Rural and Small Metropolitan Intelligent Transportation Systems

Case Studies on Developing and Deploying ITS in Rural Regions and Smaller Communities

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Notice

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List of Acronyms

ADS	Automated Driving Systems
AV	Autonomous Vehicle
AVL	Automated Vehicle Location
BLM	Bureau of Land Management
CAD	Computer-Aided Dispatch
CAT	Cooperative Automated Transportation
CAV	Connected and Autonomous Vehicle
CCTV	Closed-Circuit Television
CDC	Centers for Disease Control and Prevention
CHART	Coordinated Highways Action Response Team
COG	Council of Governments
CV	Connected Vehicle
CVeSS	Center for Vehicle Systems and Safety
CVP	Connected Vehicle Pilot
DARE	Dynamic All-Red Extension
DII	Driver Infrastructure Interface
DMS	Dynamic Message Sign
DOT	Department of Transportation
DSRC	Dedicated Short-Range Communication
DST	Decision Support Tool
DZPS	Dilemma Zone Protection System
EMDSS	Enhanced Maintenance Decision Support System
FHWA	Federal Highway Administration
fNIRS	Functional Near-Infrared Spectroscopy
FTA	Federal Transit Administration
FWS	United States Fish and Wildlife Service
GAO	Government Accountability Office
HAR	Highway Advisory Radio
IDPM	Incident Duration Prediction Module
III-CS	Integrated Intelligent Intersection Control System
IMO	Integrated Mobile Observations
IOOs	Infrastructure Owners/Operators
ITB	Invitation to Bid
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation Systems
IVR	Interactive Voice Response
LED	Light-Emitting Diode
MBTA	Massachusetts Bay Transportation Authority
MDT	Mobile Data Terminal
MPO	Metropolitan Planning Organization
NADO	National Association of Development Organizations
NMEA	National Marine Electronics Association
NPS	National Park Service
NTCIP	National Transportation Communications for Intelligent Transportation System Protocol
PACMod	Platform Actuation and Control Module
PCB	Professional Capacity Building
RAD	Recreation Access Display
RDO	Regional Development Organization
RICAS	Rural Intersection Collision Avoidance System
RMNP	Rocky Mountain National Park
RPO	Rural Planning Organization
RRFB	Rectangular Rapid Flashing Beacon
RSIP	Rural Safety Innovation Program
RTPO	Regional Transportation Planning Organization
RWIS	Road Weather Information System
SAE	Society of Automobile Engineers
SEAT	Southeast Area Transit
SPaT	Signal Phase and Timing
SS4A	Safe Streets and Roads for All
T2O	Transit Tech Ohio

TAM	Transferability Assessment Method
TIM	Traffic Incident Management
TMC	Transportation Management Center
TMDD	Traffic Management Data Dictionary
TPAC	Transportation Policy Alternatives Committee
Tri-Met	Tri-County Metropolitan **Transportation District of** Oregon
TTC	Transportation Technology Center
USFS	United States Forest Service
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
VTC	Volunteer Transportation Center
WIT	Western Iowa Transit

1 Introduction

Advances in digital communications, geospatial technologies, and information transfer have increased opportunities to improve safety, mobility, accessibility, user experience, and traveler information across all transportation modes. Over the past decade, intelligent transportation systems (ITS) deployments for highways, public transportation, and bicycle and pedestrian travel have ranged from closed-circuit television (CCTV) camera and dynamic message sign (DMS) deployments at single locations, to integrated connected vehicle and weather information systems.

In its *History of Intelligent Transportation Systems: 2021 Update Report*, the U.S. Department of Transportation (DOT) ITS Joint Program Office (JPO) defines ITS as "an operational system of various technologies that, when combined and managed, improve the operating capabilities of the overall system."[1] The communication between different systems is central to the utility of ITS, allowing a vastly greater effect than any technology working alone. Interactions between personal devices, vehicles, and transportation infrastructure increase transportation safety, reduce productivity-harming congestion, and provide commuters and incident response teams with real-time information.

The purpose of this report is to provide an overview of rural and small metropolitan transportation challenges and opportunities related to ITS, as well as a series of case studies of ITS projects in rural areas or ITS technologies that could be deployed in rural areas. This document is one resource designed to help fill an informational need on ITS applications for rural transportation audiences and their partners, including practitioners working in local government agencies, regional entities (such as regional or rural transportation planning organizations), rural transit agencies, or Tribal governments. However, professionals with responsibility for rural transportation within state departments of transportation, Federal agencies, and other public and private sector partners might also benefit from using this report.

This document is organized with introductory material on ITS in Chapter 1, followed by an overview of rural and small metropolitan ITS issues in Chapter 2. Chapters 3 through 8 each present multiple case studies on a particular ITS theme, ranging from more mature and widely deployed technologies such as traveler information applications through newer issues, including connected and autonomous vehicles and smart infrastructure. The case studies present basic information about the partners involved in developing or deploying the ITS project, project purposes, any outcomes or lessons learned identified during the research, and the costs and other resources to the extent information was available.

Rural ITS informational resources, such as this initiative, and other professional development resources, including webinars, peer learning cohorts, trainings, and panel presentations, will continue to be important for rural practitioner audiences. Although ITS has existed for decades, application in rural areas tend to lag urban ITS projects, and technologies will continue to change.

Emerging technologies outlined in the *Intelligent Transportation Systems Joint Program Office Strategic Plan 2020-2025* suggest significant potential for ITS advancement and deployment in coming years. The estimated economic and social benefits of ITS exceed $2.3 billion each year, with untapped potential in

[1] U.S. DOT, ITS JPO, (2021). History of Intelligent Transportation Systems: 2021 Update Report, www.its.dot.gov/history/pdf/HistoryofITS_book.pdf

connected vehicles, autonomous vehicles, and artificial intelligent and machine learning.[2] Similarly, practitioner input from the *Intelligent Transportation Systems Deployment Tracking Survey: 2020 Key Findings* pinpoints areas where growth has been strong, or the potential exists to expand ITS:

- Some safety-oriented technologies have been adopted by most responding freeway owner or operator agencies.
- ITS implementations that are very common, such as inductive loops and video imaging, indicate that those technologies are mature.
- Adoption has been slow for some technology implementations that could help agencies to manage arterials.
- Mobile apps to communicate about travel information and transit ITS implementations are both areas that saw marked growth between the deployment survey conducted in 2016 and in 2020.
- Transportation agencies are interested in integrated corridor management, using external data sources, and cybersecurity.[3]

With both existing and potential benefits contingent upon data exchange within technology ecosystems, urban communities have historically been the primary beneficiaries of ITS. Greater population density offers an advantage in testing certain systems, while urban communities may also benefit from easier access to certain systems and trained personnel. Federal, state, local, and non-government actors have taken steps to prevent rural and small metropolitan communities from comparatively falling behind. These measures not only offer to these communities the benefits experienced elsewhere, but ensure deployed systems collect training data on the unique challenges of rural transportation. Prior to this report, the National Association of Development Organizations (NADO) Research Foundation researched the February 2020 report titled *Rural and Small Metropolitan Intelligent Transportation Systems Case Studies*, detailing earlier ITS deployments of this nature.

The transportation issues faced by rural and small metropolitan communities can be distinct from those faced by urban communities. With lower population and population density, rural roads typically experience less congestion and offer less data for ITS systems, while being more vulnerable to both weather- and wildlife-related disruptions. Funding drawn from a smaller tax base must be allocated to transportation services, infrastructure, and maintenance work over a larger area, and rural communities face higher costs importing and exporting goods.[4] Limited access to power and communications may pose an obstacle to ITS deployment in rural areas, and limited funding may similarly hinder robust cybersecurity measures. These measures are of increasing importance in connected technological ecosystems, where any single vulnerability could compromise a larger network of systems.[5][6] In researching this report, a review of how ITS has been and is being deployed in rural areas was conducted

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[2] U.S. DOT, ITS JPO, (2020). Intelligent Transportation Systems Joint Program Office Strategic Plan 2020-2025 www.its.dot.gov/stratplan2020/ITSJPO_StrategicPlan_2020-2025.pdf

[3] U.S. DOT, ITS JPO (2021). Intelligent Transportation Systems Deployment Tracking Survey: 2020 Key Findings

[4] National Academies of Sciences, Engineering, and Medicine (2022). *Rural Transportation Issues: Research Roadmap*. Washington, DC: The National Academies Press. https://doi.org/10.17226/26343.

[5] U.S. DOT, John A. Volpe National Transportation Systems Center (2021). Cybersecurity Assessment and Best Practices for Truck Stop Technologies, https://rosap.ntl.bts.gov/view/dot/59265

with the support of Federal agencies, state DOTs, rural development organizations (RDOs) and regional transportation planning organizations (often called RTPOs or RPOs), and local agencies.

This initiative takes these reports a step further by documenting a series of case studies that identify how local and regional agencies are involved in ITS planning or projects, the extent to which applications have made a difference in addressing issues beyond metropolitan area boundaries, and identifiable lessons learned from the transportation professionals who are implementing the projects. The research process included reviewing primary source documents such as transportation plans, project documentation, and agency websites, as well as email, telephone, and in-person interviews conducted with transportation professionals. The case studies reflect a range of ITS deployments that fall into categories that the National Center for Rural Road Safety identified in its 2018 Rural Intelligent Transportation Systems Toolkit. The toolkit places ITS applications into seven categories:

1. Crash countermeasures
2. Traffic management
3. Operations and maintenance
4. Emergency services
5. Surface transportation and weather
6. Rural transit and mobility
7. Tourism and travel information

Using these categories as a framework, this initiative examined how these commonly used rural applications are being implemented. The challenges and opportunities involved in implementation are described in the following section summarizing some of the relevant literature.

2 ITS in Rural and Small Urban Areas: Overview of Needs and Concerns

Rural ITS applications improve driver awareness and safety as well as enhancing situational awareness and operations for agencies responsible for operating the transportation system. The primary benefits of applying ITS tools in rural areas include improved weather information and warnings, increased safety through road curve signage, high-speed crash prevention, and reduction in animal-vehicle collisions, according to the report *Rural Connected Vehicle Gap Analysis: Factors Impeding Deployment and Recommendations for Moving Forward*. The gap analysis identified several challenges to advancing ITS implementation in rural areas. Reasons include, but are not limited to, lower traffic volumes than urban areas, a lower tax base to pay for ITS projects, and less predictable congestion patterns, less political clout (compared to larger urban areas) to implement and operate transportation technologies. When congestion does occur in rural areas, it is often due to short-term road construction, special events, or weather. When asked about their top ITS concerns, experts identified the primary issues as return on investment, (versus deploying the same ITS application in a more dense and populous location), difficulty in applying ITS in areas with physical barriers or rugged terrain, and cellular network capacity.[6]

In late 2022 and early 2023, the NADO Research Foundation conducted a query of regional rural and small metro transportation practitioners. Questions included:

- Whether participants were aware of ITS projects in their regions
- If ITS and technology comes up in regional transportation planning or stakeholder discussions
- What information and professional development resources are needed to implement ITS

Respondents in small metropolitan areas tended to report that they had an existing ITS plan and knew of ITS implementations in their region. In contrast, respondents from more rural places tended to report that ITS projects were implemented primarily in other more urban regions or were in the purview of the state DOT (and, as a result, not a significant part of local or regional transportation plans or processes).[7]

2.1 Roadway and Traveler Information ITS Applications

ITS applications being piloted or permanently deployed in rural areas range from small-scale, single-location projects to large-scale, multi-jurisdictional projects reliant on interconnected communications. Sample single-location projects include the use of standard signs that are enhanced with light-emitting diode (LED) bulbs that flash to alert drivers or vehicle sensor deployments at locations with high crash rates. These advance warning systems, which combine vehicle detection mechanisms, flashing beacons,

[6] U.S. DOT, Intelligent Transportation Society of America (2017). Rural Connected Vehicle Gap Analysis: Factors Impeding Deployment and Recommendations for Moving Forward, https://rosap.ntl.bts.gov/view/dot/34723

[7] NADO Research Foundation (nd). 2022-2023 Regional Transportation Query Responses.

and signage, are typically piloted in locations where cross traffic is not visible or when speeds are high and gaps in traffic are difficult to predict. Railroad crossing approaches or alternative transportation facility crossings (e.g., bicycle, equestrian, pedestrian, or recreational vehicle paths) are important locations for testing these relatively simple and basic ITS technologies, as are roads with significant curves and other roadway geometry challenges, such as the flashing chevron seen in Figure 1.[8]

Source: Virginia DOT, 2019

Figure 1. Solar-powered chevrons use flashing lights to warn drivers whose speed approaching this curve might put them at greater risk of a crash

In other locations where conditions change on a frequent basis, more dynamic systems may be implemented. One example is the use of dynamic message signs (DMS) to communicate information on conditions related to incidents, construction, detours, parking, and weather conditions. Federal land agencies and rural communities have increased use of DMSs to post traveler information at a geographic juncture where the driver has time to decide to continue to travel as originally planned or detour to a different route or activity.[9] In some areas, travelers may have the option of choosing a different mode of transportation, but this is not always immediately available in rural places. In addition to physical signs, additional types of traveler information dissemination include highway advisory radio (HAR) announcements, 511 systems, and social media communication. Within social media communication, Facebook is generally used to relay information for advance planning, and Twitter is relied on to distribute

[8] Virginia DOT and other agencies have deployed ITS at curves; VDOT (2022). Legislative Update: I-81 Corridor Improvement Program, https://www.virginiadot.org/about/resources/staunton_district_legislative_update_summer_2022/LU_2022_I81_CIP_acc062922.pdf

[9] U.S. Department of Interior, National Park Service (2014). Congestion Management Toolkit, https://www.nps.gov/orgs/1548/upload/NPS-CMS_Toolkit.pdf

immediate messages on changing conditions.[10] Agencies may also expand their understanding of specific traffic incidents through monitoring relevant posts on these platforms.[11]

2.2 Public Transportation Applications

Public transportation ITS applications are often oriented toward operations, security, and customer interfaces, with technologies increasingly allowing for innovation in the delivery of transit and mobility services. Participants in the Federal Transit Administration (FTA) Mobility on Demand (MOD) Sandbox Program, as well as other mobility innovation investment programs, are beneficiaries from developing ITS applications.[12] Agencies, including some included in case studies within this report, are exploring technologies that allow for greater flexibility and centralization of scheduling, payment, tracking, and other information. Streamlining operations in this manner cuts costs and saves time, with rural residents afforded greater access to transit systems than distance would otherwise allow.

The U.S. Government Accountability Office (GAO) conducted interviews with transportation and transit officials to discuss public transportation ITS deployments in rural areas, leading to a report published in 2016. Sample deployments include geographic information systems-based General Transit Feed Specification (GTFS) or GTFS-Flex feeds that serve Google Maps and Google Transit or agency-based trip planners. Other intelligent technologies commonly used by public transportation systems include security systems (e.g., audio or video surveillance), computer-aided dispatch (CAD), and automated vehicle location (AVL) systems. Smaller systems reported using technology for maintenance management, traveler information systems, automatic passenger counters, electronic fare payment, and transit signal prioritization. The results of the GAO interviews mirror an earlier 2005 Transit Cooperative Research Program report on *Strategies to Expand and Improve Deployment of ITS in Rural Transit Systems* in which statewide ITS planning focused on enhanced traveler information, automatic vehicle location, automated dispatch and scheduling, online ride requests, and electronic fare collection.[13]

Stemming from a GAO recommendation, an ITS survey was conducted by U.S. DOT specifically for small urban and rural transit providers in 2019. The results of that study showed:

- High usage of security cameras and systems (83% of respondents) and automatic vehicle location (75%).
- Moderate usage of computer-aided dispatch (56%), Geographic Information Systems (54%), and traveler information systems (51%).

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[10] U.S. DOT, John A. Volpe National Transportation Systems Center (2011). Intelligent Transportation Systems in the National Parks System and Other Federal Lands, https://rosap.ntl.bts.gov/view/dot/9554

[11] P. Chen, F. Chen, and Z. Qian. (2014). "Road Traffic Congestion Monitoring in Social Media with Hinge-Loss Markov Random Fields," *2014 IEEE International Conference on Data Mining*

[12] Martin, E., A. Cohen, S. Shaheen, and L. Brown. (2023). FTA Report No. 0242, Synthesis Report: Findings and

Lessons Learned from the Independent Evaluation of the Mobility on Demand (MOD) Sandbox Demonstrations, https://www.transit.dot.gov/sites/fta.dot.gov/files/2023-02/FTA-Report-No-0242.pdf

[13] United States Government Accountability Office (2016). Intelligent Transportation Systems: Urban and Rural Transit Providers Reported Benefits but Face Deployment Challenges, https://www.gao.gov/assets/680/677919.pdf

- Low usage of maintenance management systems (27%), electronic fare payment (20%), automatic passenger counters (16%), and transit signal priority (3%).[14]

In separate research conducted in New York State, transit and transportation agency representatives identified the following barriers to rural ITS implementation:

- Limited staff size,
- Limited financial resources,
- Digital capabilities of customers,
- Levels of smartphone ownership,
- Computer usage, and
- Broadband access.

Best practices identified by transportation agency managers include knowing customer preferences for receiving information, providing up-to-date maps, schedules and service alerts, and leveraging technology used by larger agencies, such as the statewide 511 system and state DOT technical assistance.[15]

2.3 Automated and Connected Vehicle ITS Applications and Smart Infrastructure

In addition to roadway, mobility, and alternative transportation ITS applications, this report includes case studies on connected vehicle (CV) pilot projects that are aimed at improving highway safety, providing real-time weather conditions for travelers and truck fleets, and coordinating state DOT snowplow operations. Vehicle connectivity is being tested in some rural areas, a notable example being the Wyoming Department of Transportation (WYDOT) CV Pilot along I-80 – a U.S. DOT funded initiative.[16] In addition, autonomous vehicle (AV) testing in select rural areas is filling in the gap in training data weighted in favor of urban roadways, which would otherwise leave most systems ill prepared for the unique conditions and challenges of rural roadways.[17]

A National Cooperative Highway Research Program (NCHRP) report on *Strategies to Advance Automated and Connected Vehicles* touches on the aspect of how AVs and CVs are tied to existing regional transportation planning subject matter such as traffic safety and crashes, congestion, land development, and mobility.[18] AVs could reduce most driver-related errors while introducing a new set of transportation challenges. Advancements in automation could shape traveler behavior and land-use

[14] U.S. DOT, John A. Volpe National Transportation Systems Center (2020). Intelligent Transportation Systems: Findings from the 2019 Small Urban and Rural Transit Provider Survey, https://rosap.ntl.bts.gov/view/dot/50549

[15] Altman, S. & Bregman, S. (2019). Reaching Rural Transit Riders, Presentation at ITS America, June 14, 2019

[16] Wyoming DOT (nd). Wyoming DOT Pilot. https://www.its.dot.gov/pilots/pilots_wydot.htm

[17] University of Iowa (nd). ADS For Rural America, https://adsforruralamerica.uiowa.edu/

[18] Transportation Research Board, National Cooperative Highway Research Program (2017). NCHRP Research Report 845 Briefing Document: Strategies to Advance Automated and Connected Vehicles, https://www.nap.edu/catalog/24873/strategies-to-advance-automated-and-connected-vehicles

patterns beyond increased efficiency and reduced transportation. Vehicles able to drop off passengers and return when needed would reduce the need for local parking and potentially enable novel vehicle storage systems.

