufacturer involvement or private vendors.

- Connected vehicles are seen as having the same types of benefits as other ITS technologies, but with the potential to have dramatically more effects because of the amount of data that can be generated and used in a cost-effective manner.

- Is there a gap? – Interviewees are split on whether or not there has been sufficient attention paid to rural issues in the Connected Vehicle research program. Those that do not think so believe that there should be more focus on development of communication infrastructure, road condition and weather data, and long freight corridors. All were able to identify differences between urban efforts and rural efforts (such as crash severity, communications challenges, etc.)

- The roles for the public sector are many and varied, from information provider to information consumer; policy creator; and to more traditional roles such as planner, designer, deployer, operator, and maintainer. The most interesting role for DOTs, according to interviewees, is to be leaders in the CV field by staying up-to-date and aware of what is going on.

- State DOT business models varied from active participant to do-nothing, to create a research-friendly set of roadways to encourage the private sector to come to that state to test and pilot the newest technologies.

- A possible funding opportunity arose through the V2I Deployment Coalition offering to promote CV deployment. They have a SPaT challenge to help rural areas get CV deployments initiated, where states can identify a corridor of 20 intersections and obtain funding to deploy DSRC transmitters at these intersections. The aim is to have all 50 states with CV deployments by 2020.

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# Appendix B. Workshop

The Rural Connected Vehicle Gap Analysis workshop took place August 12, 2015 and the National Rural ITS Conference in Snowbird, Utah. The workshop was prepared for and conducted by ITS America (Patrick Son, Adam Hopps and Carlos Alban).

## Workshop Goal

To gather information from rural emergency response and ITS practitioners regarding the challenges and benefits to Connected Vehicle deployment specifically in the rural environment.

## Attendees

The NRITS Conference workshop attendees and the corresponding organization are listed in Table 2.]

**Table 2. Workshop Attendees**

| Name | Organization |
|---|---|
| Steve Albert | WTI |
| Blaine Leonard | Utah DOT |
| Bill Legg | Washington State DOT |
| Doug Galarus | WTI |
| Rhonda Young | University of Wyoming |
| Trenton Rawlinson | Wyoming DOT |
| Leslie Fowler | Kansas DOT |
| Daris Ormesher | South Dakota DOT |
| Brenda Boyce | Kansas DOT |
| Tim  Simodynes | Iowa DOT |
| Jim Larsen | Ada County Highway District |
| Mike Brown | National Association of Fire Chiefs |
| Jim Misener | Qualcomm |
| Bill Hinkle | Intrado |
| Nancy Pollock | National Emergency Number Association |
| Tom West | California PATH (UC Berkeley) |
| T.J. Nedrow | National Volunteer Fire Association |
| Skip Yeakel | American Trucking Association |
| Cynthia Manley | Agero |
| Dan Dytchkowskyj | National Sheriff's Association |

*Source: ITS America*

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# Notes

## Identifying Benefits

**Freight:**

- Can use the whole fleet to demonstrate benefits.

- Minimal privacy issues

- Long haul freight is still the single biggest user of fuel.

- DSRC can solve all the examination and weigh stations that helps freight and rural interstates.

- Pre-clearance modernization is a national benefit (and a rural one)

- Truck Platooning for fuel savings

- Truck parking in/out of urban areas

- Blind spot warnings

- Weather (another benefit below): Freight haulers are covering roads where weather information is badly needed and putting sensors on those trucks would be helpful.

- Truck safety can be important, including blind spot monitoring and vulnerable road users.

**Tourism:**

- The economy of rural states is dependent upon tourism and is a driver of jobs. Enhancing or influencing travel choices/ability could be a huge benefit.

- Also necessary since users will expect the technology to work the same way. Second stage adopters must have a similar experience as early adopters.

- Incident and Emergency Management:

- Work-zone and incident applications

- Route diversion

- Coming around turns in proximity to a scene / traffic.

**Weather:**

- Much more of a rural benefit

- High wind warnings and animal

**Other Topics:**

- General Safety: geometric benefits that are applicable to rural. Queue warnings, rural construction zones,
- Restriction warnings for freight on height, weight, width, time of day and being able to weave that into freight operation.

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- Snow plow usage: Possibly using previous traveled routes

- School bus stops

## Challenges between State vs. Regional vs. Federal Land Management

**Varied Resources:**

- Some states do not have any TMC or have them only focused on an urban area. Counties do not necessarily have a need for those centers. Link between functionality of connected vehicles in rural area and the expectation of central data centers.

