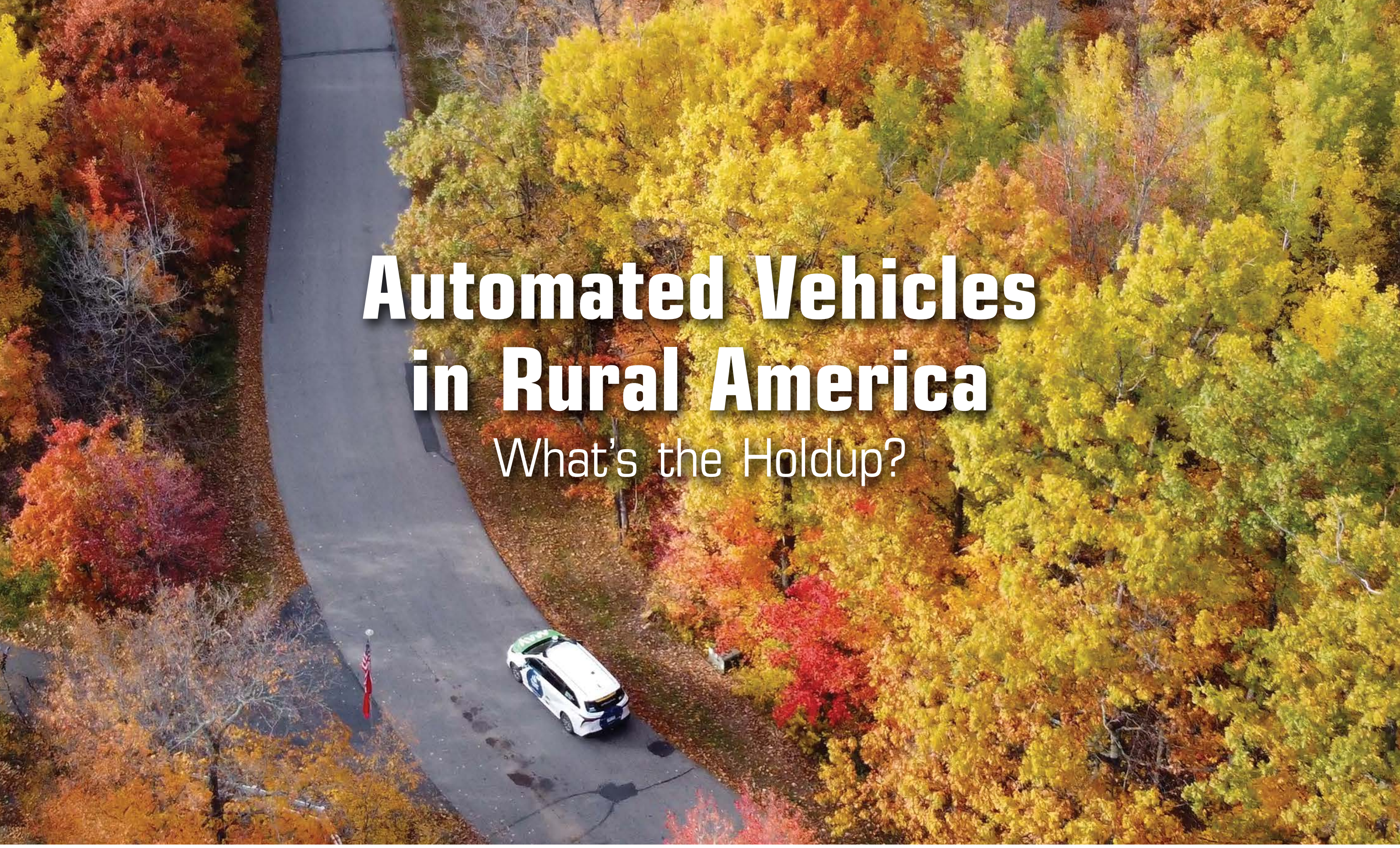

Automated Vehicles in Rural America

What's the Holdup?

Courtesy of goMARTI

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Autumn splendors frame a self-driving passenger shuttle on its route around Grand Rapids, Minnesota, gateway to the Northwoods wilderness. Such pilot programs aim to demonstrate the potential of automated vehicles to improve mobility in rural communities by safely navigating unpaved, snowy, or poorly marked roads.

Rural areas, home to just one in five Americans, contain an outsized share of the nation's roadways, accounting for 68 percent of total lane miles (*1*). These roads, which transport agricultural, manufacturing, and other freight as well as people, differ significantly from their urban and suburban counterparts. And that complicates efforts to introduce automated vehicles (AVs) as a way to improve safety, mobility, and access to essential services in rural communities, where getting to work, the supermarket, or a doctor's office often requires a long-distance drive.