2.4 Case Research Results and Conclusions

This report expands on prior case studies by addressing the planning and partnerships involved in financing, implementing, and evaluating the impacts of rural ITS applications. Each case study was selected because it involves technology tools that are possible for rural and small urban area agencies to implement within a single jurisdiction or across a larger geographic area when working in partnership with federal, state, or multi-jurisdictional partnerships. These projects address practical transportation network needs, such as safety, traveler information, and accessibility. In addition, the featured projects provide a glimpse at how rural regions are taking steps to build capacity for ITS and are considering technology solutions to address ongoing issues, enhance safety, and make the most of limited human and physical resources.

During research and literature review, several cross-cutting themes were identified that appear in these case studies and during interviews conducted with other transportation professionals. These themes include the roles of state, regional, and local governments, and other partners; the significance of capacity building; and the importance of broadband.

State, Regional, Local, and Private Sector Roles

State agencies serve as a critical partner in planning and implementing ITS. States own and operate significant portions of the transportation system, so the ITS that benefits rural and small metropolitan regions and communities is often part of the state's ITS network. States provide an important pathway to state or federal funding either through their state's programming processes or as partners on proposals for competitive funding opportunities. States might provide training to local and regional partners in using ITS or accessing the data from ITS assets.

RDOs, RTPOs, and metropolitan planning organizations (MPOs) play an important role in supporting ITS and transportation more generally in many areas. RDOs, RTPOs, and MPOs often conduct regional transportation planning work with support from their state DOTs and involvement from the local governments they serve. In this role, some of the regional planning organizations are working on transportation plans, including coordinated transportation plans, that align with ITS efforts. Others have purchased technology assets such as DMS and speed radar trailers that are available to be shared among several local governments as needed, without each rural jurisdiction needing to purchase its own. Regional organizations serve as effective conveners, bringing together elected officials and professional staff from multiple local governments to discuss approaches to common issues.

Local governments are the owners and operators of some roadways, bicycle and pedestrian facilities, and ITS assets, and in some areas are also involved in providing public or human services transportation. As transportation owners and operators, local officials and career staff are able to identify challenges that might be addressed through ITS, and they often hear from constituents about transportation concerns.

Other regional and local agencies including transit and ferry agencies, air and water port authorities, bridge and road toll authorities, and utility commissions play an important role in seeking resources and deploying solutions to the transportation challenges most closely related to their organizational missions and the needs of their stakeholders. Area businesses often benefit from improved transportation operations and information resulting from ITS and may be willing to support transportation efforts that align with their interests.

Agencies interviewed as part of this initiative encouraged relationship development and communication among a range of transportation agencies. For example, there are tools that can improve travel safety or the efficiency of commutes, some simple and some more complicated. State and local governments should share best practices to improve outcomes. It is also important to maximize access to data for research that can improve safety and other outcomes.

In addition, individuals interviewed for case studies described how there are private sector innovations that can provide benefits to transportation problems experienced by the public. However, business models (and a potential lack of coordination between public and private parties that may be able to mutually benefit) may obstruct the full potential of some ITS technologies. A technology ecosystem is important, as seemingly unrelated technologies can support each other and contribute to a foundation upon which public and private actors will feel more confident investing personnel and resources, thereby creating more opportunities for coordination and adoption of new technologies.

Future research may benefit from further investigating relationships between private entities where appropriate, as well as among public agencies at the federal, state, regional, and local levels (including regional agencies serving places with a rural character, such as regional, rural transportation planning organizations known as RPOs or RTPOs, as well as smaller communities within metropolitan regions served by metropolitan planning organizations). Roles such as funding, owning, operating, and maintaining transportation assets differ from place to place. This will affect planning, project development, funding, implementation, maintenance, and data sharing practices, all with the end goal of transportation functioning as a seamless network, regardless of public and private sector responsibilities.

Capacity Building

Professionals who provided information in this research effort emphasized the different types of knowledge needed to support successful ITS deployments. Vendors and software developers know the capabilities of various technologies very well and potential use cases, but they do not have the operational knowledge of transportation owners and operators or the accountability to the public and stakeholders. Transportation agencies often rely on outside expertise to provide or develop technology solutions. That knowledge exchange builds the capacity of each side to support successful ITS efforts. Within transportation agencies and local governments, staff often need to develop new knowledge and skills to be able to fully make use of new information or to adequately maintain ITS technologies. External audiences may also need support or information to best utilize ITS, including riders of public and human services transportation, visitors at tourism and recreation sites or accessing special events, or the traveling public who may see safety or operational improvements from ITS.

Information and capacity will be necessary to successfully design and implement ITS with partners and the public. Individuals who provided research for the case studies included in this report emphasized: Effectively bringing new technology to a community often requires a communications strategy: creating awareness, explaining benefits, and addressing safety concerns. Community stakeholders in positions of trust can be essential in achieving this.

Broadband

Many of the ITS case studies included in this research include elements of communications platforms. Some investments in ITS occurred concurrently with investments in fiber and wireless broadband. This has been necessary to connect the ITS devices to allow them to transmit video feeds, operational signals, and communications. Practitioners report challenges with achieving adequate broadband in some rural places, however, as well as concerns about whether emerging or future technologies will work well in places that are hard to reach with broadband or where there is little demand for residential subscriptions to broadband service. Future capacity building work could clarify for rural practitioners the types of ITS implementations that can function without connectivity to broadband infrastructure.

Concerns over communications infrastructure are one reason why practitioners may not seek opportunities to deploy rural ITS projects. Some individuals emphasized taking action anyway, that it is better to make a decision now and try to adapt to changes later than to make no decision and realize the community is hopelessly behind. Technology will always change, partnership and efforts to keep pace are what lead to success.

3 Traveler Information Case Studies

Case studies in this section cover ITS implementations that improve travel for travelers by providing information about the transportation network. Examples come from rural counties as well as federal lands. These ITS implementations include a range of technologies, including road weather information systems, closed circuit television, dynamic message signs, and social media.

3.1 Weather and Road Condition Information in Georgia

Safe travel in winter can be difficult in the mountains of Union County, Georgia. U.S. Route 19/Georgia 11 serves as an important corridor, connecting the county seat of Blairsville and other parts of the county through Neels Gap to health facilities and other amenities in nearby Gainesville, Georgia, in Hall County or further south to Atlanta.[19] A scenic route where the Appalachian Trail crosses the road, this route is particularly important for public safety, ambulance calls, and anyone needing to access the hospital in Gainesville.[20] A partnership to connect broadband to state- and county-owned ITS assets, including cameras and a road weather information system, is improving access to information about travel conditions for residents and others traveling through the county.

Project Purpose

Union County owns two traffic cameras at Neels Gap that were installed around 2016, and the Georgia Department of Transportation (GDOT) has an additional traffic camera and weather system on-site that records air temperature, roadway temperature, the dew point, and other data.[21] However, this infrastructure was only connected to county and state systems by a cell phone internet connection, which was unreliable in storms or even when the mountain was surrounded by thick, low clouds. The internet connection was so slow that the cameras could only transmit one frame with a vehicle passing through the area, which did not provide any information about how vehicles were traveling. Without reliable technology, the county government's chief executive and Sole Commissioner became the travel information system himself, driving to the top of the mountain in poor weather, even in the middle of the night, and posting updates on Facebook to let the public know about conditions.[22]

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[19] Cash, Cathy (2019). Co-op Fiber and Drone Capability Improve Safety on a Georgia Mountain Pass, National Rural Electric Cooperative Association, www.electric.coop/georgia-co-op-broadband-fiber-drone-improves-safety

[20] Personal communication with Lamar Paris, June 2019

[21] Personal communication with Lamar Paris, June 2019, and Emily Dwyer, September 2019

[22] Personal communication with Lamar Paris, June 2019

Source: Blue Ridge Mountain EMC, 2019

Figure 2. Workers use a drone to pull broadband cable up a mountain, avoiding impacts to environmentally sensitive areas, in order to connect ITS infrastructure at Neels Gap, GA

In 2019, Union County worked with Blue Ridge Mountain Electric Membership Corporation (EMC), the region's rural electric cooperative, to bring broadband to Neels Gap to connect the ITS assets there and provide a connection to the outdoor sporting store Mountain Crossings, which serves Appalachian Trail hikers and others.[23] Traditional methods for laying fiber would have been cost prohibitive in the mountainous area and would be difficult to navigate from a permitting perspective, going through the Chattahoochee National Forest. However, Blue Ridge Mountain EMC worked with Southern Company Services to fly a drone between ridge tops to place a pull line that would take fiber up the mountain, as shown in the image on page 8. With this process, Blue Ridge Mountain EMC obtained a permit from GDOT to run the cable at the proper height over a state-owned roadway and a permit to run the cable over trees in the national forest. Typically, a project to run fiber along the power lines would require extensive tree cutting under the line to allow access. This would necessitate a much more extensive permitting process in which EMC staff identify the trees to be removed, following which Forest Service staff measure the board feet of those trees. By avoiding impacts to the trees, the paperwork was much quicker for Blue Ridge Mountain EMC to complete and for the Forest Service to approve. The process of placing the fiber took hours to complete rather than weeks that would have been required without use of the drone, a significant cost and time savings.[24]

[23] Personal communication with Lamar Paris, June 2019

[24] Cash (2019); personal communication with Daniel Frizzell, March 2020

Outcomes

The new broadband service was connected to Union County's cameras in early 2019, and now the county has better connection to the video feeds, with up to 100 frames of a single vehicles passing through the area, much closer to a full motion video than the delayed communications previously.[25] GDOT's camera and road weather information system (RWIS) at the location are also being connected to the new broadband connection. This will provide better and more timely information to state and local agencies.[26] (*See "Georgia's Connected Data Platform" for more information on the state's ITS network.*)

The GDOT camera at Neels Gap can be moved remotely to zoom, tilt, pan and view a larger area, while the county's cameras are fixed in place and pointed toward the roadway. With improved broadband allowing for better quality video transmission, the GDOT camera might become an asset in the future for other public safety purposes, as officials conduct about 10 searches per year for hikers who are lost along the Appalachian Trail in that area.[27]

Resources

For Union County, procuring the cameras cost approximately $1,500. Eventually, the cameras will need to be replaced. The county pays Blue Ridge Mountain EMC about $50 per month to maintain a broadband subscription to the cameras. County staff anticipate being able to learn more about the information they can access from GDOT's ITS assets at Neels Gap, but other than some staff time provided by GDOT and Union County, that should not require significant resources devoted to training or influence staffing levels.[28]

3.2 Using ITS to Improve Traffic Conditions and Visitor Experiences in the National Parks

In recent years, the National Park Service (NPS) encouraged visitors to plan before visiting parks to minimize traffic congestion and conserve resources. The NPS developed a Congestion Management Toolkit in 2014 that includes recommendations for implementing ITS to address vehicle congestion at park entrances and along park roadways, entrance gate delays, and over capacity parking near attractions or trailheads.[29] The NPS became more involved in regional initiatives to mitigate traffic issues by coordinating with other federal partners, regional agencies, state departments of transportation, local governments in gateway communities, and chambers of commerce or visitor bureaus. ITS applications in the national park environment include DMS, visitor apps for parking and traffic updates, and use of Twitter for real-time traffic conditions. This case study focuses on use of national park ITS technology in Arizona, Colorado, Montana, New Mexico, Oklahoma, Texas, and Wyoming. A separate case study examines how ITS is used to provide visitor information at the Rocky Mountain National Park.

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[25] Personal communication with Lamar Paris, June 2019

[26] Personal communication with Emily Dwyer, September 2019

[27] Personal communication with Lamar Paris, June 2019

[28] Personal communication with Lamar Paris, June 2019

[29] National Park Service (2014). Congestion Management Toolkit, https://www.nps.gov/orgs/1548/upload/NPS-CMS_Toolkit.pdf

Project Purpose

In 2018, the National Park Service recorded over 318 million recreation visits, more than a 15 percent increase from the National Parks' 275 million recreation visits in 2008.[30] All park regions of the U.S. experienced increased visitation, with some individual parks having notable increases. For example, Glacier National Park had a 64 percent increase in visitors in the ten-year period from 2008 to 2018.[31] Modest fee increases were approved in spring 2018 at the 117 parks that charge entrance fees to address $11.6 billion in deferred maintenance at all 417 NPS units.[32] Fees are used to repair infrastructure and respond to increased stress and demand placed on the parks' transportation network. As noted earlier, the National Park Service developed a Congestion Management Toolkit to formally prepare for growing congestion in the parks and to mitigate traffic's effect on air quality and the natural environment. Sample tools recommended to manage congestion include DMS, parking information, expanding transit service, posting information on social media, and expanding bicycle and pedestrian options.

Dynamic Message Signs

National Parks have been using DMS in Colorado to convey information about road closures or traffic since a 2011 pilot between Estes Park, Colorado, and Rocky Mountain National Park. Dynamic message signs relay information at strategic locations to provide visitors the opportunity to enter a park or take the option of detouring or returning to a gateway town if traffic conditions are poor. Glacier National Park is using DMS during peak season at its Many Glacier entrance at the Blackfeet Reservation near Browning, Montana. The park also used DMS during the Going-to-the-Sun Road rehabilitation project from 2007 to 2019 during peak season. Montezuma Castle National Monument, located in Coconino National Forest in Arizona, has coordinated with a federal partner, the National Forest Service, to place a DMS on its entrance road to relay parking information. The National Park Service has leased or borrowed signs and placed them in coordination with a state DOT, adjacent county, or as mentioned, with a non-Department of Interior federal agency. The NPS unit takes responsibility for updating sign messages.

Apps and Websites

Western parks are taking visitor messaging a step further by providing real-time information to visitors as part of the NPS's emphasis on visitors learning details before they arrive. Information is shared by traditional webpages or by customized apps, as seen in Figure 3. Arches National Park near Moab, Utah, uses webcams and parking status web pages to inform visitors of the current wait time at the park entrance. An NPS webcam provides a regularly updated visual of the Arches entrance gate, and a Utah DOT webcam posts real-time images of photos of U.S. 191 at the park entrance road. Arches National Park's website parking pages, while static, do list lot names, number of spaces, open/closed status, and usage levels.[33]

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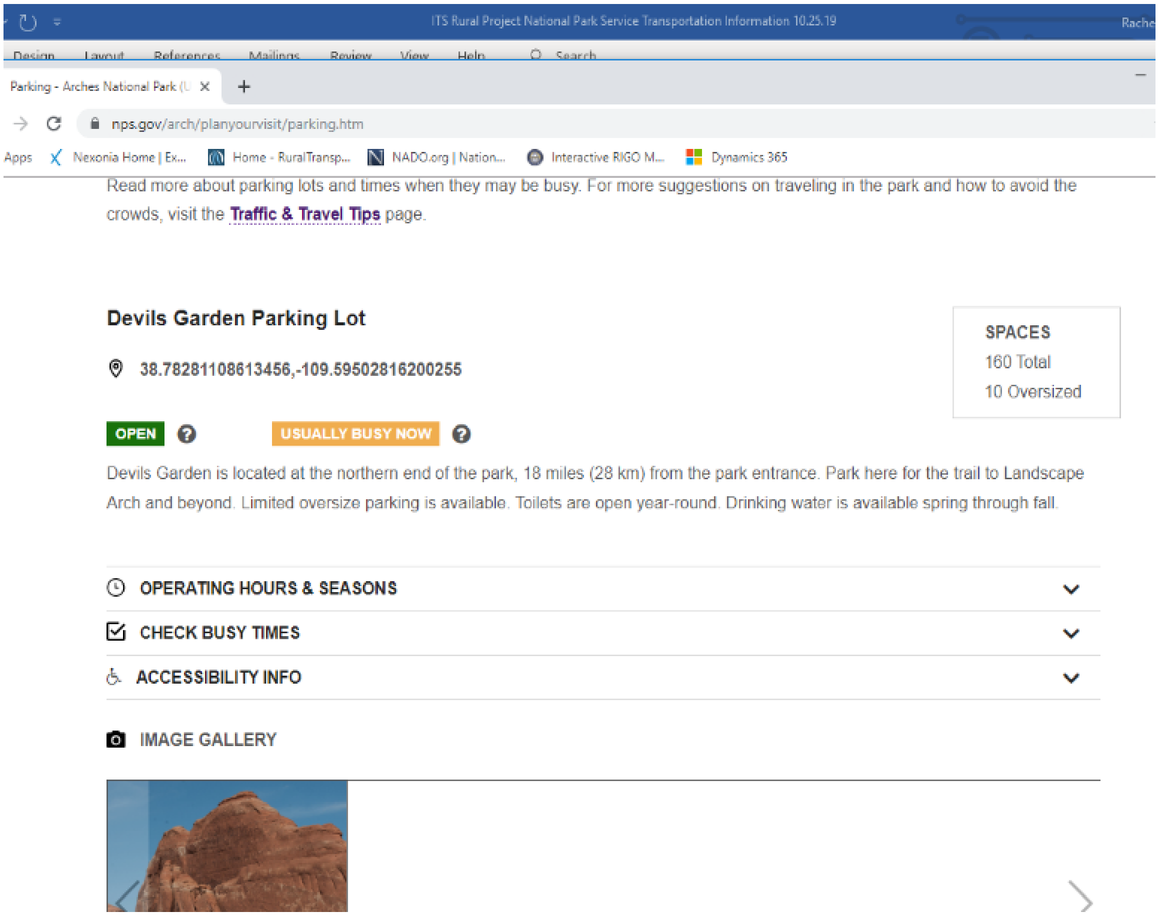
[30] National Park Service (2018, 2008). Annual Visitation Summary Reports, https://irma.nps.gov/STATS/Reports/National

[31] National Park Service (2018, 2008). Annual Visitation by Park or Region, https://irma.nps.gov/STATS/Reports/National

[32] National Park Service (2018). National Park Service Announces Plan to Address Infrastructure Needs & Improve Visitor Experience, https://www.nps.gov/orgs/1207/04-12-2018-entrance-fees.htm

[33] National Park Service, Arches National Park, https://www.nps.gov/arch/planyourvisit/directions.htm



Source: Department of Interior, Arches National Park, 2019

Figure 3. Arches National Park provides parking lot information on its website

Glacier National Park has launched a Recreation Access Display (RAD) application that is used during the park's peak season. The app dashboard provides updates on parking, road closures, and vehicle access restriction, as well as information on campground status and weather.[34] Another app example is Bryce Canyon's Shuttle Tracker app, which allows visitors to view stops and the location of the park's transit shuttles along the route network.[35]

At the current point in time, there is no standardized app in use by all national parks. Off-the-shelf apps are being used to provide NPS visitor and transportation information.

Social Media

Individual national parks use social media accounts to provide transportation condition updates, as seen in Figure 4 in the traffic updates provided via Twitter from Rocky Mountain National Park. Twitter is primarily used for immediate updates. Facebook is used for general information about expected travel

[34] National Park Service, Glacier National Park, https://www.nps.gov/applications/glac/dashboard/

[35] Bryce Canyon Shuttle. http://www.brycecanyonshuttle.com

conditions (e.g., holiday weekend travel).[36] National Park Service staff note that visitors need to consider that cell phone coverage is not always available in order to access real-time information. Visitors are asked to allow time for unexpected events, pack their patience, and enter parks during off-peak periods (e.g., before 10:00 a.m. or after 2:00 p.m.). The types of information shared by Twitter include road closures, traffic volumes, and weather conditions.[37] Social media is a form of intelligent transportation communication in and of itself, and posts provide a mechanism to highlight the different types of ITS used in the parks. Many parks enjoy very active Friends of the Park private organizations which help supplement the NPS staff with needed support on facility maintenance and traveler information on the Friends' social media pages and accounts.