- Federal land management or tribal areas just have resource managers with no understanding of transportation.

**Jurisdictional Issues:**

- Utah owns many arterial roads throughout the state, including signals, etc. so deployment is easier, but this is definitely the exception.

- In Minnesota, they are responsible for every road in the state. We need to be sensitive that it works differently in each state.

- Every inch of New York State is incorporated. You have to be sensitive because of the history of each particular state. There will be varying degrees of educated people on this particular subject.

- Other states, the county is responsible for things like snow clearance and maintenance.

- In every one of these cases, you have a boundary. The boundary needs to be seamless. There are usually some local commissions that guard their area. Need to make sure there is cooperation amongst parties.

**Funding:**

- All ITS deployment would go into urban area if given straight to the state. Solve that by distributing money statewide and allow regional decisions.

- State might deploy but not with maintenance and operational support

**Politics:**

- Toll authorities are additional stakeholder

- Some local commission or board will guard

## Institutional Challenges

**Planning:**

- Risk is a much better measure than use: ITS in Wyoming is about managing freight traffic on I-80. MN has deployed 50 rural intersection systems.

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- Rural ITS has not matured because it has just 'hotspot' applications and no systemized efforts that may or may not even be connected back. However, there could be power already in place.

- Interstates are the safest place to drive, but they are also where most of the money goes.

- 60% of fatalities are road departure and some ITS applications that are there could be integrated into other systems like connected vehicles.

- Backhaul is the big thing to look out for (see below)

- Is it going to become part of STIP?

- Is CV part of the development of ITS? Because in the past 25 years ITS deployment has been all over the place. State of institutional deployment of ITS should be followed as we talk about CV deployment. CV work should be integrated into TSM&O.

**Operations:**

- Concept is relatively new. Very few people are planning around operations.

- Open and closed roads during weather events could be a huge benefit.

- Incident management is a big part, including fires and special events

- In WA most of their work is radio communications with field crews

- Institutionalization of CV deployment is important. We need to look at the state of ITS of the particular state where CV will be deployed.

- Connected Vehicles needs to be integrated into TISMO.

- There is less ITS to manage in Rural Areas. Traffic operations vary depending on the areas.

## Challenges with Power, Telecommunications and Backhaul

**Power:**

- Even if there is power, that does not mean it can be tapped into or that it is not expensive. Solar power reliability is not full proof.

- Systems that are autonomously operated/powered is where we are moving and they are independent of the TMC, which could bode well for connected vehicles. Intelligence in the field (like autonomous controller)

- Solar:
  - Kansas is looking into cloud cover and wattage issues
  - Battery systems require maintenance
  - Theft and vandalism

- Railroad options:
  - Using rail to deliver information in the rural area.
  - Trade-off for FirstNet usage or railroad police?

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- Marine batteries are used for detectors. Is battery power an option? If you are running a VMS or traffic camera, you need a lot of power.

**Communications:**

- Should be the focus be on offloading or should it be on expanding the communications?

  o Depends on the application

  o Information flow has not looked at offloading yet.

  o Not better in the next five years (in KS)

- Using satellite communication is a possibility. Sirius wants to change the TIM to accommodate this issue.

- We are always trying to get more fiber. Fiber is very important.

- UAVs outfitted to upload and download data would be a good business case. It would represent a cost savings. Knowing whether roads are clear or available is very valuable.

- Many states have a copper 'backbone'. For many states in rural areas those are expensive things to build and rely on cellular communications (which is problematic), satellite communication, or radio. Aggregating data and dump it when communication

**Backhaul:**

- If a system is just for providing warnings it probably does not need backhaul. However, we would want access.

- If you are using DSRC to warn drivers do you need backhaul? For rural safety applications, do all these applications need backhaul?

- If you are going to communicate with electronic devices, you need a way to do it. Whether it is via fiber or other ways. There are few locations where we rely on satellite, like Sirius XM. That is an increasing market.

- You could aggregate data and then dump it off when you pass a certain location.

- Information does not have to go very far to hit infrastructure. There has to be something to tap into for infrastructure for rural areas.

## Other Topics

**Definition of Rural:**

- What is the definition of rural? USDOT has a definition of what is rural. Anything that is not suburban or urban is considered rural. Mountain road are considered rural, or "rural and frontier."