Compared with roadways in developed areas, where the bulk of AV testing and development has taken place, rural roads have a wider variety of surface types and serve a greater diversity of users that range from horse-drawn buggies to combine harvesters to 18-wheeler trucks, each traveling at different speeds. Many lack safety features typically found on nonrural roads, such as lane and edge markings, sidewalks, and curbs.

Overall, rural roadways are much less structured than urban and suburban roads, with large variability even within a single road. They are also more dangerous. Despite lower traffic volumes, rural roadways have disproportionately higher crash rates compared with their urban counterparts. According to a Governors Highway Safety Administration analysis of NHTSA's Fatality Analysis Reporting System data, the risk of dying in a crash was 62 percent higher on a rural road in 2020 compared with an urban road for the same trip length (*2*). Road departures and head-on collisions top the list of common fatal crash types, with 61 percent of rural road fatalities occurring on straight sections.

Along with reducing the frequency of these crashes by mitigating some of the risk factors that lead to them, AVs have the potential to increase mobility. The Census Bureau estimates that more than a million American households—approximately 2.5 million people—in primarily rural counties lack access to a private vehicle (*3*). Moreover, rural residents do not have the convenient public-transportation options or other alternatives to driving that abound in urban areas. The limited transportation options that are available usually consist of demand–response services, which require individuals to schedule rides ahead of time from one location to another rather than being able to rely on fixed routes.

Studies suggest that AVs have the potential to improve safety and mobility. To date, however, most AV testing and development is taking place in cities or and suburbs and fails to examine specific issues that rural populations commonly experience, such as traveling long distances for routine errands or medical appointments. This is problematic for widespread, equitable, and successful implementation to ensure that AVs and their benefits become a reality for all.

This article discusses AV testing underway in rural areas and how these demonstrations can influence public perception and use of driverless vehicles. It addresses infrastructure needs and presents a health care use case, followed by lessons learned and future considerations.

Rural Demonstrations and Deployments

Automated Driving Systems (ADS) for Rural America, a U.S. Department of Transportation (U.S. DOT) ADS Demonstration Grant project led by the University of Iowa, aims to produce a publicly available dataset on the performance of automation on rural roadways in various traffic conditions, at different times of the day, and in all four seasons.[1] Using an automated transit shuttle, data were collected to help identify risks, opportunities, and insights regarding the challenges. Available data include information from the following:

- Automation sensors on the vehicle;
- Biometric monitors worn by passengers;
- Weather sensors;
- Videos of the roadway, passengers, and safety driver; and

[1] Learn more about the ADS for Rural America at https://adsforruralamerica.uiowa.edu/.

Jacob W. Frank, National Park Service

A compact package of efficiency, TEDDY—Yellowstone National Park's driverless electric bus—is the world's first 3-D–printed AV.

North Carolina DOT

During a 2021 demonstration project, visitors to Wright Brothers National Memorial on North Carolina's Outer Banks could travel around the park—including to the summit of Kill Devil Hill, site of America's first flight—aboard CASSI, the first autonomous shuttle piloted on public recreational lands.

- Qualitative responses to questionnaires by riders and safety driver.

The Electric Driverless Demonstration in Yellowstone (TEDDY)[2] [National Park] and the Connected Autonomous Shuttle Supporting Innovation (CASSI)[3] were two pilot projects conducted in 2021 by the National Park Service as part of its Emerging Mobility Initiative.[4] These demonstrations examined the use of automated shuttle technologies for public use on recreational public lands. The TEDDY pilot used a pair of Local Motors Olli shuttles, owned and operated by Beep, to transport visitors on two nonconsecutive routes from the park's Canyon Village area to nearby lodges or up to the campground. At Wright Brothers National Memorial in North Carolina, the Park Service partnered with the North Carolina Department of Transportation (DOT) to use CASSI, their leased EasyMile EZ10 shuttle, to transport passengers from the parking lot near the visitor center to the base of the First Flight Monument.

Minnesota's Automated Rural Transit Initiative (goMARTI) project, serving and led by the northern community of Grand Rapids and the state DOT, is an

[2] Find out more about TEDDY at https://www.nps.gov/yell/learn/management/automated-shuttle-pilot.htm.
[3] Explore the CASSI pilot project at https://www.nps.gov/wrbr/learn/news/autonomous-vehicle-pilot-wright-brothers-national-memorial.htm.
[4] Learn more about the National Park Service's Emerging Mobility Initiative at https://www.nps.gov/subjects/transportation/emerging-mobility.htm.

AV deployment program that provides on-demand, point-to-point rides over nearly 17 miles of roadway.[5] The pilot includes about 70 pick-up and drop-off points with a fleet of five AVs equipped with May Mobility technology. Through the goMARTI deployment, the project partners hope to

- Advance and inform the operation of AV technology in rural winter conditions,
- Engage and educate the local community by providing real-world automated vehicle experiences,
- Increase accessibility and transportation options for residents and visitors, and
- Understand the potential of this innovative pilot to spur economic development and attract future talent and technology.