Source: Department of Interior, Rocky Mountain National Park, 2019

Figure 4. Rocky Mountain National Park uses Twitter to announce traffic conditions

Partnerships

When working on regional transportation issues, the National Park Service has traditionally participated in conversations about transportation improvements. For gateway communities such as Estes Park, Colorado; Tusayan, Arizona; or Springdale in Utah, local governments, regional agencies, visitor centers, and chambers of commerce are partners when it comes to discussing remedies for national park congestion and parking needs. Jurisdictions in the Grand Valley region of Colorado, home to Colorado National Monument, work together when transportation projects affect the monument and its surrounding communities. A recent Colorado National Monument roadway construction project involved the NPS, Colorado Department of Transportation (CDOT), and local governments—Mesa County, City of Grand Junction, and the City of Fruita. These local jurisdictions' roles change with each project; however, typical support includes providing detour routing, placing information signs, and managing traffic during

[36] National Park Service, Montezuma Castle National Monument Facebook account, https://www.facebook.com/MontezumaNPS/posts/2309650859086507

[37] National Park Service, Rocky Mountain National Park Twitter account, https://twitter.com/RockyNPS?ref_src=twsrc%5Egoogle%7Ctwcamp%5Eserp%7Ctwgr%5Eauthor

construction. The partnership includes participating in each other's public meetings and providing outreach. [38] (*More examples of working partnerships between the NPS and neighboring towns are discussed in the Rocky Mountain National Park case study.*)

Parks Projects and Regional Planning

National Park Service involvement in the regional planning process depends on each park's transportation issue and relationship to surrounding jurisdictions. A recent example of community-level planning is an October 2019 public meeting held in Moab where local residents and other interested parties were invited to learn about efforts to address traffic congestion and improve the visitor experience at Arches National Park.[39] NPS planning efforts have been bolstered through collaboration with the Bureau of Land Management (BLM), the U.S. Fish and Wildlife Service (FWS), and the U.S. Forest Service (USFS). Federal land management agencies in Colorado have been engaging with CDOT to become more involved in regional planning.

Grand Valley once again provides an example of how planning includes both federal and local partners. Federal land managers and federal recreation planners are included in Grand Valley's continuing, cooperative, and comprehensive planning process, and each of the federal land management agencies (i.e., NPS, the BLM Grand Junction Field Office, and the USFS Grand Valley Ranger District) have a representative on the Grand Valley regional transportation plan steering committee.[40]

Outcomes

On an individual park basis, there have been impact and design plans and studies that focus on proposed ITS technologies or transportation projects that incorporate ITS components. ITS inventory reports for the NPS and federal public lands have likewise been produced every five or ten years since the early 2000s The National Park Service has not conducted a cumulative formal, quantitative evaluation of how intelligent transportation systems have affected travel patterns and user experiences in the parks. At this point in time, the impact of ITS and social media messaging is anecdotal.

Resources

Funding for ITS applications in the national parks comes from National Park Service operations funds (ONPS) and revenue from fees and pass sales authorized under the Federal Lands Recreation Enhancement Act (FLREA). Federal Lands Transportation Program (FLTP) funding has been used for transit in the parks and technology deployment. Another source of funds is the U.S. DOT Surface Transportation Block Grant (STBG) Program which funds transportation control measures such as intelligent transportation systems projects. Additional information about technology costs can be found in the National Park Service Congestion Management Toolkit.

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[38] Personal communication with Dean Bressler, November 2019

[39] National Park Service, Arches National Park. (2019). https://www.nps.gov/arch/learn/news/news100119.htm

[40] Personal communication with Dean Bressler, November 2019

3.3 Rocky Mountain National Park: Experiences and Lessons Learned from Using ITS for Traveler Information

Rocky Mountain National Park (RMNP) is the third most visited national park in the United States. Similar to other western national parks, Rocky Mountain has experienced a sharp increase in visitation numbers in recent years. RMNP's visitation rate increased 42 percent between 2012 and 2018.[41] Unlike some of the west's "destination" national parks—Yellowstone is an example—RMNP has a high percentage of day visitors due to the park's proximity to the Front Range metropolitan areas of Denver, Boulder, Longmont, Loveland, and Fort Collins. Over 80 percent of visitors enter through RMNP's eastern entrances just outside the gateway community of Estes Park. In response to the growing popularity of the region, both RMNP and the Town of Estes Park have initiated intelligent transportation systems technologies to inform travelers of traffic and weather conditions and to mitigate parking congestion during the park's busiest hours of 9:00 a.m. to 3:00 p.m.

Project Purpose

Each ITS implementation outlined below, including dynamic message signs and online information, had particular purposes related to managing congestion, travel experience, and traveler expectations when traveling within RMNP and the nearby community of Estes Park.

Dynamic Message Signs, Parking Restrictions, and Shuttle Service

RMNP takes a multi-pronged approach to providing visitors information about transportation. RMNP first piloted dynamic message signs in 2011. As of 2019, there are five portable changeable message signs under the jurisdiction of the park, and the Town of Estes Park has installed permanent message signing outside the park boundary. The national park's DMS are used to announce parking conditions and to post vehicle restrictions. During summer months, vehicle access along the Bear Lake corridor is limited to maintain traffic flow and enable the National Park Service to respond in case of emergency. In general, RMNP follows the practice that once parking lots are full, the park then moves to using satellite park and ride lots where visitors can board shuttles to access park trailheads and campgrounds or travel into town on the Hiker Shuttle. The Town of Estes Park uses its permanent DMS to share parking lot status as well as information about catching the park shuttle. Two town signs along U.S. 36 and U.S. 34 are used to alert drivers of delays and encourage them to use the town's new parking structure or to visit the new Estes Park visitor center.

For visitors who park their vehicles, RMNP operates three shuttle routes within the park's boundaries, including the route into Estes Park.[42] Estes Park runs a free shuttle within the town, and the two entities—RMNP and the Town of Estes Park—have streamlined administration by piggybacking onto a combined vehicle and service contract.

RMNP staff noted that local ability to control DMS content and the ability to update messages when needed have been important to the park. Even with locally controlled messaging, there are still practical factors that have affected RMNP's portable signs. For example, with the current DMS, to remotely control the messages on the signs requires the sign to connect to the cell network. With limited cell coverage

[41] Personal communication with Kyle Patterson and John Hannon, November 2019

[42] Rocky Mountain National Park (2019). Shuttle Bus Routes, https://www.nps.gov/romo/planyourvisit/shuttle_bus_route.htm

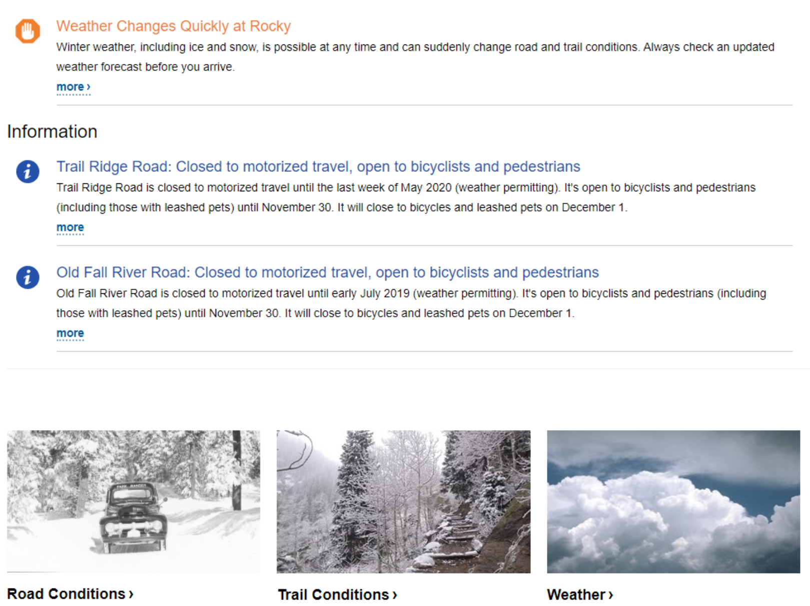
within the park, this has influenced the sign locations. A shift to permanent message signs will require more complex infrastructure such as underground cable and more detailed programming. Additionally, RMNP staff stated that as a federal agency, the park must follow federal protocol regarding software and data system protections which presents additional challenges connecting DMS to the NPS network. RMNP has considered pre-timed message schedules, but the practice has not yet been implemented. Not all message updates can be done from a remote location which affects ability to pre-schedule messages. There are occasions where staff have had to plug keyboards into the signs to change messages.

Web Information and Social Media

RMNP uses three primary social media channels: Facebook, Instagram, and Twitter. Facebook and Instagram posts are more for building relationship stories, and Twitter focuses on real-time information. The Estes Park Visitor Center is supportive by re-posting or sharing @RockyNPS tweets. In addition to social media, traditional media outlets along the Front Range also run articles or announce initiatives related to RMNP visitation.

RMNP's website, https://www.nps.gov/romo, conveys traveler information through webcam images from the Fall River and Beaver Meadow entrance gates. Webcams provide website information on how traffic is flowing (or not) at the entrance lanes. The website has 10 million visits per year, and park representatives indicate that web visitors are likely planning for a future trip.

All National Park websites include an "Alert" tab to draw immediate attention to situations affecting near-term travel. Alerts are limited in terms of the type of news that can be shared. Examples of approved alerts include fire closures, road closures, and weather information, such as those in Figure 5 below.



Source: Department of Interior, Rocky Mountain National Park, 2019

Figure 5. Rocky Mountain National Park Alerts web page

RMNP staff acknowledge there are considerations to take into account when it comes to implementing new technologies in the parks. Considerations include challenges with app software used for parking or campground status and limited staff resources which affect the prioritization and posting of transportation communication. Twitter is updated for immediate information, whereas website updates are intended for visitors who plan far ahead. Despite all the information available, there will always be visitors who do not research their trip and arrive with little idea of parking availability, road conditions, or traffic levels.

The park is trying to place information at key decision points so that visitors can decide their own tolerance for traffic congestion. Park personnel mentioned that several years ago when the park become active in posting traffic information, some businesses around Estes Park expressed concern about signage placement and how that might affect their visitation levels because Estes Park is a destination in and of itself. In more recent years, as visitation levels have increased for the entire region, there has been more conversation about congestion and how it affects everyone.[43]

RMNP wants to provide important traveler information while being careful about setting expectations, and that's one reason why the park carefully considers new technology and how useful it will be to visitors. One example is discussing the usefulness of a parking app that indicates number of spaces available. Once a traveler reaches the parking lot, will those spaces still be open? If not, then how useful is the app? Park administration considers these questions as well as infrastructure requirements and costs and staff resources associated with maintaining equipment.[44]

Planning Partnership Between RMNP and Town of Estes Park

RMNP's technology decision making is not done in a silo. Visitor messaging and transportation service are shared responsibilities of the park and its gateway neighbor, the Town of Estes Park. It's a long-standing partnership that's bolstered by a mutual interest in the preservation and success of the region. RMNP representatives attend the monthly Town of Estes Park Transportation Advisory Board and economic development meetings. In addition, there is close interaction with the Estes Park Visitor Center and Visit Estes Park website https://www.visitestespark.com. The park has been working closely with the town for decades, and current staff were also on board when RMNP first discussed implementing shuttle service based on models used at Acadia National Park and Zion National Park.

Outcomes

RMNP has not conducted a formal evaluation of how the DMS, shuttle service, and social media and web applications are affecting traveler planning and behavior. Park staff has noticed that technology use and awareness is tied to overall changes in behavior as people have gotten used to changes within the park system such as vehicle restrictions. Frequent visitors know they may need to arrive before or after the hours of the restrictions or plan to use the park's shuttle. Visitors' knowledge of the restrictions and a few years to absorb the travel and traffic changes have made a difference in in the patterns of the park.[45]

Resources

RMNP can use funds from National Park Service operations funds (ONPS) and revenue from fees and pass sales authorized under the Federal Lands Recreation Enhancement Act (FLREA). In addition, other federal transportation resources are available depending on project eligibility. Rocky Mountain is one of 17 parks allowed to collect transportation fees for administration. RMNP is looking at funding for

[43] Personal communication with Kyle Patterson and John Hannon, November 2019

[44] Personal communication with Kyle Patterson and John Hannon, November 2019

[45] Personal communication with Kyle Patterson and John Hannon, November 2019

permanent DMS down the road. The Fall River entrance will be rebuilt in the next five years with related roadwork in the next few years, so message sign installation is dependent on the timing of the reconstruction.[46] In the Town of Estes Park, sales tax is used to fund shuttle service, and a lodging tax is used for marketing. The town is exploring paid parking in its downtown core to encourage drivers to use the town's free garages, reducing congestion in its inner core.

According to a 2018 *Estes Park News* article on DMS installation, the new permanent signs near U.S. 34 and U.S. 36 the Town of Estes Park, Colorado, received $136,000 in Congestion Mitigation and Air Quality (CMAQ) funding as part of the Upper Front Range Regional Planning Commission and CDOT improvement program.[47] The town government provided local match of $98,000. The funding was used to purchase four permanent signs. According to National Park Service's Congestion Management Toolkit, the estimated capital costs for portable DMS range from $50,000 to $250,000 depending on the number of signs and whether the signs are purchased or leased. Operations and maintenance costs are estimated at $500 to $1,600 per year for a portable sign.[48]

For additional information, view the Rocky Mountain National Park Intelligent Transportation System Pilot Deployment/Evaluation (2011) at https://westerntransportationinstitute.org/research_projects/rocky-mountain-national-park-intelligent-transportation-system-pilot-deploymentevaluation.

[46] Rocky Mountain National Park (2018). Decision Reached on Fall River Entrance Improvements in Rocky Mountain National Park, https://www.nps.gov/romo/learn/news/decision-reached-on-fall-river-entrance-improvements-in-rocky-mountain-national-park.htm

[47] Town and contractors begin installation of Dynamic Message Signs (2018). *Estes Park News,* http://www.estesparknews.com/featured_articles/article_f9ffc188-52d9-11e8-bced-8b255674d0b1.html

[48] National Park Service (2014). Congestion Management Toolkit, https://www.nps.gov/orgs/1548/upload/NPS-CMS_Toolkit.pdf

4 Management and Operations Case Studies

The case studies in this chapter address management and operations of transportation facilities that are being implemented rural and small metropolitan communities, as well as emerging technologies that could prove to be beneficial in rural corridors.

4.1 Smart Intersections and Signal Timing in Fort Smith, AR

Innovations in ITS promise increasingly nuanced data interactions between an increasing number of systems. The potential benefits of community-scale information exchange have contributed to the concept of a smart community. In the transportation sector, this complex ecosystem can combine information gathering tools and data analytics to promise commuters greater safety and less congestion, among other benefits.

Project Purpose

With a population of roughly 90,000, Fort Smith, Arkansas, has transportation data and challenges that are quite distinct from higher population communities where such technologies are often deployed. In collaboration with the Frontier Metropolitan Planning Organization, Fort Smith entered a competitive challenge run by a private sector entity to test an intersection-centered system, being selected as one of four finalists to receive the system and support throughout its installation and deployment.[49]

The technology made use of a traffic signal controller and other local sensors already in place. The technology added connected this gathered data to a dashboard, allowing local engineers easy access and visualizations. An algorithm built on this data to recommend changes to signal timing, with a goal of reducing congestion and increasing intersection safety. The 20-21 intersections chosen for deployment were defined by red light running and safety concerns, with distinct challenges because of poor traffic circulation planning between low-income housing, retail shopping, pedestrian traffic, bicyclists, buses, and more.[50]

Outcomes

Frontier MPO staff noted the pandemic as an obstacle to the project's full ambitions and structure. Beyond hindering intended public outreach efforts, COVID-19 reduced traffic levels and prevented the involvement of a previously expected team of traffic signal engineers. For Frontier MPO, the data collected during the deployment was most valuable, providing a foundation for future opportunities. While it was difficult to measure impacts from traffic data altered by the pandemic, the information and partners

[49] Cho, Aileen. (2020). "Four Cities Will Receive Smart Intersection Technology." Engineering News Record. https://www.enr.com/articles/49538-four-cities-will-receive-smart-intersection-technology

[50] Cho, Aileen. (2020).

acquired during the process offered credibility and opened doors to a number of later projects, and they noted the number of small cities, similar in size to Fort Smith, that could benefit from ITS ecosystems if less constrained by funding, revenue, and resources.[51]

That data being leveraged into other efforts demonstrated the importance of a strong foundation upon which to expand success. Lessons learned from other locations were applied to efforts by Frontier MPO to develop an MPO-wide road safety plan, which received FHWA funding and has benefited further from a Safe Streets for All (SS4A) Grant. Information collected along Roger Avenue supported work that led to a $1 million bicycle-sharing grant, despite bikeshare programs typically taking place in more affluent areas. The collaborations that have been enabled by this improved data environment have not come without their own challenges, but their potential to succeed and to chase more specific projects in grant applications has emerged from a more complete information ecosystem.[52]

Operating Smart Intersections Systems

Fort Smith's Streets and Traffic Control Department was directly involved in the implementation of these smart intersection tools. The department director likened the experience to a beta test, Fort Smith being used to test software for use in similar communities, with changes and adjustments made as needed. There were challenges in the process, one being the need to install cellular communication systems on certain traffic signals to make the system function, which were funded by the vendor through the competitive challenge program. The system implemented was noted by city staff as costing approximately $40,000 to $50,000 a year, a cost including the training of personnel.[53]

Following the challenge, Fort Smith opted to go in a different direction while continuing to invest time and resources into deploying intersection improvements with a previous vendor. The Streets and Traffic Control Director noted Fort Smith's 155 signalized intersections as a prominent factor, with the system installed through the vendor challenge covering a limited number of intersections with a fixed installation that could not be moved once installed. To cover a larger swathe of intersections, Fort Smith would have had to pay more to expand the system, and they ultimately favored a smaller number of movable devices. This will allow Fort Smith to monitor patterns and conditions of the entire city, portions at a time with movable devices, at less cost to local government and taxpayers.[54]

4.2 The Dilemma Zone Protection System

The dilemma zone of a high-speed intersection represents the area in which the onset of a yellow light leaves a driver unsure of whether it is preferable to attempt a stop or proceed. This uncertainty greatly increases the likelihood of an accident, taking the form of a rear-end collision should they mistakenly stop, or a right-angle crash should they mistakenly proceed.[55] The MDOT State Highway Administration's Office of Policy and Research requested assistance in researching and developing a solution to this

[51] Personal communication with Reese Brewer, April 2023.

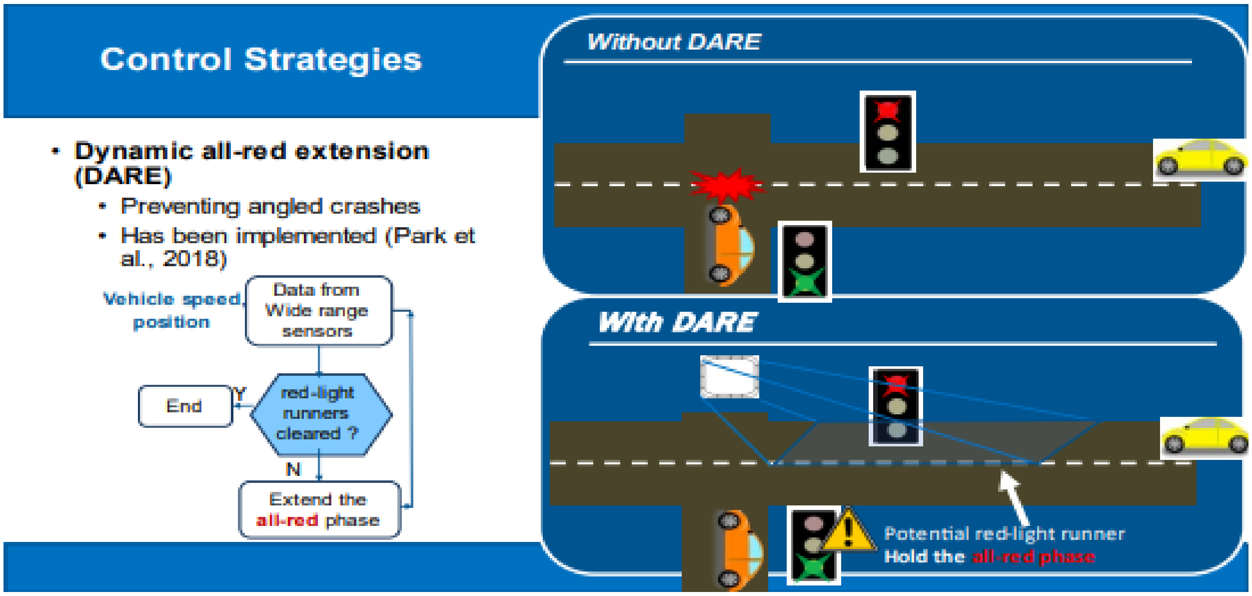
[52] Personal communication with Reese Brewer, April 2023.