- Many states have their own definition of rural. If you ask the people who live in certain cities they may not consider themselves rural (in a small city).

- Rural is more about context than anything else. Tourism is the second leading economic benefit of most rural states. Enhancing visitor's trips when visiting these states should be a priority. Help assist with funding.

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**Cultural:**

- The rural environment I grew up in, we are very skeptical about these things. If something is "shoved down our throats," people are not going to be receptive to it. The message needs to be communicated in the right way, and you must listen to the concerns of the rural stakeholders.

- Managing expectations is very important. Roll out of wireless communications for 911 for example, urban areas get that first even though people travel to rural areas with high frequency.

- People need to understand that even though CV applications work a certain way in urban environments, in rural areas you do not have the same sensors, the same technology. Similar to how text messaging or cell service may or may not work depending on where you are located. Again, managing expectations.

- You need to clarify the NHTSA requirement, and that they have opt-out rights or capabilities. This will help set a tone for people's understanding and expectations.

## Audiences to engage with on deployment

- Federal Bureau of Land Management

- National Park Service

- Tribal Councils

- State DOTs

- AASHTO (maintenance)

- ITE (county and city consultants)

- National Association of Counties

- National Association of County Engineer

- American Public Works Association

- American Council of Engineering Companies

- American Society of Civil Engineers

## Ideal Outcomes of a Gap Analysis regarding rural connected vehicle deployment

- Making management realize it's going to happen: Funding & Planning

- Education about the technology

  o Compelling statements about how it will benefit them

  o AASHTO footprint analysis was management level

  o Adapt for education

  o What it is and what it isn't

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- Would a One pager be helpful to help convince politicians to be on board? A product that would help explain the risk, explain the expectations, what it is and what it is not. In rural areas, there is a lot more sensitivity to big brother and privacy issues.

- Awareness and recognition of rural constraints and opportunities. Could be conveyed through ITS Political Action Committee. We need to prioritize these things. Cannot be a long laundry list.

- Knowing who the stakeholders are and how it will benefit them. Maybe a table that shows stakeholder groups and expected benefits.

- Implementation on wide spread scale, who is leading it? Where does the US fit within that timeline? Is it coming from Europe or Asia? A lot of it will be corridor based in Europe in particular. A lot of the world is looking at the US as V2V leaders and taking the lead on these efforts.

- Manufacturers and vendors; Where are they with this? Are manufacturers trying to figure out where their standards will fall? We are sort of waiting and once those standards are established then you may see manufacturers start to develop the products to fit these standards.

- Where the standards will fall. If indeed NHTSA references a Society of Automotive Engineers standard, it will be only on one standard on V2I.

- A good use or application for trucks may be emergency responder related. It is a great place to start thinking about putting in an application.

- There needs to be a requirement to include emergency response vehicles. How do we protect those vehicles that have this long life span? Retrofitting of these vehicles would be important. National Fire Protection Association does all standards for fire.

- School buses, in rural areas, why not take advantage of these vehicles being mandated on specs and fit these buses. All you would have to do is throw the switch that operates the lights. DSRC is in line of sight with about a half-mile range.

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# Appendix C. Information on Funding Opportunities

## FAST Act

http://www.fhwa.dot.gov/fastact/funding.cfm

http://www.grants.gov/custom/viewOppDetails.jsp?oppId=282434

## Build America Bureau

https://www.transportation.gov/buildamerica

## FHWA Center for Innovative Finance Support

Public-Private Partnerships: http://www.fhwa.dot.gov/ipd/p3/

Project Finance (Section 129 Loans, State Infrastructure Banks, Grant Anticipation Revenue Vehicles, TIFIA Credit Assistance, Private Activity Bonds and Build America Bonds): http://www.fhwa.dot.gov/ipd/finance/

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# Appendix D. Select Bibliography

5G Infrastructure Public Private Partnership (5G PPP). "5G Empowering Vertical Industries." February 2016. Accessed August 2016. https://5g-ppp.eu/wp-content/uploads/2016/02/BROCHURE_5PPP_BAT2_PL.pdf

American Association of State Highway and Transportation Officials (AASHTO). "Rural Emergency Medical Services." 2003. Accessed August 2016. http://safety.transportation.org/htmlguides/rural/section03.htm

Albert, Steve. United States Department of Transportation, Intelligent Transportation Systems Joint Programs Office. "ITS ePrimer; Module 10: Rural and Regional ITS Applications," 2, 5. September 2003. Accessed August 2016. https://www.pcb.its.dot.gov/eprimer/documents/module10p.pdf