Minnesota DOT also leads the DriveMN project, which deployed technology-equipped research vehicles on a preplanned and diverse route across more than 1,000 miles statewide to assess the existing roadway network's readiness for automated driving. The project grouped areas into eight categories that—depending on the specific infrastructure, setting, and context—could cause the technology to disengage. These findings are meant to inform existing public–private AV planning committees, advisory councils, and agency professionals when making improvements that, in most cases, will benefit ADS and human drivers.

DriveOhio's ADS for Rural America is a U.S. DOT ADS Demonstration Grant project to examine how connected and automated semi-trucks and passenger vehicles could improve safety for drivers, passengers, and other travelers in rural settings.[6] The first of two deployments included three passenger vehicles

Courtesy of goMARTI

Guided by laser-based sensors to measure distances and detect obstacles, a May Mobility–equipped goMARTI AV is one among five AVs—three of them wheelchair accessible and all operated by human safety drivers—that offers free, on-demand transportation over a 17-mile network in rural Grand Rapids, Minnesota. The goMARTI pilot, which runs through spring 2024, stops at the local hospital, high school, and airport—among other destinations.

Courtesy of DriveOhio

Human drivers are at the wheel to monitor operations during a year-long test of DriveOhio AVs, which traveled rural roads between Athens and McArthur in southeastern Ohio.

equipped with AutonomouStuff technology traveling on divided highways and rural two-lane roads in Ohio's Athens and Vinton counties. The vehicles will continue to be tested in different operational and environmental conditions, including during periods of limited visibility and in work zones. The second deployment will feature a pair of 53-foot, platoon-equipped tractor–trailers connected by technology that enables them to travel closely together at highway speeds. The findings will help define technology needs and limitations, as well as inform the safe scaling up of future automation deployments in the United States.

Table 1 shows a comparison of these rural AV projects. The type of project generally describes its scope and focus. Demonstration projects are exploratory and broader in scope, whereas deployments are designed to highlight a specific use. Demonstration projects can be seen as predecessors to a deployment, which then potentially can lead to the establishment of a service. These projects use the following two broad categories of vehicles:

- Low-speed, box-shaped shuttles that are designed to move people over short distances with a limited operational design domain and

[5] Find more about goMARTI at https://www.gomarti.com/.
[6] Explore DriveOhio's ADS for Rural America at https://drive.ohio.gov/programs/av-cv/rural-automated-driving-systems.

TABLE 1 Comparison of Rural AV Projects

Project Name	ADS for Rural America	TEDDY	CASSI	DriveOhio	goMARTI	DriveMN
Type of Project	Demonstration				Deployment	
Vehicle Type	Ford F350 Transit command-by-wire platform	Beep shuttle	EasyMile shuttle	Lincoln MKZ and Ford F350 Transit command-by-wire platforms	Toyota Sienna Auto-no-Maas vehicle	VSI Labs and University of Minnesota research vehicles
Maximum Speed	65 mph	15 mph	10 mph	70 mph	35 mph	70 mph
Route Type	Fixed	Fixed	Fixed	Fixed and on-demand	On-demand	Fixed
Road Types	Divided and undivided highways, local roads, blacktop, gravel, parking lots	Blacktop, parking lots	Blacktop, parking lots	Divided highways and two-lane roads	Local roads	Mostly two-, four-, and six-lane highways
Oversight	Safety driver and co-pilot	Trained operator	Trained operator	Safety driver	Safety driver	Human-driven data gathering

- Traditional vehicles retrofitted with onboard equipment that enables them to be controlled by automation software, driven normally by operators in mixed traffic at higher speeds, or both.

Low-speed shuttles—designed to move people over short distances such as a fixed route within a retirement community or college campus—have yet to show their utility when operating at higher speeds in mixed traffic on public roadways that typically connect rural communities. Additionally, their lack of mandated safety features limits their operation to predefined routes approved by NHTSA through a waiver process.

The route type is an important consideration for rural areas, where some passengers may be better served by on-demand services as opposed to fixed routes that may not be economically feasible. With the greater variability of road types and surfaces in rural areas compared with urban areas, it remains important to test AVs on as many different roadway types as possible. Despite showing great promise, AV testing still requires oversight by trained human safety drivers. In some cases, multiple operators may be needed to accomplish all facets of an individual project or to help passengers with disabilities get in and out of the vehicle.

Public Perception

AVs have the potential to provide many benefits to society, including increased safety, more equitable access to mobility, economic and workforce development, improved environmental quality, and more efficient movement of people and goods. For rural America to realize these advances, however, it is important to identify and understand the appropriate uses for AV technology. It is incumbent on practitioners and AV experts to educate the public on current and future AV technology and the variety of possible uses. Being present in communities from the outset is critical to the success of each project so that those deploying a system can talk with residents, present real-world uses, and answer questions.