[53] Personal communication with Matt Meeker, April 2023.

[54] Personal communication with Matt Meeker, April 2023.

[55] Zhang, Y., Fu, C., & Hu, L. (2014). "Yellow light dilemma zone researches: a review." Journal of Traffic and Transportation Engineering (English Edition), 1(5): 338-352, https://doi.org/10.1016/S2095-7564(15)30280-4

problem, entering a 5-year contract with the University of Maryland's A. James Clark School of Engineering. With federal research funding, the research team developed the Integrated Intelligent Intersection Control System (III-CS) tool, serving as technical advisors in its state-funded implementation on Maryland's Interstate 95.[56]



Source: Chang, G.-L., Chen, Y.-H., & Cheng, Y., 2022

Figure 6. A graphical depiction of the DARE algorithm as executive by the III-CS tool

The III-CS builds on concepts implemented in the state's already existing dilemma zone protection system (DZPS). Making use of components including wide-range vehicle sensors, III-CS can track the speed evolution of vehicles in the 600-1,000-foot range, providing signal phase and timing (SPaT) data to in-cabinet computer capable of implementing demanded control algorithms – altering intersection light timing to maximize safety. The earlier phases of this project saw the development of a dynamic all-red extension (DARE) strategy, with similar systems deployed both in and outside of the United States with some success. Under DARE, should sensors detect a vehicle perceived as likely to run a red light, the perpendicular light will receive a signal to prolong its own red until the intersection is cleared, protecting drivers from a potential angled collision. The III-CS expands on the DARE mechanic with two additional algorithms, allowing green-light extension or termination, as seen in Figure 6. These work under a similar logic, with the objective of minimizing the likelihood of a rear-end collision, just as DARE works to reduce angled crashes.[57]

Project Purpose

Pre-deployment simulations suggested that the computer's algorithms would reduce dilemma zone-related collisions in all three of the evaluated intersections. This was supported by the findings after

[56] Personal communication with Dr. Gang-Len Chang, July 2022.

[57] Chang, G.-L., Chen, Y.-H., & Cheng, Y. (2022). "An Integrated Intelligent Intersection Control System (III-CS) for Safety Improvement and Delay Minimization." Maryland Department of Transportation State Highway Administration, https://www.roads.maryland.gov/OPR_Research/MD-21_SHA-UM-5-12_Dilemma-Zone-Phase-III_Report.pdf

deployment, with the III-CS optimally activating or terminating its green extension to the effect of significantly reducing the number of vehicles trapped in the dilemma zone. This was observed in two studies taking place one and three months after initial deployment respectively.[iii] Beyond reducing the number of near conflicts likely to result in rear-end collisions, findings suggested III-CS deployment could positively shape behavior of drivers encountering a yellow light, reduce red-light running and the need for DARE activation, provide additional data for traffic engineers monitoring queue evolution patterns, and even monitor congestion and arterial incidents, all without adding to congestion.[58] The benefits of III-CS are highest in high-speed areas with relatively low congestion, which applies to a number of rural intersections where challenges of design can complicate measures intended to reduce collision rates.[59]

Outcomes

The algorithms that allow III-CS to improve safety and driver outcomes may be effective at intersections or areas meeting the criteria of high-speed and low congestion. The system operations of III-CS are not published, nor are the published details easily translated into operations. Local, state, and federal agencies interested in applying this technology to their own intersections are encouraged to contact MDOT SHA's Office of Policy and Research for the in-depth technical information required for implementation. While sophisticated in design, the III-CS is built to be easily used by state- and local-level operators. The research team created a training video instructing said operators in connecting and calibrating the tool to a given intersection.[60]

In terms of physical resources, the III-CS has several components which must be functional for it to achieve its desired impact. As crashes do not occur every day, it would be possible for the sensors or signal controller to cease functioning without immediate awareness by operators. This necessitates a need to actively monitor the continued functionality and interconnectivity of the equipment, which by nature is low visibility when functioning properly. This is a common vulnerability of automatous and connected systems, warranting upkeep or measures to regularly assess function. To facilitate system monitoring, the in-cabinet computer sends information to its control center on each run red-light.[61]

4.3 A Decision Support Tool for Crash Response and Management

To increase the speed and efficiency of a post traffic incident response, numerous highway-operating agencies have developed and implemented Traffic Incident Management (TIM) programs. When functioning properly, a TIM should inform an agency of an impact, calculate the optimal response, and

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[58] Chang, G.-L., Chen, Y.-H., & Cheng, Y. (2022).

[59] Maze, T. H., Hochstein, J., Souleyrette, R., Preston, H., & Storm, R. (2010). "NCHRP Report 650: Median Intersection Design for Rural High-Speed Divided Highways." National Cooperative Highway Research Program, https://www.virginiadot.org/business/resources/LocDes/nchrp_rpt_650_Median_Intersection_Design_for_Rural_High_Speed.pdf

[60] Chang, G.-L., Chen, Y.-H., & Cheng, Y. (2022). "An Integrated Intelligent Intersection Control System (III-CS) for Safety Improvement and Delay Minimization." Maryland Department of Transportation State Highway Administration, https://www.roads.maryland.gov/OPR_Research/MD-21_SHA-UM-5-12_Dilemma-Zone-Phase-III_Report.pdf

[61] Personal communication with Dr. Gang-Len Chang, July 2022.

ensure delay to the public is minimized. In collaboration with a research team from the University of Maryland's A. James Clark School of Engineering, the MDOT SHA Office of Policy and Research a TIM system on Interstate 95.

Project Purpose

This first Incident Duration Prediction Module (IDPM) was designed to assess a given incident and the number of vehicles involved, evaluating among other factors the likely clearance time. The success of the IDPM-I-95 led to work on a Transferability Assessment Method (TAM), allowing data and prediction tools designed for I-95 to design new IDPMs for other Interstates and major routes in Maryland.[62] The initial IDPM was tested in a corridor with major urban centers, but it can also benefit more rural corridors, particularly those with heavier use or higher risk of incidents.

The IDPMs fall under the aegis of a prototype TIM system called the Decision Support Tool (DST) software, intended to provide real-time response and incident management data. The original IDPM-I-95 was labeled DST-1, with the subsequent expansion of coverage to the four new IDPMs accordingly labeled as DST-2.[63] The development of the TAM is of particular importance to the continued evolution of these devices, as previous methods of training proved far more time and resource intensive. Each of the four new IDPMs served a congested highway with distinct traffic and incident patterns, with the tools collectively encompassing two types of beltways, a typical commuting freeway, and a major expressway. Should TAM enable greater generalizability of TIM systems, responsible highway agencies will be able to account for a lack of data or quality data and improve performance.[64]

Outcomes

When deployed, the IDPMs assessed incident clearance time and the resulting traffic impacts with an average prediction accuracy rate for I-495 of 82.14%, I-695 of 82.82%, I-70 of 81.67%, and US 29 of 77.27%. These figures can be compared to provided rates for the I-95 IDPM of 74.3%. In all cases, the testing datasets showed worse accuracy than with earlier training datasets, typically by low-to-mid single digits barring the case of US 29 where the difference was 16%.[65] These predictions are likely to become increasingly accurate with advances in sensory equipment, computing, and design, and often are shaped by changing information in real-time just as would be a response without TIM assistance. MDOT's system includes an estimated incident severity score that actively shifts as traffic management center operators collect new information. When compared to the null alternative of no technological assistance in incident response, accuracy in the range of 80% offers a clear and present advantage with tangible benefits to both safety and congestion.[66]

Human input remains a necessity to ensure systems are functional and correct for discovered inefficiencies. However, a stated long-term goal of future project research is to automate incident duration

[62] Chang, G.-L., Huang, Y.-L., Lu, Y.-C., & Lin, Y.-T. (2021). "DEVELOPMENT OF A TRAFFIC MANAGEMENT DECISION SUPPORT TOOL (DST) FOR FREEWAY INCIDENT TRAFFIC MANAGEMENT PLAN DEVELOPMENT." Maryland Department of Transportation State Highway Administration, https://www.roads.maryland.gov/OPR_Research/MD-21-SHAMD5-32_FITM-II_Report.pdf

[63] Chang, G.-L., Huang, Y.-L., Lu, Y.-C., & Lin, Y.-T. (2021).

[64] Chang, G.-L., Huang, Y.-L., Lu, Y.-C., & Lin, Y.-T. (2021).

[65] Chang, G.-L., Huang, Y.-L., Lu, Y.-C., & Lin, Y.-T. (2021).

[66] Chang, G.-L., Huang, Y.-L., Lu, Y.-C., & Lin, Y.-T. (2021).

calculation, better increasing response time in a manner beneficial to both persons involving in traffic incidents and the commuting public.[67] An additional goal is to account for the widespread lack of resources for highway sensor deployment, operations, and maintenance, a hindrance to the efficiency of TIM and other highway-adjacent systems that may warrant development of new technologies such as sensor-bearing drones.[68]

The system is built for efficient performance and easy user interface, flexibly incorporating engineers' knowledge as supplemental information, and modularly integrating with other existing systems. Its calculations are done with the maximum level of transparency, and it is designed to be capable of making predictions with minimal data and accommodating deficiencies in data's quality and precision.[69] In no circumstances is flawed or partial data preferable, but complete data are a luxury not always readily available. This problem is the central conceit of the TAM and the premise of future work to create a broadly generalizable IDPM for all Maryland highways, urban and rural, even where a lack of data or resources would have previously hindered deployment. As clearance operations conducted by the same incident response agency are expected to possess several common traits even when occurring on different highways, classification rules are expected to be transferable between IDPMs so long as they meet requisite confidence and support thresholds based on incident records.[70]

Looking beyond MDOT's Coordinated Highways Action Response Team (CHART) operations, similar transferability methods could apply to areas served by other response teams. Differences in methodologies presently require jurisdictions to develop their own tools, though improving transferability and data-sharing may change approaches in the long-term. The developed steps and methodologies of TAM and the lessons learned from IDPM may prove an asset to state- and local-level agencies pursuing their own TIM systems, with the MDOT SHA OPR and its partnered research team a potential resource in doing so.[71]

Resources

This research team effort has so far been implemented in a pilot, research context. As a result, resources required to deploy it widely are not yet known.

4.4 Dynamic Message Signs and Speed Radar Detectors Deployed to Address Special Events and Safety

In Missouri, RDOs provide rural transportation planning services in areas not designated as MPOs under a contract from the Missouri DOT to the Missouri Association of Councils of Government. This partnership gives rural-serving RDOs an opportunity to identify transportation concerns and potential projects through ongoing outreach and dialogue among the local, regional, and state levels. In the northwestern part of the

[67] Personal communication with Dr. Gang-Len Chang, July 2022.

[68] Chang, G.-L., Huang, Y.-L., Lu, Y.-C., & Lin, Y.-T. (2021).

[69] Personal communication with Dr. Gang-Len Chang, July 2022.

[70] Chang, G.-L., Huang, Y.-L., Lu, Y.-C., & Lin, Y.-T. (2021).

[71] Personal communication with Dr. Gang-Len Chang, July 2022.

state, three RDOs have worked together to advance work in transportation safety across the jurisdictions they all serve.

In 2015, Green Hills Regional Planning Commission (RPC), Mo-Kan Regional Council (Mo-Kan), and Northwest Missouri Regional COG (NWMORCOG) applied together for funding from the Northwest Missouri Coalition for Roadway Safety to acquire a dynamic message sign that is shared among the RDOs (known collectively as RPCs in Missouri) and can be deployed in any of the communities they serve. A speed radar trailer and traffic counters are also available to be used across the three-RDO region, which encompasses 20 counties in northwest Missouri while Mo-Kan serves an additional two counties in Kansas. Recognizing the potential opportunities for DMS, Mo-Kan used a portion of its MoDOT planning grant in 2018 to purchase an additional LED sign, seen in Figure 7, that has also has traffic counting capabilities.[72]

Source: Mo-Kan Regional Council, 2017

Figure 7. LED dynamic message signs are flexible ITS assets available for local governments in Northwest Missouri.

Project Purpose

Area local governments can request to use the DMS to display notices for any special event or traffic disruption, as shown in the images on page 20. Local governments must complete an agreement to reserve the sign, pay a $250 deposit in case of damage, and pay a $50 maintenance fee and $0.50 per mile travel fee (which is deducted from the deposit upon return of the sign). The fee is waived if the intended purpose is safety or other public benefit. This allows rural, local governments to access an ITS asset with flexible applications for minimal cost. The speed radar trailer is available to local entities within the three-RDO service area under a similar arrangement.[73]

MoDOT or Kansas DOT are often responsible for the roads and right-of-way where local agencies and organizations seek to use the signs or speed radar trailer. As a result, when the RDOs receive a request

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[72] Personal communication with Rebecca Thacker, March 2019

[73] Northwest Missouri Regional Council of Governments (nd). Transportation, https://nwmorcog.org/programs/transportation

to deploy one of their ITS assets, they coordinate with the state DOT about placement of the sign, duration, and the wording to be used.[74]

Whether owned by one RDO or jointly by three, having DMS and other assets such as the speed radar trailer available to local communities has been beneficial for a variety of applications. At times, these assets are used to address ongoing challenges, with messages about reducing speed in smaller towns that do not have their own local law enforcement. In other cases, the signs are used to manage temporary events, such as when flooding closed an interstate and trucks and other through-traffic had to pass by an elementary school on a detour route through a small town. For special events, such as the adventure cycling event Bike Across Missouri (BAM), air shows, and the total solar eclipse of 2017, the signs have been used to provide information on parking or amenities or to warn of slow traffic or other roadway conditions related to the events. During May, DMS has alerted motorists to bike-to-work month, with reminders of cyclists in the roadway and for motorists to share the road.[75]

The DMS, speed radar trailer, and traffic counters can be used by themselves or in conjunction with another safety asset developed by Mo-Kan and the St. Joseph Area Transportation Statistical Organization (SJATSO). SJATSO serves as the MPO for the St. Joseph, Missouri urbanized area, which falls within the counties served by Mo-Kan.[76] Together, Mo-Kan and SJATSO applied to Northwest Missouri Coalition for Roadway Safety for funding to develop the region’s first Safety and Innovation Mobile Lab to support pop-up safety demonstrations. The Safety and Innovation Mobile Lab trailer contains materials that local agencies can use for temporary safety installations, allowing them to test out modifications such as traffic configurations such as bike lanes, pedestrian bump outs, or new pavement markings such as crosswalks or “sharrows” before making a major investment in upgrading their infrastructure. The trailer contains roadway grade materials such as caution cones, delineators, pavement tape, chalk paint, and stencils. Permanent paint can be used for installations known to be needed in a location, such as painting a stop bar at a stop-controlled intersection.[77]

The DMS, speed radar trailer, and traffic counter owned by Mo-Kan are important tools that can be deployed along with the resources in the Mobile Lab trailer. DMS can be used to inform transportation users that there is a pop-up installation and to expect a change in how they are used to traveling through the area. The sign’s data collection capability is useful for pre- and post-event data without being obvious to passing motorists, although the speed radar trailer is also available and provides count, time of day, and speed of passing vehicles, and local police have offered use of a speed radar gun to transportation planning staff. Other information on motorist behavior, such as whether drivers made full stop at stop signs within an elementary school zone where the Safety and Innovation Lab was used to create permanent pavement markings, has been observed and recorded by planning staff seated in a nearby parked car. Technology solutions to capture those data points were not available.[78]

[74] Rebecca Thacker (2019). Presentation to the National Regional Transportation Conference

[75] Rebecca Thacker (2019). Presentation to the National Regional Transportation Conference

[76] Personal communication with Rebecca Thacker, March 2019

[77] Rebecca Thacker (2019). Presentation to the National Regional Transportation Conference

[78] Rebecca Thacker (2019). Presentation to the National Regional Transportation Conference

Outcomes

The DMS and speed radar trailer have been useful for addressing recurring conditions, such as speeding, as well as providing safety and information support for non-recurring special events. In addition, these ITS assets, the Innovation Mobile Lab trailer, and observation by transportation staff provide a set of tools for conducting and assessing transportation safety interventions. The first pop-up demonstration project using these tools occurred at Minnie Cline Elementary School, where a pop-up was held in 2018 (*depicted in the image on page 22*). This gave the administration and staff important information to protect students traveling to school. While motorist behavior improved, it was not to the desired level. The project evaluation results guided further interventions such as continuing to use adults as crossing guards (rather than older students helping younger students to cross), high visibility vests for the crossing guards, and a solar-powered flashing stop sign obtained by SJATSO with funding from the Northwest Missouri Coalition for Roadway Safety.[79]

Over time, the RDOs in northwest Missouri and SJATSO hope that use of ITS in conjunction with other tools will result in improved safety outcomes, including protecting bicyclists and pedestrians and reducing speeds where needed in certain zones. These tools can also promote economic activity through improvements in safety leading to improved walkability and resident and visitor access to businesses and services.[80]

Resources

These ITS assets have been acquired at minimal cost to the region. The Northwest Missouri Coalition for Roadway Safety (serving a 20-county section of the state) provided $13,600 for the first DMS purchased jointly by the three RDOs, which is stored in the Green Hills service area. The coalition also provided Mo-Kan and SJATSO with its Blueprint Grant for $4,600 to purchase the trailer and stock it with initial supplies, while Mo-Kan and SJATSO provided approximately $10,000 in supplies, equipment, and the value of staff time, and Buchanan County provides space in its Hazmat building to store the trailer. Mo-Kan used funds from its planning partnership grant with MoDOT to secure the second DMS for $14,700.[81]

On an ongoing basis, user fees offset some of the cost of maintaining and insuring the signs, speed radar trailer, and other equipment. MoDOT's planning partnership grant is an important source to supplement those local funds. In terms of staffing needs, one message sign can be deployed on-site by just one person, while the other DMS is larger and requires two staff. Each time the ITS assets or Mobile Lab are deployed, staff take the time to coordinate not only with the agencies responsible for roadway ownership and maintenance, such as the state DOTs for many area roads, but also emergency management and area stakeholders. Mo-Kan and SJATSO will work together to restock safety supplies in the Innovation Lab trailer as needed.[82]

For more information, visit the RDO and MPO agencies' websites: www.mo-kan.org, www.nwmorcog.org, www.ghrpc.org, and stjoempo.org.