Consortium for ITS Training and Education (CITE). "Online Interactive Advanced Transportation Training and Education." 2017. Accessed July 2017. http://www.citeconsortium.org/

Federal Highway Administration, Office of Planning Environment and Realty. "Planning for Transportation in Rural Areas," 4. July 2001. Accessed July 2016. http://www.fhwa.dot.gov/planning/publications/rural_areas_planning/page03.cfm

House of Representatives. "FAST Act; Advanced Transportation and Congestion Management Technologies Deployment," Report 114, Section 6004, 671. 2015. Accessed August 2016. http://transportation.house.gov/uploadedfiles/crpt-114hrpt-hr22.pdf

Insurance Institute for Highway Safety (IIHS). "Roadway and Environment; Urban/Rural Comparison." 2014. Accessed June 2016. http://www.iihs.org/iihs/topics/t/roadway-and-environment/fatalityfacts/roadway-and-environment/2014

Maciag, Mike. Governing. "Broadband Expands into Rural America, But How Many Will Adopt?" November 2014. Accessed June 2016. http://www.governing.com/topics/transportation-infrastructure/gov-broadband-rural-expansion.html

National Academy of Sciences; NCHRP 20-10. "Impacts of Connected Vehicles and Automated Vehicles on State and Local Transportation Agencies." 2016. Accessed August 2016. http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3824

National Highway Traffic Safety Administration (NHTSA) "Traffic Safety Facts 2014; A Compilation of Motor Vehicle Crash Data from the Fatality Analysis Reporting System and the General Estimates System." 2014. Accessed June 2016. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812261

National Operations Center of Excellence (NOCoE). "SPaT Challenge Overview." Accessed July 2017. https://www.transportationops.org/spatchallenge

U.S. Department of Transportation
Office of the Assistant Secretary for Research and Technology
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Rural Connected Vehicle Gap Analysis | 43

National Operations Center of Excellence (NOCoE). "TWG I: Deployment Initiatives." 2016. Accessed August 2016. http://www.transportationops.org/twg-1-deployment-initiatives

Nossaman LLP. "E-Alerts: FHWA Initiates SEP-15 to Promote Public-Private Partnerships and Other Innovations in Project Development and Finance." Accessed July 2017. http://www.nossaman.com/fhwa-initiates-sep15-promote-publicprivate-partnerships-other

Pew Research Center. "The Web at 25 in the U.S." February 27, 2014. Accessed June 2016. http://www.pewinternet.org/files/2014/02/PIP_25th-anniversary-of-the-Web_022714_pdf

Pina, Mike. U.S. Department of Transportation. "Section 129 Loan Program Guidance." June 2017. Accessed July 2017. https://www.its.dot.gov/presentations/2017/NAGC%202017.v3.pdf

Rakauskas, Michael E., Nicholas J. Ward, and Susan Gerberich. PubMed. "Identification of Differences between Rural and Urban Safety Cultures," in Accident Analysis & Prevention 41 (2009): 3. Accessed July 2016. https://www.researchgate.net/profile/Michael_Rakauskas/publication/26726311_Identification_of_differences_between_rural_and_urban_safety_cultures/links/55d3edd308ae0a3417226f26.pdf

Smith, Aaron. Pew Research Center. "Smartphone Adoption and Use," 3. July 11, 2011.  Accessed June 2016. http://www.pewinternet.org/2011/07/11/smartphone-adoption-and-usage/

Smith, Diana. Mobile Future. "The Truth About Spectrum Deployment in Rural America," 2-3, 8. March 2015. Accessed June 2016. http://mobilefuture.org/wp-content/uploads/2015/03/031615-MF-Rural-Paper-FINAL.pdf

Swift, Art. Gallup. "Americans Split on How Often They Upgrade Their Smartphones." July 8, 2015. Accessed July 2016. http://www.gallup.com/poll/184043/americans-split-often-upgrade-smartphones.aspx

U.S. Department of Transportation. "AASHTO Connected Vehicle Field Infrastructure Footprint Analysis; Preparing to Implement a Connected Vehicle Future." 2014. Accessed August 2016. http://www.its.dot.gov/itspac/Dec2014/AASHTO_FootprintAnalysis.pdf