Firsthand experience with AV technologies can be one of the most effective ways to build trust and acceptance. Pre- and post-ride survey data from the ADS for Rural America shuttle, for example,

Courtesy of the Driving Safety Research Institute, University of Iowa

Tested over hundreds of miles on rural roadways, the University of Iowa's sensor-studded autonomous bus proved capable of navigating paved and gravel surfaces with good, poor, or no lane markings in different weather conditions. Researchers hope the findings, which include passenger-experience data, will help improve automated driving technologies.

show that the percentage of passengers who strongly or somewhat agreed that they could trust an AV increased from 50 percent to 71 percent (*4*).

It is also important to engage and get input from rural community members on AV technology and its perceived future benefits. Post-ride interviews with ADS for Rural America passengers indicated that access to transportation can be a huge challenge for rural residents, particularly those with mobility impairments. While respondents could see the potential of AVs, they also understood that challenges remain before the technology reliably can be rolled out.[7]

Rural Health Care Potential Use Case

The number of hospitals in rural counties is declining, and the remaining facilities tend to have very few, if any, beds in intensive care units. Rural residents who experience a medical emergency often must travel to neighboring counties for critical care. This trend is driving up demand for options to convey people from their rural homes to regional hospitals. AVs have the potential to be part of the solution by providing mobility where no other public transportation options exist. For that to happen, however, they must safely navigate many different types of roadways. To serve people with the greatest mobility needs, AVs also must function as point-to-point vehicles that can pick up passengers from homes located off unpaved and gravel roadways.

Infrastructure Needs

AVs rely on information about their surrounding environments, such as traffic signals, speed limit or other posted signs, and lane and intersection geometry. A vehicle can use onboard sensors, such as cameras, to get this information. While that reduces the need for additional roadway infrastructure, a camera-based approach may be less accurate. For example, an onboard camera approaching an intersection has the potential to look at the wrong traffic signal or miss the signal head altogether if its view is blocked by a tall vehicle, such as a semi-truck. An infrastructure-based system, though more accurate, requires the installation of special equipment at each intersection. This represents a major challenge for rural municipalities that barely have funding to maintain physical roadways.

At high levels of automation, an AV also must be able to locate and position itself much more precisely in its lane of travel than traditional GPS systems permit. A digital high-definition map, which shows such minute details as road signage and lane markers—combined with onboard equipment—enables such pinpoint positioning and allows automation where no lane markings are present or when lane markings are covered by snow. One drawback, however, is that high-definition maps must be updated when construction changes the roadway or new striping is applied. Onboard equipment that helps a vehicle locate itself is prone to interruptions in communications due to poor weather or inadequate cell service. Furthermore, an AV that relies on high-definition maps can't operate on roadways for which no high-definition map is available. This presents additional challenges for municipalities with long stretches of rural roadways.

Lessons Learned and Next Steps

With AV technology and best practices constantly evolving, it can be challenging for practitioners to know how to prepare for AVs in rural areas. At present, with no universally accepted standards or investment guidelines, the best approach for practitioners is to learn as much as possible about AV technologies and the potential benefits for their communities. Practitioners at all levels—federal, state, and local—can determine what responsibilities they are willing to take on to help AV technology function. Agencies can be continually involved in discussions as state DOTs weigh the investments necessary to support the future of transportation built on technology and the benefits to the public today.

Two key areas of focus for rural communities when thinking about preparing for AVs are pavement markings and network communications. Traditionally, AVs have struggled to operate on gravel, dirt, and other roads that lack clear pavement markings. Enhanced pavement markings could improve performance and safety for autonomous and human-driven vehicles. While newer technologies are less dependent on the presence of pavement markings, the pace of change makes preparation and specific guidance challenging. The same can be said for network communications. It is likely that future AV technology will require some level of system connectivity. However, this is all under active research and may vary, depending on the architecture of the system that is ultimately implemented and its resilience against loss of connectivity. Since improving Internet connectivity in rural areas is a widespread political and economic priority, these challenges likely will become less significant over time.

Resources such as the 2022 Minnesota Local Road Research Board project, Autonomous Vehicles: What Should Local Agencies Expect? provide further detail on what practitioners can do to prepare for AVs.[8] The main takeaway is that the guidance is constantly changing, so the best course of action for practitioners is to become as educated as possible on AV technologies and how they potentially could benefit the communities they serve.

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[7] Participate in an ADS for Rural America webinar at https://www.youtube.com/watch?v=yNWMYp8fUsg.

[8] Navigate through the interactive resource guide at https://lrrb.org/autonomous-vehicles-what-should-local-agencies-expect-2/.