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[79] Rebecca Thacker (2019). Presentation to the National Regional Transportation Conference

[80] Personal communication with Rebecca Thacker, March 2019

[81] Personal communication with Rebecca Thacker, March 2019

[82] Personal communication with Rebecca Thacker, March 2019

4.5 Flood Gate System Improves Road Closure Operations and Public Safety

Washington County, Oregon, is one of six member agencies of TransPort, a subcommittee of Portland Metro's Transportation Policy Alternatives Committee (TPAC) that focuses on transportation system management and operations. Transportation systems engineers from Oregon DOT, Tri-County Metropolitan Transportation District of Oregon (TriMet), Clackamas County, Multnomah County, Washington County, and the City of Portland meet regularly to discuss regional planning for and investment in technologies to support efficient transportation as the members have overlapping responsibility for the road network within the region and want local projects to align with regional initiatives. Washington County, located west of the City of Portland is 726 square miles and had a 2010 population of 529,710.[83] The county's urbanized areas are within the Portland Metropolitan Planning Organization's planning area boundaries, but much of the rest of the county has a rural character. Land use within the county is a mix of urban development, agricultural land, floodplains, and forest. Much of the county is within the Tualatin Valley, surrounded by the Tualatin Mountains. Due to topography, Washington County's roadways are affected by periodic flooding, particularly within the 100-year floodplain, and microclimate weather conditions that result in ice, fog, or snowy conditions.

Washington County developed an initial ITS plan in 2005 and updated the plan in 2013.[84] In addition to Washington County department agencies, other regional ITS stakeholders include the City of Beaverton, City of Hillsboro, City of Sherwood, City of Tigard, City of Tualatin, Oregon DOT, Portland General Electric, TriMet, Tualatin Hills Parks & Recreation District, and Tualatin Valley Fire & Rescue. County planning projects that support rural ITS strategies within the purview of Washington County's Traffic Engineering and Operations include a flood gate system, road weather information system, automated snow zone warnings, and speed feedback signage. Some of these ITS projects are still in development; however, the flood gate system is complete. Washington County's flood gate system uses ITS sensors and cameras to assess flood conditions, with a goal of improved public safety and efficient deployment of county and first responder resources.

4.5.1 Project Purpose

A segment of Fern Hill Road, located south of the City of Forest Grove, is a residential and commuter route that's located in the 100-year floodplain and subject to flooding approximately six times per year. Prior to 2018, Washington County Maintenance and Operations staff, in coordination with the City of Forest Grove Fire and Rescue or Tualatin Valley Fire and Rescue, would pre-stage and place mobile barricades across Fern Hill Road and send staff to the field to visually check flooding status. When flooding receded, county staff would return to inspect the roadway for damage, clean the road surface, make any necessary repairs, and manually return signage and barricades to their staging area. The process was costly, time consuming, and posed a safety risk when members of the public chose to physically move the barricades or drive around to enter the closed roadway segment.

[83] U.S. Census Bureau (2018). Quick Facts, https://www.census.gov/quickfacts/washingtoncountyoregon

[84] Washington County, Oregon (2014). Washington County ITS Plan Executive Summary, https://www.co.washington.or.us/LUT/Divisions/TrafficEngineering/Programs/TrafficManagement/ITSystem/upload/WaCo-ITS-Plan-Executive-Summary-2014-2.pdf

To address the ongoing issues, Washington County decided to install fixed, manually lockable gates, seen in Figure 8, that are supported by water depth sensors and surveillance cameras. Automated gates were considered; however, terrain constraints, the potential for flood damage, the need for maintenance staff to be able to assess road conditions, the need for emergency personnel to access the road when needed, and infrastructure costs were considerations that affected the decision to install manual gates. While the flood gates rely on county staff for the closing and opening process, what makes the system notable is the ITS component. With the new system, Washington County can monitor the gates and water levels through cameras and sensors without making multiple field visits to the gates. The real-time status information is then shared at both the county and state level through the county's transportation information system and Oregon DOT's TripCheck portal.

Source: Washington County, Oregon, 2019

Figure 8. A Washington County Operations employee opens an arm of the Fern Hill flood gate

The gate deployment process works through a series of steps. A U.S. Geological Survey stream gage field sensor alerts Washington County Operations when the gage height reaches 16.3 feet. Staff will monitor Fern Hill Road camera information for roadway conditions. When the stream gage reaches the high field sensor (16.5 feet), Washington County responds to the alert by closing the road segment. The flood gates, which include "Road Closed" signage and flashing red beacons, are manually locked. Pan-Tilt-Zoom cameras posted nearby enable real-time status checks of gate conditions and flooding levels. Gate position sensors transmit road closure information every five minutes to the TripCheck Traveler Information system, the county's communication system, and information service providers such as

Waze. Closure information is also shared with the public through https://www.wc-roads.com, the county's transportation information website, and social media.

Outcomes

Installation of the flood gate system required coordinated planning between the county's separate Traffic and Operations and Maintenance departments. A portion of the road segment is bounded by Washington County's Clean Water Services and the new flood gates are a technological update to an existing operations practice, so a traditional public involvement process was not used. The gates were installed in November 2017 and first used during the 2017 – 2018 winter season.[85] Washington County Land Use and Transportation engineers report that the gates worked as projected during flooding. The gates were damaged during their first use by a vehicle driver determined to enter the roadway. The county crews were able to repair the damaged gates, and they had also prepared for this type of situation by ordering a second set of gates at the time that the system was installed.[86]

The flood gate system, along with the county's other planned rural ITS projects, serve the role of improving public awareness and safety, providing a means to monitor road conditions remotely, providing real-time condition information, and decreasing the staff time needed to open and close the roadways. As of March 2023, Washington County is in design for another flood gate system, similar in design to the Fern Hill system with minor changes informed by lessons learned about sensors and maintenance access, with hopes of construction in the coming fiscal year.[87]

Resources

The Fern Hill Road flood gate system, and its sister project on Susbauer Road, were county-initiated projects. Flood gate system repair and maintenance needs are addressed by the county's overall Operations budget. In Washington County, Oregon, there are several funding program options for rural ITS projects including Gain Share revenues, a Major Streets Transportation Improvement Program (MSTIP) funded through county taxes, Metropolitan Transportation Improvement Program (MTIP) funds, federal Congestion Mitigation Air Quality (CMAQ) funding, and county road funds.

In the case of the Fern Hill flood gates, the system was funded through Gain Share, an Oregon-specific program. According to the Washington County Land Use and Transportation website, Gain Share funds consist of a share of the state income tax revenues generated from jobs creation related to Strategic Investment Program (SIP) agreements. SIP was created to attract job-producing companies by allowing local governments to negotiate alternative taxing agreements with businesses that agree to invest at least $100 million in an urban area or $25 million in a rural area in Oregon.[88] The 2015 Oregon legislature capped the shared amount to $16 million annually for any participating county. The Washington County Board has decided to focus Gain Share funds on one-time projects rather than on-going projects or services.

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[85] Washington County Oregon (2018). Fern Hill Road Closed Due to High Water; Gates in Place, https://www.co.washington.or.us/LUT/News/fernhillflooded012718.cfm

[86] Personal communication with Stacy Shetler and John Fasana, October 2019

[87] Personal communication with John Fasana, March 2023

[88] Washington County, Oregon (nd). Department of Land Use and Transportation: Gain Share Funding, https://www.co.washington.or.us/LUT/TransportationFunding/gain-share-program.cfm

For more information on Washington County's ITS Plan and the WC-Roads.com Transportation Information website, visit https://www.co.washington.or.us/LUT/Divisions/TrafficEngineering/Programs/TrafficManagement/ITSystem/plan.cfm.

5 Transportation Safety Case Studies

Transportation safety is an area of concern for travelers using any mode as well as for transportation facility owners and operators. Rural travel comes with particular risks; in 2020, 43% of motor vehicle traffic fatalities occurred in rural areas, although only 19% of the population lives in rural areas.[89] This chapter includes case studies where ITS may help with improving transportation safety.

5.1 Dynamic Warning Systems Enhance Safety for Cyclists and Vehicles on Scenic Roadways

Historic and scenic roads on federal lands and in U.S. national parks are enjoyed by both motorists and cyclists. Many of these roads were designed in the early 20th century and were constructed to the design standards of the era. As park attendance has increased in recent decades, so have traffic volumes, and the types of vehicles using the roads now includes recreation vehicles, vehicles pulling trailers, and tour buses. A growing interest in cycling within national parks means more interaction between cyclists and motorists along roads with no shoulders, curves, hairpin turns, and tunnels. To decrease the number of conflicts and crashes that occur in these locations and remind all road users of safety practices needed to share the road, the NPS is using technology to improve conditions in its units. Colorado National Monument's Rim Rock Drive is one location where a dynamic warning system has been installed to alert drivers that cyclists are on the road, as seen in Figure 9. The new system was part of a 2017–2018 roadway reconstruction project.[90]

[89] National Highway Traffic Safety Administration (2022). Rural/Urban Comparison of Motor Vehicle Traffic Fatalities, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813336

[90] Western Transportation Institute, Montana State University (2018). Dynamic Warning System to Alert Motorists to the Presence of Bicyclists, https://westerntransportationinstitute.org/wp-content/uploads/2016/09/CNMBikeWarningOverview4-18.pdf

Source: Department of Interior, National Park Service, 2019

Figure 9. Dynamic Warning System light and sign on Rim Rock Drive.

5.1.1 Project Purposes

Rim Rock Drive is a narrow, steep roadway carved out by the Civilian Conservation Corps in the 1930s. The drive is 23 miles long, includes three tunnels, and is considered one of the "most spectacular drives in the United States."[91] The road is used not only by tourists but also by vehicles accessing the town of Glade Park on the western side of the national monument. The NPS reported that the roadway averaged one documented vehicle-bicycle incident per year between 2013 and 2018, and during the peak cycling months of March through October, cyclists make up 10 percent of the traffic on the road. During this peak period the park receives, on average, one complaint per week about a near miss between a vehicle and a bicycle.[92]

The new dynamic warning system has been placed in the uphill lane at two locations along the drive. Newer inductive loop technologies, such as those deployed at Colorado National Monument, are better able to differentiate between bicycles and motor vehicles. The loop detection system triggers a flashing

[91] National Park Service (2017). Historic Rim Rock Drive, https://www.nps.gov/colm/planyourvisit/historic-rim-rock-drive.htm

[92] Hamilton, Amy (2018). Safety Upgrades at Monument. *The Daily Sentinel,* https://www.gjsentinel.com/news/western_colorado/safety-upgrades-at-monument/article_dfef337e-7056-11e8-96c8-10604b9f1ff5.html

light attached to a sign indicating that a bicyclist is ahead of the vehicle. In addition to serving as an alert for motorists, the warning system also serves the purpose of counting cyclists using Rim Rock Drive.

5.1.2 Outcomes

Data collection for the Rim Rock Drive warning installations will be part of an evaluation of the safety outcomes of the project. Vehicle and bicycle counts, counts of how often the system is triggered, how well the system differentiates cyclists in mixed traffic, and the number of vehicle-cycle incidents will be monitored. Surveys will evaluate driver and cyclist opinions about the system as well as operations and maintenance experiences. Reducing driver speeds and increasing the awareness of drivers are two goals of the project.[93]

5.1.3 Resources

The detection warning system was funded through Federal Highway Administration (FHWA) Coordinated Technology Implementation Program funds and was part of a roadway reconstruction project in Colorado National Monument. The exact cost of the warning system is not known; however, a system to warn motorists of cyclists or pedestrians in the Knapps Hill Tunnel near Chelan, Washington, is estimated at $16,000 for installation, according to the National Center for Rural Road Safety ITS Toolkit.[94]

5.2 Sign Technology Affects Driver Behavior at Railroad Crossings

Federal Railroad Administration (FRA) statistics from 2018 indicate that the year closed with over 2,200 collisions, 265 fatalities, and more than 800 injuries during highway-rail incidents at railroad crossings.[95] As of September 2019, over 1,600 highway-rail incidents were reported, 225 casualties, and 575 non-fatal incidents for 2019.[96] Railroad companies, state departments of transportation, and local jurisdictions are exploring proactive solutions to reduce the number of vehicles that stop on railroad tracks in congested traffic to help prevent future incidents. One example is a 2019 pilot lighting and signage project in Massachusetts to test whether intelligent signage would affect driver behavior around railroad crossings. The U.S. DOT John A. Volpe National Transportation Systems Center (Volpe Center) tested flashing LED-equipped warning signs in early 2019 at the request of the Massachusetts Bay Transportation Authority (MBTA) after several recorded injuries and a fatality at the Brighton Street railroad crossing in the town of Belmont. The installation of new R8-8 “DO NOT STOP ON TRACKS”

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[93] Western Transportation Institute, Montana State University (2018). Dynamic Warning System to Alert Motorists to the Presence of Bicyclists, https://westerntransportationinstitute.org/wp-content/uploads/2016/09/CNMBikeWarningOverview4-18.pdf

[94] National Center for Rural Road Safety (2018). https://ruralsafetycenter.org/wp-content/uploads/2018/03/CC3.pdf

[95] Operation Lifesaver. Collisions & Casualties by Year (2019). https://oli.org/track-statistics/collisions-casualties-year

[96] Federal Railroad Administration Office of Safety Analysis (2019). https://safetydata.fra.dot.gov/OfficeofSafety/publicsite/Query/gxrtally1.aspx

signs enhanced with LED lights is a small-scale ITS pilot that can be replicated at rural or small-town crossings where congestion is created during peak times due to construction, employment center work shifts, school traffic, freight train schedules, and special events.

Project Purpose

Brighton Street in Belmont is a two-lane road, and the area adjacent to the MBTA rail crossing includes school and business land uses, left-turning traffic, bus stops, crosswalks, and a bicycle/pedestrian trail that runs parallel to the tracks.[97] The Belmont grade crossing includes flashers, roadway gates, and pedestrian gates. R8-8 signs are posted on both directional approaches, along with grade crossing advance warning signs, and pavement markings including “Do Not Block the Box” lettering that was painted on the approach roadways in 2017.

The technology that the Volpe Center tested consists of 6-volt, solar-powered battery lights that frame the “DO NOT STOP ON TRACKS” sign, seen in Figure 10. During the test period, the lights were set to flash constantly. Once the signs were in place, Volpe analyzed the effect the signage had on driver behavior and whether drivers were more apt to stop in non-dangerous sections of the roadway versus moderately dangerous to very dangerous zones, including the track area itself.

Source: TAPCO, 2019

Figure 10. Warning sign with flashing LED lights.

Outcomes

The Volpe Center analyzed driver stopping behavior before and after the enhanced sign installation. Prior to installation, 1,065 vehicles stopped in one of the identified violation zones for both northbound and southbound directions during the week of March 18, 2019. Of this total, 29.6 percent of northbound vehicles stopped in the most dangerous zone—the track zone—and 30.1 percent of southbound vehicles stopped in the track area.

After the new signage was installed, 20.9 percent of northbound vehicles stopped in the track area, and 20.4 percent of southbound vehicles stopped in the track area. With the LED signs, the percentage of

[97] U.S. DOT, Federal Railroad Administration (2019). Effectiveness of LED-Enhanced Signs in Reducing Incidents of Vehicles Stopping on Tracks, https://rosap.ntl.bts.gov/view/dot/41694

vehicles stopping on the railroad tracks was reduced to just over 20 percent of vehicles stopped. For southbound motorists alone, there was about a 42 percent reduction in vehicles stopping in the most dangerous zone. One practice of Brighton Street drivers that continued, regardless of signage, is that northbound drivers had to stop on or near the tracks at times to let pedestrians or bicyclists who were on the bike path cross Brighton Street. In these incidences, the drivers were rarely stopped on the tracks for long.[98] Overall, the flashing LED signs have been effective in reducing the number of vehicles stopping on the tracks at the Belmont location.

Resources

The cost of the LED-enhanced signs depends on the manufacturer. The Volpe Center tested signs from two companies, TSC and TAPCO. An LED-enhanced sign with mounting brackets from TSC cost $1,740 and TAPCO's sign was approximately $1,600. A sign with a pole and base costs approximately $3,300 for the Belmont, MA signage project. A copy of the full project and analysis report is available through the U.S. DOT's National Transportation Library at https://rosap.ntl.bts.gov/view/dot/41694.

5.3 South Dakota DOT Implements Intersection Conflict Warning System

Looking for a solution to reduce conflicts between vehicles at rural intersections, the South Dakota DOT implemented a Rural Intersection Conflict Warning System (RICWS) in 2017. The system, seen in Figure 11, is based on warning technology used by the Minnesota DOT to reduce right-angle crashes and reduce traffic injuries and fatalities.[99] South Dakota's warning system project has been implemented in two locations: the junction of Highways 46 and 37 in Bon Homme County in southeastern South Dakota and at the intersection of U.S. Highway 281 and SD 20 near Mellette in Spink County.[100]

[98] U.S. DOT, Federal Railroad Administration (2019).

[99] South Dakota State News (2017). New Intersection Warning System South of Tripp, https://news.sd.gov/newsitem.aspx?id=22314

[100] Traxler, Marcus (2018). At key intersection, rural alert system working well so far. *Agweek, https://www.agweek.com/news/traffic-and-construction/4492524-key-intersection-rural-alert-system-working-well-so-far*

Source: South Dakota DOT, 2017

Figure 11. South Dakota DOT's Conflict Warning Sign

The warning system consists of vehicle detector loops on the side roads of these rural intersections. The loop detection triggers a flashing light and electronic board sign with a message indicating that traffic is approaching on the side road. The lights and sign remain off when there is no side-road traffic approaching the main highway. The specific messaging triggered by traffic on SD 20 is "Traffic Entering When Flashing" and the traffic sign on U.S. 281 reads "Traffic Approaching When Flashing."[101]

Project Purpose

The first conflict warning system in South Dakota is located where two rural two-lane highways intersect. This intersection has a long history of crashes. Between 2006 and 2017, the intersection of SD 46 and SD 37 had experienced nine injury crashes and one fatal crash. Different safety techniques have been deployed over the years to address the issue. A South Dakota DOT engineer had heard about Minnesota DOT installing warning systems and decided to try a similar pilot. South Dakota DOT hired Minnesota-based SRF Consulting to do the design, using concepts and advice from both Minnesota and Iowa projects. In the end, South Dakota wanted a system that was based on those concepts but was tailored to work for South Dakota's conditions.

[101]South Dakota State News (2018). New Intersection Warning System in Spink County, https://news.sd.gov/newsitem.aspx?id=23574

Outcomes

As of September 2020, Minnesota DOT had recently completed an analysis of the intersection conflict warning system installations in their state and found no clear crash reductions in the past three to five years, although minor reductions indicated the potential for reduction of right-angle crashes.[102] A separate usability study conducted by the University of Minnesota suggested that drivers might behave differently depending on the warning system's design, including wording on the sign and how to use electronic components to indicate the sign is on and when traffic is approaching.[103] Both Minnesota and South Dakota DOTs planned to continue to evaluate its existing locations before installing the system at additional intersections. South Dakota also planned to monitor its pilot locations before adding more intersections. There had been one crash at the SD 46 and SD 37 intersection since 2017's warning system installation, with insufficient data available to draw conclusions about effectiveness of either of South Dakota's warning projects.[104]

As of April 2023, SDDOT reported mixed results at its two RICWS locations. The junction of SD 46 and SD 37 had seen a slight increase in crashes since installation in comparison to the five years prior to installation. SDDOT has an ongoing project to remove this RICWS and will be turning the intersection into an All Way Stop control, a decision informed by system performance at the intersection and information sharing with Minnesota. Conversely, the intersection of U.S. Highway 281 and SD 20 has shown an improvement: one injury crash in the four plus years since installation compared to three injury crashes and two property damage-only crashes in the five years prior to installation.[105]

Resources

The cost of the warning system infrastructure at the SD 46 and 37 intersection was approximately $170,000 including design. The second intersection at U.S. 281 and SD 20, where a divided four-lane highway intersects with a two-lane highway, cost $214,000 including design. Design includes detection type, loop or video sensors, and determining the amount of delay between the time a vehicle is detected and the light is triggered. Design also includes setting up the type of sign messaging.