U.S. Department of Transportation, Build America Bureau. "About The Build America Bureau." Accessed July 2017. https://www.transportation.gov/buildamerica/about

U.S. Department of Transportation, Federal Highway Administration, Center for Accelerating Innovation. Regional Models of Cooperation." November 7, 2016. Accessed July 2017. https://www.fhwa.dot.gov/innovation/everydaycounts/edc-3/regional.cfm

U.S. Department of Transportation, Federal Highway Administration. "Fact Sheets on Highway Provisions." Accessed July 2017. https://www.fhwa.dot.gov/safetealu/factsheets/tifia.htm

U.S. Department of Transportation, Federal Highway Administration. "FAST Act, Section 1116 National Highway Freight Program (NHFP) Guidance: Designating and Certifying Critical Rural Freight Corridors and Critical Urban Freight Corridors." Accessed July 2017. https://ops.fhwa.dot.gov/fastact/crfc/sec_1116_gdnce.htm

U.S. Department of Transportation
Office of the Assistant Secretary for Research and Technology
Intelligent Transportation Systems Joint Program Office

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U.S. Department of Transportation, Federal Highway Administration. "Fixing America's Surface Transportation Act or "FAST Act." Accessed July 2017. https://www.fhwa.dot.gov/fastact/funding.cfm

U.S. Department of Transportation, Federal Highway Administration. "National Highway Freight Network." Accessed July 2017. https://ops.fhwa.dot.gov/freight/infrastructure/nfn/index.htm

U.S. Department of Transportation, Federal Highway Administration. "Public Involvement Techniques for Transportation Decisionmaking." 2015. Accessed July 2017. https://www.fhwa.dot.gov/planning/public_involvement/publications/pi_techniques/fhwahep15044.pdf

U.S. Department of Transportation, Federal Highway Administration. "Public Private Partnerships (P3s)." Accessed July 2017. https://www.fhwa.dot.gov/ipd/p3/

U.S. Department of Transportation, Federal Highway Administration. "Section 129 Loan Program Guidance." May 2014. Accessed July 2017. https://www.fhwa.dot.gov/ipd/pdfs/finance/Section_129_Loan_Guidance_051514.pdf

U.S. Department of Transportation, Intelligent Transportation Systems Joint Programs Office. "Connected Vehicle – ITS Research 2015-2019." Accessed August 2016. http://www.its.dot.gov/research_areas/connected_vehicle.htm

U.S. Department of Transportation, Intelligent Transportation Systems Joint Programs Office. "ITS Professional Capacity Building Program / *Advancing ITS Education*." Accessed August 2016. http://www.its.dot.gov/research_areas/connected_vehicle.htm

U.S. Department of Transportation. "CVRIA 2.2 Heritage." June 27, 2017. Accessed July 2017. http://local.iteris.com/arc-it/html/servicepackages/spsheritagecvria.html

U.S. Department of Transportation, Intelligent Transportation Systems Joint Programs Office. "CV Pilot Deployment Program" Accessed August 2016. http://www.its.dot.gov/pilots/

U.S. Department of Transportation. "National Connected Vehicle Field Infrastructure Footprint Analysis," 45, 66. May2, 2014. Accessed August 2016.

U.S. Department of Transportation. "Smart City Challenge." July 08, 2016. Accessed July 2016. https://www.transportation.gov/smartcity

U.S. Department of Transportation. "Smart City Challenge: Interested Organizations." August 16, 2016. Accessed August 2016. https://www.transportation.gov/smartcity/interested-organizations/list

U.S. Department of Transportation. "Wyoming DOT Connected Vehicle Pilot Program" 8, 10. September 30, 2015. Accessed July 2016. http://www.its.dot.gov/pilots/pdf/04_CVPilots_Wyoming.pdf

U.S. Government Accountability Office (GAO). "Intelligent Transportation Systems; Urban and Rural Transit Providers Reported Benefits but Face Deployment Challenges," 42-43. June 2016. Accessed June 2016. http://www.gao.gov/products/GAO-16-638

U.S. Department of Transportation
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Intelligent Transportation Systems Joint Program Office

Rural Connected Vehicle Gap Analysis | **45**

Wyoming Department of Transportation (WYDOT). "Wyoming Project will Connect Snowplows, Trucks, Fleet, Management Centers." October 07, 2015. Accessed August 2016. http://www.dot.state.wy.us/news/wyoming-project-will-connect-snowplows-trucks-fleet-management-centers-1

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