In terms of maintenance, South Dakota DOT staff state that the intersection conflict warning system is similar to maintaining a traffic signal but on a smaller scale. Maintenance includes repairing damaged loops, restoring lost power, and maintenance specific to the technology. Maintenance is conducted by South Dakota DOT.

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[102] Maranatha Hayes and Derek Leuer. Minnesota DOT (2019). A Study of the Rural Intersection Conflict Warning System, https://www.dot.state.mn.us/trafficeng/safety/docs/ricws-report.pdf

[103] Disi Tian, Nichole Morris, and David Libby (2018). Rural Intersection Conflict Warning System Evaluation

and Design Investigation, Center for Transportation Studies, University of Minnesota, https://conservancy.umn.edu/handle/11299/198534

[104] Personal communication with Andy Vandel, September 2019

[105] Personal communication with Dustin Witt, April 2023

Public outreach about the intersection projects included news releases shared through South Dakota News, media articles, and the South Dakota DOT has posted video of the intersection warning systems on the South Dakota DOT YouTube channel.[106]

5.4 Using Passive Pedestrian Detection for Trail and Roadway Crossings

The Florida DOT District 7 office, working in coordination with regional agencies, is piloting the use of passive pedestrian detection at the intersection of one of the state's long-distance, multi-use trails, the Fred Marquis Pinellas Trail, and Skinner Boulevard (S.R. 580) in Pinellas County. The multi-month project will test how technology can serve the dual purpose of improving pedestrian and bicyclist mobility and safety as well as collect pedestrian and cyclist counts.

Four agencies are partnering to conduct the pilot: City of Dunedin, Florida DOT, Forward Pinellas (the Metropolitan Planning Organization), and Pinellas County. Each organization took on a role in project planning and implementation. Florida DOT proposed a detection sensor system and connected technology vendors to the local agencies. In addition, Florida DOT has the responsibility of conducting a before and after evaluation. Forward Pinellas had the role of coordinating planning and engineering among the project parties. Pinellas County financed the purchase of a new Rectangular Rapid Flashing Beacon (RRFB) and provided the personnel to install the equipment, including the camera detector purchased by the City of Dunedin.

Project Purpose

As background, the first segment of the Fred Marquis Pinellas Trail opened in 1990. Federal and state funds, along with funding from a local option sales tax, have supported completion of the trail. As of 2019, the facility is approximately 50 miles long, running north-south along former CSX railroad right-of-way.[107]

Skinner Boulevard (S.R. 580), a principal arterial, is currently two lanes in each direction with striped on-street bicycle lanes. The Pinellas Trail crossing at the pilot location includes a ladder crosswalk, a median refuge area, and push button signals. According to trail counts, the average daily crossings consist of 65 percent pedestrians and 32 percent bicyclists, yet a higher percent of pedestrians than cyclists (80 percent) actuate the signal at the Skinner Boulevard crossing. The location, seen in Figure 12, was selected in part because of the bicycle and pedestrian crossing volumes, and the solar power conducted at the crossing had inadequate battery storage capacity for the passive detection system and flashing lights integral to a RRFB planned for the crossing.[108]

Passive detection does not require trail users to push a crossing button. Detectors track movement and are linked to signal timing. In addition to facilitating crossings, detectors can be used to conduct counts, clock speed, and identify direction of travel. Thermal energy emitted from cyclists and pedestrians trigger sensors linked to an installed RRFB that includes yellow rectangular lights that flash. According to the FHWA's Safe Transportation for Every Pedestrian (STEP) Countermeasures, RRFBs can reduce

[106] South Dakota DOT (2017). SD 46 and SD 37: https://www.youtube.com/watch?v=bg8raRtKins; U.S. 281 and SD 20: https://www.youtube.com/watch?v=V_IX4lsFZDE

[107] Pinellas County, Florida (nd) Parks & Conservation Resources, https://www.pinellascounty.org/trailgd/

[108] Florida DOT presentation (2019). Forward Pinellas Bicycle Pedestrian Advisory Committee Meeting – June 17, 2019, http://forwardpinellas.org/wp-content/uploads/2019/06/BPAC-June-17-2019-Agenda.pdf

pedestrian crashes by 47 percent. RRFB installation ranges from $4,500 to $52,000 with an average installation cost of $22,250 per site.[109]

Florida has the nation's highest levels of pedestrian fatalities, and the state is focusing on efforts to reduce pedestrian risks. Florida DOT's Strategic Highway Safety Plan includes emphasis on using a "…systematic approach to identify locations and behaviors prone to pedestrian and bicycle crashes and implement multi-disciplinary countermeasures" and creating "urban and rural built environments to support and encourage safe bicycling and walking."[110] In the case of the Pinellas Trail and Skinner Boulevard crossing, the location was the site of 11 bicycle crashes and six pedestrian crashes between 2011 and 2019, making it a key location for the state's safety improvement plans. Funding support for the cyclist and pedestrian detection system came through a combination of city and county funds with other agencies providing personnel support for installation, maintenance, and evaluation. Pinellas County will maintain the camera detection and RRFB system according to a master agreement signed between the county and Florida DOT. Florida DOT arranged for the technology vendors to provide installation and usage training during project implementation.[111]

[109] U.S. DOT (2018). Rectangular Rapid Flashing Beacon Safe Transportation for Every Pedestrian Countermeasure Tech Sheet, https://safety.fhwa.dot.gov/ped_bike/step/docs/TechSheet_RRFB_508compliant.pdf

[110] Florida DOT (2016). Florida Strategic Highway Safety Plan, https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/safety/safety/shsp2016/fdot_2016shsp_final.pdf?sfvrsn=3c118f35_0

[111] Personal communication with Peter Hsu and Whit Blanton, October 2019

Source: Forward Pinellas, 2019

Figure 12. New crossing detection system in place at Pinellas Trail and Skinner Boulevard

Outcomes

As the Pinellas Trail crossing is part of a pilot test, results and evaluation of the new crossing detection have not yet been finalized. An evaluation report is expected to be available in early 2020. According to Florida DOT district engineering staff, initial results have been positive per trail user feedback.

6 Transit and Mobility Case Studies

ITS technologies such as mobile apps and payment systems, automated vehicle location, automated scheduling and dispatching, and more are some of the innovations that rural transit agencies are adopting. The case studies in this chapter describe how technology is offering new opportunities or improving operations for transit and mobility services.

6.1 The GoBus Mobile App

The GoBus system operated by the East Texas Council of Governments (ETCOG) covers a fourteen-county region of 10,019 square miles with around 30 wheelchair accessible vehicles in service, like the one in Figure 13. GoBus allows passengers to book simple or multi-stop trips in advance, pledging safe and reliable transportation each weekday.[112] GoBus and similar rural transportation systems provide a necessary service. Rural communities typically require longer trips to social or commercial centers and services like healthcare. For many people, such long commutes can pose obstacles to wellbeing.[113]

Source: East Texas Council of Governments, 2023

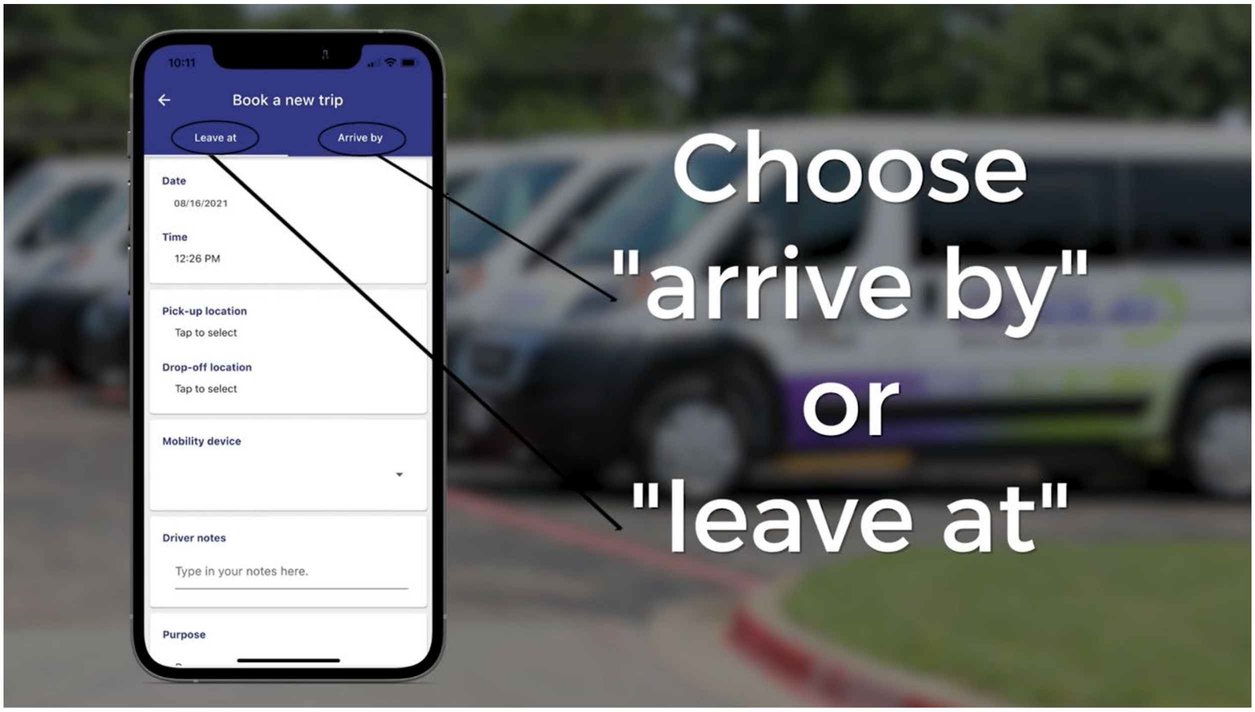
Figure 13. A GoBus vehicle, with the dispatch number visible; on-vehicle advertising allows potential customers easier access to GoBus services

In August 2021, GoBus launched the GoBus Transit app, seen in Figure 14. The app offers its users mobile booking, fare calculation and mobile payment, real-time tracking, and even on-the-go adjustments

[112] East Texas Council of Governments. (2019). "New GoBus Website Takes Online Requests for Trips." https://www.etcog.org/new-website-for-gobus-takes-online-trip-requests

[113] Rural Health Information Hub. "Transportation to Support Rural Healthcare." https://www.ruralhealthinfo.org/topics/transportation

to route or itinerary.[114] The option to develop an app was offered by a scheduling service, prompting a switch from a previous software provider that added the mobile option afterward, reflective of growing demand for such services in rural areas.[115]



Source: East Texas Council of Governments, 2023

Figure 14. A screenshot from a video on the GoBus Transit mobile app, showing an example of the interface when a user is booking a new trip

Implementing Mobile Transit

The largest concern post launch was a potential lack of utilization, the chief cause of which was likely to be difficulty learning the new system or a lack of desire to do so. There is plenty of parking in the areas served by GoBus; it is not a system for choice riders, and most passengers are older adults or people with disabilities. A survey of passengers prior to requesting funding confirmed that many owned Smartphones, but that was no guarantee of usage. Creating a profile to first use the app requires an email, another step which might weed out potential users. Utilization concerns were exacerbated by the app's launch mid-pandemic, reducing both ridership and access to riders who might be receptive to informational and training sessions.[116]

Those who have adopted the app and realized its time-saving benefits—among them the ability to recall and auto-populate recurring multi-step commutes—have become repeat riders. App users accounted for

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[114] East Texas Council of Governments. (2021). "ETCOG Launches New Mobile App Enabling GoBus Customers to Manage Their Trips and Track the Bus in Real-Time." https://www.etcog.org/etcog-launches-new-mobile-app-enabling-gobus-customers-to-manage-their-trips-and-track-the-bus-in-real-time

[115] Personal communication with Katey Pilgram, March 2023

[116] Personal communication with Katey Pilgram, March 2023

545 scheduled trips in FY2022.[117] As GoBus can note a triple-digit trip count on the average day, there is much ground to cover to persuade riders to give the app a chance.[118] This has made promotion a focus area, with active plans to schedule public meetings in high-ridership communities and offer training sessions and set-up assistance.[119] For those who are open-minded, the prospect of not needing to call or wait on hold to schedule a trip—or to check bus arrival time—may prove quite compelling.

The Keys to a Transit App

Jurisdictions interested in developing an app for their own transportation systems will not require crash courses in coding. Development and maintenance of the software are conducted by a number of providers, with updates coming automatically. The provider used by GoBus allows users to select their agency through their own application via dropdown bar, but GoBus requested a standalone app, considering the higher price and yearly app store renewal process worth the greater visibility to users.[120]

Discretionary funding from a yearly competitive grant funded the mobile app, an interactive voice response (IVR) phone system, and an in-process fare collection software—a replacement for Square that would allow greater app integration and a user account balance.[121] Any jurisdiction considering its own mobile app would be best served by contacting multiple software providers and comparing prices and add-ons offered. One such software add-on offered is a microtransit system that facilitates on-demand ride requests, with GoBus conducting a route study on areas where that service might be beneficial.[122] Another, actively in development, is the Centers Portal, which allows informational integration for GoBus passengers who use it in commutes to and from dialysis centers. Rides could be scheduled through the portal by caretakers or caretaker-informed center staff.[123]

Central to the success of any transportation system app, rural or otherwise, is for it to be promoted. GoBus Transit faced headwinds from the ongoing pandemic that hindered in-person promotional opportunities. While print media and social media increase visibility, promotion in the field offers high visibility and opportunities to set-up accounts in advance. Drivers may be the strongest potential promoters for such apps, their in-person interactions and trusted relationships with passengers allowing them to best communicate the potential benefits. These lessons learned to date have informed and strengthened ETCOG's campaign to increase self-service trips, with over 1,500 scheduled through the app in the first six months of FY23 and a target of 3,000 for the year.[124]

For more information, visit https://www.gobustransit.com/contact.

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117 Personal communication with Katey Pilgram, March 2023

118 East Texas Council of Governments. (2021). "ETCOG Launches New Mobile App Enabling GoBus Customers to Manage Their Trips and Track the Bus in Real-Time." https://www.etcog.org/etcog-launches-new-mobile-app-enabling-gobus-customers-to-manage-their-trips-and-track-the-bus-in-real-time

119 Personal communication with Katey Pilgram, March 2023

120 Personal communication with Katey Pilgram, March 2023

121 Personal communication with Katey Pilgram, March 2023

122 Personal communication with Katey Pilgram, March 2023

123 Personal communication with Katey Pilgram, March 2023

124 Personal communication with Katey Pilgram, March 2023

6.2 Technology Improves Western Iowa Transit Operations

Western Iowa Transit (WIT) is a program of the Region XII Council of Governments (COG), an RDO that serves six counties and 56 cities with a total regional population over 74,000.[125] WIT was formed in 1977 and has grown to 60 vehicles and a transit division staff of 39, who provided 158,000 rides and over 1.1 million revenue miles in 2018. WIT operates two commuter routes as well as demand response transportation scheduled by calling the main office or submitting an online rider form with contact information, origin, destination, and the time of the client appointment. Transportation to congregant meals is provided, as well as special services such as transportation from a senior center to a grocery store each week, general public transportation, and non-emergency medical transportation.[126] Historically, WIT had used a variety of methods to communicate between dispatching staff and drivers, from posts on bulletin boards to phone, fax, cell phone, and two-way UHF radio, even at times tracking down drivers by calling their favorite area restaurant to let them know of a change in their schedule. In 2017, WIT began to research options and initiate procurement for needed communications upgrades.[127]

Project Purpose

The two-way radios that provided the backbone of communication with drivers were comfortable for staff. However, they only worked in about 60 percent of WIT's rural service area. The analog radio system provider notified WIT that it would stop supporting that system, so a change needed to occur. At the time of initial publishing of this case study in September 2020, WIT described its switch to a cellular-based system, installing tablets using the Android operating system in each vehicle to use for automated vehicle location (AVL), to share manifests, and to communicate with drivers.[128] As of March 2023, WIT had switched platforms, providing each driver with an iPad with the below apps pre-installed.[129]

WIT had started using software around 2016 for scheduling, which eliminated paper manifests. WIT similarly adopted software from a different vendor for dispatching and geolocation. The two software companies worked with WIT to feed scheduling data from the scheduling into the separate dispatching software. This software combination provided several features that improve transportation operations over using the old two-way radios.[130] Previously, drivers were sometimes unsure who needed to pay at the time of the ride, but the new software allowed drivers to see whether a rider was self-pay or if their trip was funded through a contract or other mechanism, and to access information about a rider's needs rather than relying on memory, relayed messages, or handwritten notes.[131] Since the shift to iPads, all passenger tasks are accomplished through just one app. Drivers are able to log in using their vehicle number and odometer, accessing passenger schedule and logging pick-ups and drop-offs. This and GPS monitoring can be viewed remotely. Phone numbers, addresses, and special notes are all included, and dispatchers can adjust a driver's schedule and correct data errors in real time. The Team on the Run app

[125] Region XII Council of Governments (2019). http://www.region12cog.org

[126] Chris Whitaker (2019). Regional Mobility & Intelligent Transportation Systems, presentation developed with Tom Feldman, Region XII COG, and presented at the 2019 National Regional Transportation Conference

[127] Personal communication with Rick Hunsaker, March 2019

[128] Whitaker (2019)

[129] Personal communication with Matt Cleveland, March 2023

[130] Personal communication with Rick Hunsaker, June 2019

[131] Whitaker (2019)

similarly remains in use, allowing individual and group messaging and the monitoring of drivers' speeds and locations if necessary.[132]

This connectivity is helpful to map trips. WIT provides medical transportation and Job Corps transportation into neighboring regions and states, so drivers are not always familiar with the route and destination. AVL adds a measure of comfort, since the WIT director can check on a driver's location on an out-of-state trip to see whether the driver is still in service, shown in the image below. Drivers can use an emergency button to quickly indicate an urgent problem to staff in the office. The data also assist WIT with conducting driver safety evaluations, using trip information such as speed to support evaluations and training.[133]

Outcomes

The cellular-based system provided 80 to 90 percent coverage of the six-county service area, much higher than the two-way radio coverage.[134] A focus on ease of use was key, ensuring that drivers were comfortable with the tablets and later iPads, knowing how to access manifests and enter rider information. This transition has been successful, with the new software providing many benefits at a lower cost than upgrading the two-way radios would have been.[135], [136]

Overall, communication and reporting have significantly improved with both technology upgrades. The current system has eliminated the need for paper logging, saving time for both drivers and transit staff and allowing reports to be pulled directly from the unified scheduling and dispatching app, simplifying end-of-month billing and end-of-quarter reporting. The sole downside reported is the potential for driver error given regular manual entering of data on the go, which can be time consuming during a morning review of the previous day's trips.[137]

Resources

The upfront cost for a scheduling software license was $25,400, half of which was supported through a grant from Iowa DOT. After the fifth year of the license, WIT pays an annual maintenance fee of $1,400 and cloud fee of $2,500 to keep the software up to date. The separate dispatching software license that was previously used was charged at $6 per driver per month; this secondary cost was eliminated after the agency transitioned to using iPads that allowed for use of a unified scheduling and dispatching app.

During the initial Android tablet phase, other associated costs total less than $1,000 in a typical month. This includes a shared monthly cellular data plan of $160, connection fees of $10 per line for up to 40 tablets, and $35 per line for four staff smart phones. The tablets were provided for free by the cellular provider, U.S. Cellular. WIT acquired headsets for the drivers from another vendor at $20 – 30 per set. The monthly cellular fees represented a significant cost savings over upgrading the two-way radio

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[132] Personal communication with Matt Cleveland, March 2023

[133] Whitaker (2019)

[134] Whitaker (2019)

[135] Whitaker (2019)

[136] Personal communication with Matt Cleveland, March 2023

[137] Personal communication with Matt Cleveland, March 2023

system, which would have cost $3,500 per month and provided less functionality and coverage.[138] Although the transition to iPads entailed taking on new hardware costs, WIT reported the costs of the devices, software, and data were worth the simplification and time saved in billing and reporting to Iowa DOT.[139]

For more information on WIT, visit http://www.region12cog.org/public-transit/.

6.3 Scheduling and Dispatching Deployment and Broadband Expansion in Rural Ohio

In 2015, the Ohio Department of Transportation (ODOT) and project partners were selected to receive $6.8 million for a project called Transit Tech Ohio (T2O) in federal funding to improve rural transportation through the Transportation Investment Generating Economic Recovery (TIGER) VII competitive grant program. The funding supported the state's efforts to work with rural transportation providers for software access and to improve rural broadband. Without connectivity across their service area, transportation providers cannot get the full benefit of software.[140]

Project Purpose

ODOT assessed the transportation services and software of each partner rural transportation agency and the availability of broadband within its service area to assist with developing estimates of the need. Some agencies had scheduling software already, but many did not. Several areas were found to have insufficient broadband access. Most rural transit agencies provide demand response service, but two provide fixed route service.[141]

[138] Whitaker (2019); personal communication with Tom Feldman, March 2020

[139] Personal communication with Matt Cleveland, March 2023

[140] ODOT (nd). Transit Tech Ohio Overview, http://www.dot.state.oh.us/Divisions/Planning/Transit/Pages/Tiger-Grant.aspx

[141] ODOT (2016). Invitation to Bid 142-17: Transit Scheduling and Dispatching Software

DEMAND-RESPONSE SOFTWARE SPECIFICATIONS

The required minimum standards developed by ODOT and the T2O steering committee included data elements that the software application would need to collect about clients and trips, communication ability to update manifests and connect drivers and the base, real-time tracking, hardware requirements for in-vehicle tablets, and reporting. Certain software functionalities were listed as necessary in the specifications, such as auto-scheduling demand-response trips, editing records, and calculating pick-up times and fares. In addition to the software requirements, the standards addressed a minimum amount of initial and annual training to be provided by the vendor, maintenance including software upgrades and technical support.

Source: ODOT ITB 142-17: Transit Scheduling and Dispatching Software

To minimize the burdens on individual rural transportation systems for procuring new technology, ODOT developed a set of minimum standards for hardware such as tablets and GPS, software for scheduling and dispatching, and services such as installation, maintenance, and training. ODOT then issued an invitation to bid (ITB) to select approved vendors who meet those standards as well as federal procurement requirements, from which rural systems could choose to procure services through the project.[142] A similar ITB was developed to select vendors to provide software to support fixed route service.[143]

To maximize the benefit of acquiring new software, ODOT worked with Connect Ohio, a subsidiary of Connected Nation operating as a nonprofit to expand broadband in Ohio.[144] Connect Ohio mapped broadband speeds in the counties served by participating rural transportation agencies. This was achieved by conducting drive tests with a cell phone in a car that was used to test connection speeds on the major cellular networks in the state. The project also identified state- and other publicly owned assets such as water towers or land where wireless broadband towers could be placed. The asset data were overlaid with locations identified through the drive tests as having no signal.[145] This allowed Connect Ohio and ODOT to identify that there were several locations where towers could be placed on public land or facilities to improve broadband access. Connect Ohio and ODOT issued an ITB for wireless broadband service; however, it proved more difficult than anticipated to incentivize private partners to invest in wireless broadband infrastructure in rural areas of Ohio, even with subsidy and the use of public facilities such as water towers to install the wireless infrastructure.[146]

The T2O project has supported transportation providers' licenses to access the software offered by the vendors who met the requirements through the ITB and contracting process for demand response and fixed route. It also supported the agencies' access to mobile routers that provide cellular connectivity to

[142] ODOT (2016). Invitation to Bid 142-17: Transit Scheduling and Dispatching Software

[143] ODOT (2017). Invitation to Bid 405-18: Fixed Route CAD/AVL, Real-Time Passenger Information

[144] Connected Nation (nd). About Connected Nation Ohio, https://connectednation.org/ohio/about

[145] Chuck Dyer (2019). Presentation at the 2019 National Regional Transportation Conference, June 2019

[146] Chuck Dyer (2019). Presentation at the 2019 National Regional Transportation Conference, June 2019

two cellular providers, which the transportation agencies were able to choose based on coverage that had been mapped in their service area.

Outcomes

Some rural transportation providers around Ohio already had been using ITS to support scheduling and dispatching, but the T2O project has opened new opportunities for many agencies. South East Area Transit (SEAT), one of ODOT's rural transit partners in the T2O project, serves Muskingum, Guernsey, and Noble Counties and went live with CTS software, obtained through the T2O project, to support its demand-response service in January 2018. New staff hired in mid-2017 brought in prior knowledge of other software with similar functionality, which was of benefit to the agency in making the transition from older software.

The SEAT Operations Director credited the progress SEAT has made to work in the months leading up to going live with new software, cleaning out old data and determining in advance where the CTS techs could assist with support or customization work.

This analysis led to new operational decisions about where and how to deploy the agency's own vehicles for fixed route and demand response trips, which locations would work better contract out the trips, as well as how to better coordinate trips to maximize efficiency. Once the software was live, SEAT staff relied on trial and error for a few months to set up parameters within the software, being willing to change their approach in order to use the software as fully as possible to improve scheduling, dispatching, communications, data validation, reporting, and other functions.[147]

Together, the changes that SEAT underwent along with adopting CTS have led to significant transportation outcomes. Prior to using the new software, SEAT was scheduling 2,300 trips per month. By December 2019, SEAT scheduled 9,300 trips per month, more than a 400 percent increase in two years. Over the same period, SEAT's passenger per hour rate increased from 1.6 to 5.3, and the operational cost per passenger decreased by $2 per passenger. Previously, most calls for demand-response trips came in 72 hours in advance, but now SEAT can accommodate same-day requests. No-shows for trips have decreased from 17 percent to 2 to 3 percent.[148]

SEAT shared its successes with other agencies, having conducted outreach and trainings to about two dozen other rural transportation agencies to share lessons learned such as analyzing business operations in order to determine priorities for using new software, and using block scheduling rather than open scheduling.[149]

The then Tuscarawas County Mobility Manager identified several promising outcomes from launching CTS with Horizons Rural Public Transit, including wayfinding and customer service. In a community where some lack mailboxes or live on roads with minimal signage, GPS proved welcome, as did up-to-date information provided on demand and prior to pick up. Being able to use farecards that the drivers can scan also simplified the need to have exact cash for certain riders using transit for employment, education, or other institutions.[150]

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[147] Personal communication with Howard Stewart and Andrea Dupler, January 2020

[148] Personal communication with Howard Stewart and Andrea Dupler, January 2020

[149] Personal communication with Howard Stewart and Andrea Dupler, January 2020

[150] Personal communication with Shannon Hursey, December 2019

Multiple parties involved identified a lesson learned for other rural regions considering a similar transition of identifying training opportunities to better align software capabilities with transit operations. The agencies all received training in how to use the software but felt training provided by individuals with transit operations experience could have helped to optimize their use of CTS early on. Initially, some drivers did not find the system intuitive for tracking trips, so data validation became a large task until everyone became comfortable with the new processes.[151]

Rural transportation agencies have had varying degrees of success with using the auto-scheduling function of the software. SEAT has seen major efficiency gains from using auto-scheduling, particularly with rides provided on the agency's buses, which carry more passengers than many of their vendors' vehicles and are used most heavily in Zanesville, Ohio, a city of 25,000 that serves as a regional hub.[152] In contrast, Horizons Rural Public Transit has not used the auto-scheduling feature as extensively. Its operations see many clients needing non-emergency medical transportation to destinations outside of Tuscarawas County. With a small fleet, it has been more difficult for the auto-scheduler to handle from an operations perspective to manage the number of vehicles on longer trips at the same time and the number of miles traveled.[153] As of May 2023, Access Tusc is the public transit provider for Tuscawaras County.[154]

Ohio continues to prioritize broadband expansion through ODOT's work, and a state broadband strategy adopted in 2019, but there are still gaps in coverage. These gaps in coverage cause hiccups in the agencies' use of new technology, but the vehicles' tablets do catch up when signal is restored.[155]

Despite these challenges, opportunities to increase mobility are continuing to grow. SEAT staff outreach to area medical offices has encouraged many to also begin using CTS to schedule their patients' transportation, a major change from an earlier survey where health partners indicated a lack of knowledge about transportation options. With a new focus on mobility as part of the medical offices' business model, one facility has even purchased four vehicles and plans to partner with SEAT to deploy them, and other medical offices have begun to pay for clients' trips if they are not eligible for other funding support.[156]

Mobility managers across Ohio have seen their partners become much more open to possibilities to improve transportation outcomes. Not all of the changes are tied to accessing new software, but accessing ITS solutions have been part of the change.[157] Tuscarawas County, the three counties served by SEAT, and several other neighboring counties are all part of a regional coordinated transportation planning pilot program conducted by the area's RDO, Ohio Mid-Eastern Governments Association (OMEGA), funded by ODOT.[158] ODOT's support of this and other related mobility pilot projects such as a regional call center pilot project partnership between SEAT and Tuscarawas County Mobility Management

[151] Personal communication with Shannon Hursey, December 2019, and Howard Stewart and Andrea Dupler, January 2020

[152] Personal communication with Howard Stewart and Andrea Dupler, January 2020

[153] Personal communication with Shannon Hursey, December 2019

[154] Personal communication with Howard Stewart, Jr., May 2023

[155] Personal communication with Shannon Hursey, December 2019

[156] Personal communication with Howard Stewart and Andrea Dupler, January 2020

[157] Personal communication with Shannon Hursey, December 2019

[158] Personal communication with Sean Sammon and Kevin Buettner, March 2019

Program and other rural efforts enhances transportation providers capacity to learn from peers and innovate. At the state level, efforts are underway to harmonize requirements across state agencies and simplify the process of providing transportation.[159]

Resources

ODOT and its partners received $6,839,860 in federal funds to support the project and used $466,000 of state funds. Local match of $34,000 statewide included a $1,000 paid by each rural transportation agency to access the software.[160] The grant funds and state match provided the remaining support for software licenses, hardware installation, data subscriptions for mobile routers on the vehicles, and other expenses related to procuring the software and accessing broadband. Where trips have increased, many of the additional trips are eligible for non-emergency medical transportation (NEMT) funding through Medicaid or other public and private sources, which supports operational costs. Ongoing efforts are being made by state and local governments, as well as their RDO partners, to secure additional capital funding for rural broadband from multiple sources.[161]

6.4 Software Supports Volunteer Transportation

Volunteer transportation management is fundamentally different from managing volunteers who are contractors or employees, says a representative of the Volunteer Transportation Center Inc. (VTC).[162] VTC provides essential mobility services in Northern New York and in New Hampshire using only volunteers, seen assisting a rider in Figure 15. VTC is a nonprofit leader in its coverage area, breaking down transportation barriers for the most vulnerable populations, having completed 5.7 million miles driven on over 158,000 one-way trips in 2018. A staff of 29 individuals manage a mission-driven volunteer team of over 350. VTC provides two categories of transportation, (1) contracted trips that are arranged and reimbursed by an agency or insurer (Fidelis, Nascentia, Medicaid, and others), and (2) trips funded by the donations of the local communities the volunteers serve. Volunteers use their own vehicles and receive reimbursement for miles traveled.[163]

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[159] Personal communication with Shannon Hursey, December 2019

[160] ODOT (nd). Transit Tech Ohio Overview, http://www.dot.state.oh.us/Divisions/Planning/Transit/Pages/Tiger-Grant.aspx

[161] Chuck Dyer (2019). Presentation at the 2019 National Regional Transportation Conference, June 2019

[162] Personal communication with Sam Purington, September 2019

[163] Sam Purington (2019). Volunteer Transportation Center, Inc., presentation given at On the Road to Prosperity Virtual Peer Exchange #5: How Transportation Technologies Are Meeting Mobility and Economic Development Needs in Rural America

Source: Volunteer Transportation Center, 2019

Figure 15. A VTC volunteer assists a rider from the vehicle to the door of their destination

Project Purpose

Off-the-shelf software exists for tracking rides, but it does not account for the human interaction and social capital needed for volunteer management. Without a readymade software solution, VTC brought two developers on board in 2017 to create software built for volunteer centric transportation options.[164] The software tracks origins, destinations, and times for the trips, along with volunteer availability and assistive route design to coordinate trips and maximize efficiency. The software also records the funding source for each trip. Important for VTC's mobility model, the software also includes volunteer credentialing controls (such as tracking background checks and vehicle inspections, vehicle registration, completed orientation, signed handbook, and any training that the volunteer needs to complete). For example, VTC's trips include transporting children in foster care, so volunteers that transport children must attend training on installing and using car seats among other classes. In addition to tracking information about trips and

[164] Purington (2019)

volunteers, the software also alerts clients when their ride is approaching. Alerts can be delivered by text or email to clients themselves or others who book transportation for clients, such as a case manager at an assisted living facility.[165]

As of mid-2019, 240 volunteers are using the new software application, which may grow as funding allows and as volunteers become more comfortable shifting away from using paper records. VTC has issued tablets to most of these volunteers, but volunteers who have a smartphone and an adequate data plan (typical usage is 500 mb per month) can add the app to their own personal device.[166]

Usability was central to the software development project from the start. VTC hired two individuals as developers who already had some transportation experience. They used site visits and phone calls to learn the requirements, terminology, and business practices of providing volunteer transportation in rural areas in order to build an application that addressed compliance and privacy, tracked the right indicators, and maintained human interaction with the volunteers rather than automating all the dispatching functions.[167]

Volunteers not only provide rides but are also critical data collectors, responsible for tracking the rides they provide to clients. The average age of the VTC volunteer pool is about 60, with some individuals who are eager technology adopters and many who are less comfortable with new technologies. VTC reached out to the volunteers least interested in transitioning away from paper records to guide the development of the app. This focus on user experience has been successful; engaging volunteers who might otherwise be reluctant to change helped to ensure that they would have a user-friendly interface to report information about their rides and receive reimbursement. In fact, VTC staff report, volunteers who have switched to digital never want to go back to paper.[168]

In addition to the software's ability to simplify information management about trips and volunteers, VTC is testing additional functionalities that will be deployed over time. For example, a feature being tested in 2019 would use algorithms to automate volunteer assignment, matching up volunteer location with the trip location, as well as the type of vehicle needed (such as wheelchair accessible) and the days and hours of the week that a volunteer is available. Assistive route design is a software feature, with the option to fully automate volunteer assignment once that feature is rolled out. This is expected to help with trip coordination, but it would not replace the work of VTC's dispatch staff in connecting with volunteers by phone; having the app allows the agency to balance managing volunteer assignments, which can be done automatically through the app, with managing volunteer relationships, which requires personal communication between staff and volunteers. Once the person has accepted a request from a dispatcher to provide a ride, they can receive trip information through the app.[169]

Outcomes

The new software is already improving some metrics and is expected to help improve others as it becomes more fully implemented. With the features in use so far, volunteers are reporting that the app is easy to use and simplifies their recordkeeping role. For VTC staff, the app streamlines data tracking and

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[165] Personal communication with Sam Purington, September 2019

[166] Personal communication with Sam Purington, September 2019

[167] Personal communication with Sam Purington, September 2019

[168] Personal communication with Sam Purington, September 2019

[169] Personal communication with Sam Purington, September 2019

compliance. Over time, VTC will track additional metrics using the software regarding efficiency and effectiveness. These include deadhead miles driven without a client on board (volunteers are reimbursed for mileage to and from their home), missed appointments, and near misses when a client barely arrives in time to keep their appointments.[170]

VTC conducts outreach to other regions and organizations looking to create a volunteer transportation program. The "VTC in a Box" program provides tools for running a volunteer transportation program; guidance during development and implementation; training for program staff, transportation coordinators, and volunteers; as well as access to its proprietary software.[171] "VTC in a Box" has been provided to other areas of New York and other locations where there is interest in improving mobility through volunteer transportation. VTC is also working with the non-profit MOVE in Stanislaus County, California, to develop a volunteer program in the rural Central Valley area of the state. Once it is implemented, the volunteer program will be brought into a mobility app that integrates public transportation, volunteer transportation, and other available services to allow clients to request rides. The app is being developed by professionals at the University of California-Davis.[172]

Resources

Beginning several years prior to software development, Purington says that VTC negotiated a higher rate for its transportation contracts, working with funders to explain that transitioning to digital recordkeeping would require effort and expense. VTC was able to build up enough of a fund balance to support the development, testing, and deployment of the app.[173] Having developers on the VTC team will not be a long-term situation. Although new functionality and support over time will be needed, the developers will spin out the software as a social enterprise after it is deployed more fully by VTC. That way, the social enterprise can provide the software to other volunteer transportation programs at a low per-ride fee. This future process will enable nonprofits and other organizations with minimal budgets for transportation to access the app without large upfront investments in purchasing a license or an expensive subscription model. VTC can continue to focus on its mission of providing mobility and avoid having developers on staff permanently, without spending time marketing or supporting other organizations' use of the software.[174]

Training for volunteers and administrative staff can be incorporated into orientation procedures without much additional time investment. Case managers or others booking rides can access a user-friendly website to book trips with minimal training needed. Riders receive email or text communications about their rides via the app. There is no current need for riders to interface directly with the app itself, although that may change in the future.[175]

The tablets issued to volunteers cost about $100 to acquire, including needed accessories such as a protective case, charger, and all associated cords. In addition, VTC pays about $12 per month for each

[170] Personal communication with Sam Purington, September 2019

[171] Purington (2019)

[172] Personal communication with Sam Purington, September 2019

[173] Personal communication with Sam Purington, September 2019

[174] Personal communication with Sam Purington, September 2019

[175] Personal communication with Sam Purington, September 2019

tablet to have a cellular data plan. Some volunteers use their own smart phone and have an adequate data plan, increasing the number of volunteers using the app without additional cost to VTC.[176]

For more information on the VTC, visit https://volunteertransportationcenter.org.

[176] Personal communication with Sam Purington, September 2019

7 Preparing for Vehicle Connectivity and Automated Vehicles Case Studies

Vehicle connectivity and automated vehicles are emerging issues for rural and small metro areas. Improvements in technology might lead to improved safety or other travel outcomes for transportation in rural and small metro regions. Chapter 7 includes case studies where vehicle connectivity or automated vehicles are undergoing testing and demonstration for suitability in smaller places.

7.1 AV Demonstrations in Small Town Minnesota

Rapid advancements in transportation technologies such as AVs present a major challenge and unprecedented opportunity to enhance safety and mobility. Beyond mitigation of congestion, injury, or death caused by human error, AVs offer restored mobility to those limited by age and/or disability. Lacking the ability to drive or access to a vehicle can severely harm economic and social opportunities, and that harm will become more widespread as America's population ages.[177] Reduced mobility of this sort is predominantly concentrated in rural communities, which account for a large and growing share of the aging population and often require lengthier commutes to reach both essential and community services.[178]

Project Purpose

Recognizing the potential of AVs to assist mobility-limited community members, a research team from the University of Minnesota's Roadway Safety Institute approached a few communities in Minnesota to conduct an AV demonstration. Conducting a demonstration requires presenting a demonstration plan in accordance with local laws, making note of potential hazards, the proposed vehicle, route scheduling and logistics, and cost. Sponsored by U.S. DOT, the research team approached communities not to introduce the shuttles directly, but to explain the potential benefits and offer their expertise and support in facilitating the process for those interested. They ultimately were successful in entering agreements with Fergus Falls (pop ~14,000) and White Bear Lake (pop ~24,000). The proposed routes were 1.8 and 1.5 miles respectively, avoiding left turns and (with one exception in White Bear Lake) signalized intersections. Proposed alternate destinations and routes were adopted following community input.[179] The Fergus Falls proposed route is seen in Figure 16.

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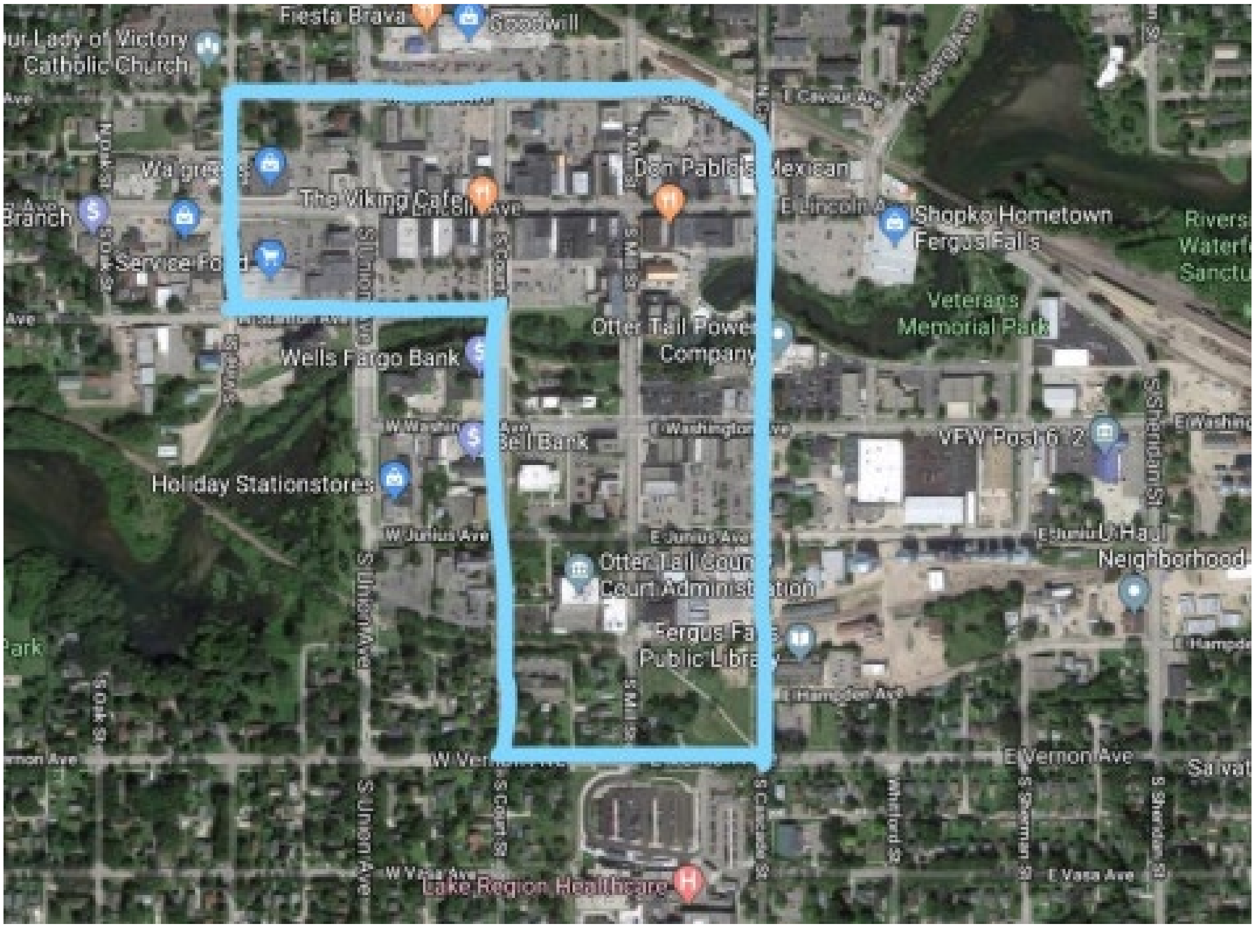
[177] Vespa, J. (2018). "The Graying of America: More Older Adults Than Kids by 2035." United States Census Bureau, https://www.census.gov/library/stories/2018/03/graying-america.html

[178] Oberdorfer, E. & Wiley, K. (2014). "Housing an Aging Rural America: Rural Seniors and Their Homes." Housing Assistance Council, https://ruralhome.org/wp-content/uploads/storage/documents/publications/rrreports/ruralseniors2014.pdf

[179] Douma, F. & Petersen, E. (2019). "Scenarios and Justification for Automated Vehicle Demonstration in Rural Minnesota." University of Minnesota Center for Transportation Studies,



Source: University of Minnesota Center for Transportation Studies, 2019

Figure 16. The proposed AV route in Fergus Falls following community input. Such routes can visit residences, community centers, public libraries, supermarkets, and other locations

Outcomes

The most significant lesson from collaborating with the two communities was the importance of engaging and involving local stakeholders. In Fergus Falls, the research team found an ally in City Engineer Brian Yavarow, who facilitated a first meeting with the City Council and served as liaison. Yavarow's involvement was critical to the team having quick and informed feedback on their ideas, but working exclusively with city staff kept the project within its academic boundaries.[180] The outcome in White Bear Lake, by contrast, showed the momentum that can build from a broader coalition of stakeholders. A member of the local Chamber of Commerce (now retired) championed the project to several other community leaders, raising interest and awareness that proved critical in bringing in outside support. This saw a growing role for a community-based transit manager, a review of liability insurance and other potential requirements by a local consulting firm, and additional funding through a MnDOT grant

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https://www.cts.umn.edu/publications/report/scenarios-and-justification-for-automated-vehicle-demonstration-in-rural-minnesota

[180] Personal communication with Frank Douma, June 2022

program.[181] Winning over community firms and leaders and allowing them to win over each other activated pre-existing networks, turning White Bear Lake into a model for early AV action.

The proposed route has evolved into Bear Tracks, a free, “low speed (10-12 mph), self-driving, electric, multi-passenger shuttle” for up to ten passengers at a time, pictured in Figure 17.[182] The shuttle’s onboard safety attendant is trained to address vehicular and passenger emergencies. The shuttle’s sensors will gather data to fill gaps in information and inform future usage of AV technology in other communities.[183]

Source: Bear Tracks, 2022

Figure 17. The Bear Tracks self-driving shuttle in operation

There is an informative comparison of the results in Fergus Falls, where the initiative ended with the conclusion of the study, and in White Bear Lake, where the study helped plant the seed for the current shuttle demonstration. Community engagement and enthusiasm are powerful assets in introducing an AV shuttle route, and likely with any public-facing use of driverless vehicle technology. Public trust in new technology is built on common understanding and familiarity, and AVs are largely unfamiliar. Polling from the AARP suggested 79% of baby boomers were afraid to ride in an AV in 2018, with 71% considering it unsafe to share the road with one.[184] Yet the shuttles used in demonstrations are often slow-moving and

[181] Personal communication with Frank Douma, June 2022

[182] "Hop On Board MnDOT’s Destination CAV White Bear Lake Self-Driving Shuttle!" https://beartrackswbl.org

[183] Bartkey, J. (2022). "MnDOT launches Bear Tracks automated shuttle project in White Bear Lake." Minnesota Department of Transportation, https://www.dot.state.mn.us/news/2022/08/05-statewide-launches-bear-tracks.html

[184] Kiger, P. (2018). "Boomers Think Autonomous Vehicles Are Unsafe." AARP, https://www.aarp.org/auto/driver-safety/info-2018/self-driving-vehicles-unsafe.html

built for caution that is beyond that of human drivers.[185] Because of their existing networks and ties, community leaders and stakeholders become essential allies in communicating the safety data collected from previous demonstrations and the potential benefits with the public. The UMN research team looked to existing AV demonstration plans and laws as of June 2019 to create a series of questions, demonstrating to interested communities both a judicious concern for safety and the steps required to create a plan best tailored to their specific needs.[186]

In any community, it will be essential to develop a plan acceptable to local law and with complete information about potential hindrances posed by adverse weather or unclearly marked roadways. The community has multiple options to acquire the shuttle, able to purchase one outright, contract a transit management provider, or lease a vehicle while managing its operations—with each option requiring access to vehicle charging infrastructure and the presence of one or more on-board safety operators prepared to manually assume control in response to a vehicular or passenger emergency.

For more information, the Roadway Safety Institute's website can be found at http://www.roadwaysafety.umn.edu. Additional information on the Bear Tracks shuttle and contact information for involved parties can be found at https://beartrackswbl.org.

7.2 Bringing Automated Driving Systems to Rural Roadways

"While 19% of Americans live in rural areas, nearly 50% of traffic fatalities occur on rural roads." This quote, from a September 2022 report from the Governors Highway Safety Association,[187] is found on the homepage of the Automated Driving Systems (ADS) for Rural America website. Traffic safety is an ongoing policy discussion, with NHTSA estimates pointing to an excess of 31,000 deaths in crashes during the first 9 months of 2022—and the largest increases relative to 2021 on rural interstates.[188] Automated vehicle (AV) technology is in its early stages, but its future lifesaving and life-improving potential could be considerable, particularly for rural residents who are often farther from needed facilities and may be mobility limited by health or resources.[189]

The factors which increase the danger of rural driving—unpaved or unclearly marked roads, sharp turns or limited visibility, and obstructions by animal crossings or weather—are those least present in training data largely gathered in urban areas. The need for training data on rural roadways gave ADS for Rural America its purpose. The U.S. DOT-funded project is run by a team at the University of Iowa's Driving Safety Research Institute, who have previous experience collaborating with the Iowa DOT. Their

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[185] Beene, R. (2017). "Robot Vehicles Are Overly Cautious Drivers." Government Technology, https://www.govtech.com/transportation/robot-vehicles-are-overly-cautious-drivers.html

[186] Douma, F. & Petersen, E. (2019). "Scenarios and Justification for Automated Vehicle Demonstration in Rural Minnesota." University of Minnesota Center for Transportation Studies, https://www.cts.umn.edu/publications/report/scenarios-and-justification-for-automated-vehicle-demonstration-in-rural-minnesota

[187] Raymond, P. (2022). "America's Rural Roads: Beautiful and Deadly." Governors Highway Safety Association, https://www.ghsa.org/resources/GHSA/Rural-Road-Safety22

[188] National Highway Traffic Safety Administration. (2023). "NHTSA Estimates for First Nine Months of 2022 Suggest Roadway Fatalities Beginning to Level Off After Two Years of Dramatic Increases." https://www.nhtsa.gov/press-releases/nhtsa-estimates-traffic-deaths-2022-third-quarter

[189] National Highway Traffic Safety Administration. (2023). "Automated Vehicles for Safety." https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety

wheelchair accessible Ford Transit shuttle bus, seen in Figure 18, is outfitted with eight different types of sensors, cameras, and scanners provided by tech partners. This AV follows a 47-mile predetermined route with a safety driver capable of instantly taking control when needed, as well as a co-pilot. Informed volunteers of sufficient age or with disabilities have been recruited to ride along.[190]

Source: University of Iowa, 2021

Figure 18. The ADS for Rural America automated shuttle on a gravel road within the project route

Project Purpose

If AVs are to collect the data needed to improve their rural performance, projects like ADS for Rural America require both resources to outfit vehicles with sensory equipment and community acceptance to enable. The shuttle is operated on public roadways with traffic around it—a necessity to gather data on various road types and in real-world traffic conditions—and any safety incident could see community members protest its presence. Safety and transparency have been made cornerstones of the project, with a comprehensive safety plan made available to government partners and interested parties on request. Safety and operational information have similarly been shared with similar out-of-state projects, such as the Ohio DOT's DriveOhio.[191]

The project's data portal reports a total of 3,027 miles driven, of which 2,459 (81%) were automated. These drives have included 108 ride-along passengers and sensor detection of over 860,000 obstacles.[192] The most notable lesson learned from this testing has been the vulnerability of highly interconnected systems, where a system might continue to operate when another system essential to its

[190] ADS for Rural America: How it works. https://adsforruralamerica.uiowa.edu

[191] Personal communication with Omar Ahmad, Cher Carney, and Kristine Roggentien, August 2022

[192] AutonomouStuff Ford Transit Platform. https://autonomoustuff.com/platform/ford-transit

proper functioning has failed. A specific incident described involved the formation of ice on the LiDAR sensor while driving in freezing rain, causing the systems to erroneously report no traffic around it.[193] The potential for hardware or software to malfunction, possibly without prompt warning, warrants an on-site team trained in troubleshooting. The presence of the safety drivers and a comprehensive approach to training and safety are central, with the ADS for Rural America team issuing a warning to consider the technology's potential and the potential to overestimate its present sophistication.

Outcomes

There are a number of AV systems available for research and development platforms, with ADS for Rural America having selected based on its needs, resources, and safety concerns.[194] The vehicle's Platform Actuation and Control Module (PACMod) 3.0 System is designed to resume manual control with a single step, as easily as ending cruise control, with an auditory alert communicating PACMod failure. Its sensory equipment as used by ADS for Rural America includes GPS and DSRC antennae, a traffic light camera, LiDAR, webcam, collision avoidance, a transmitter for road data and weather, and a long-range radar to detect objects front and rear.[195] Long-range radar and other sensors are visible in Figure 19. A fully equipped AV shuttle represents an investment for a community, research team, or organization, highlighting the importance of collaboration and pursuing grants or other funding opportunities. The ADS for Rural America team shares its own safety plan, but any organization conducting AV testing should consider its unique needs and ensure its ever-present team is trained in system troubleshooting and safely assuming control as needed.

[193] Personal communication with Omar Ahmad, Cher Carney, and Kristine Roggentien, August 2022

[194] AutonomouStuff Ford Transit Platform. https://autonomoustuff.com/platform/ford-transit

[195] Personal communication with Omar Ahmad, Cher Carney, and Kristine Roggentien, August 2022

Source: University of Iowa, 2021

Figure 19. The ADS for Rural America automated shuttle over light snow, with the long-range radar visible

Presently, the most rapid advancements are occurring on the individual sensor level, with each breakthrough allowing LiDAR to do more at less cost.[196] This will simplify future rural testing, but only the collection of additional data will allow technologies to communicate with each other and account for roadway-specific variances. AV technologies are built around global standards, and a sensor that can detect snow may not yet know to change its behavior as a driving human would. Communities interested in conducting rural testing should keep abreast of changing sensor efficacy and recognize the urgent need for investment in training.

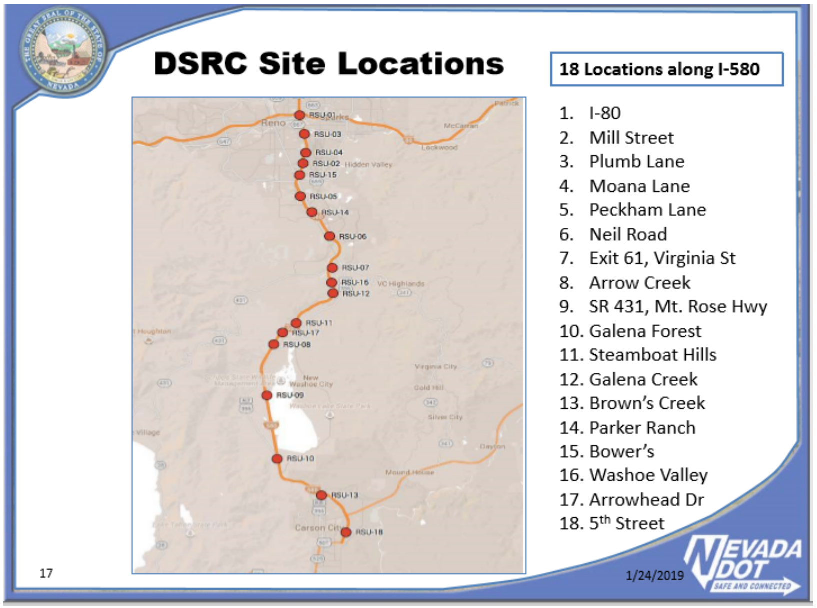
More information can be found at the project's website, https://adsforruralamerica.uiowa.edu.

7.3 Using Vehicle Connectivity Technology for Roadway Weather Response

To improve safety, roadway conditions, and motorist advisory warning information during winter weather, the Nevada DOT recently launched a pilot to test dedicated short-range communications (DSRC) to improve the collection of weather condition data from snowplow vehicle and roadside units along the I-580 corridor between Reno and Carson City, shown in Figure 20. The pilot is the third in a series of Integrated Mobile Observations (IMO) projects that Nevada DOT first launched in 2011. According to the FHWA, the IMO applications "promote the collection of mobile, weather, road, and vehicle data from

[196] Personal communication with Omar Ahmad, Cher Carney, and Kristine Roggentien, August 2022

agency fleets to improve situational awareness of road conditions."[197] The application builds on a foundation Nevada DOT set with using Enhanced Digital Access Communications System radio for communication and cellular connectivity capabilities.



Source: Nevada DOT, 2019

Figure 20. A map of the I-580 corridor indicates the locations of Nevada DOT's Dedicated Short-Range Communications Systems roadside units

Project Purpose

In the Phase III snowplow connectivity project, roadside units, cellular signals, and on-board instruments are used by nine snowplow vehicles and one service patrol vehicle to provide real-time road and atmospheric condition data that will assist Nevada DOT's Enhanced Maintenance Decision Support System (EMDSS) for roadway treatment. In addition to Nevada DOT's internal use of the data, the information is used to inform the state's 511 system and other traveler information software.

The flow of communication between the sensor equipment mounted in Nevada DOT's vehicles and Nevada's data exchange is illustrated in the graphic below. How does the information flow from the vehicle-mounted units to the state's server and data exchange? As a first step, roadway and atmospheric weather conditions are read by sensor equipment in the vehicles. The sensor records the date, time, location, speed, altitude, air temperature, barometric pressure, humidity, dew point, road temperature, wiper status, and spread rate of treatment material. In the second step, the conditions report is relayed using cellular or roadside units that communicate with a central server.

Once the data is received by the Nevada IMO server, the server exports a CSV file. Data in the CSV file is then sorted through the Nevada Data Exchange where the information is shared with weather and road

[197] Pisano, P. (2019). Are Your Roads Weather Savvy? FHWA Research and Technology, https://www.fhwa.dot.gov/publications/publicroads/19spring/03.cfm

condition providers (e.g., Nevada 511, Waze). The data generated is also used by Nevada DOT for dynamic message signs, highway advisory radio messages, and the EMDSS.

The on-board vehicle sensors update conditions data every eight seconds. There are 18 DSRC systems locations along Nevada's I-580 corridor between the I-80 interchange in Reno to 5th Street in Carson City, indicated in the map below. DSRC is used along I-580 and cellular coverage is used between the I-580 corridor and Lake Tahoe. DSRC has an effective range of 300 meters (less than one-quarter mile) at highway speeds, which can lead to longer caching times and delays in information exchange. In areas where DSRC, Wi-Fi, and cellular are not available, data is stored on the vehicle until communications are reestablished.[198]

Nevada's Integrated Mobile Operations system meets the standards of the National Transportation Communications for Intelligent Transportation Systems Protocol (NTCIP), Society of Automobile Engineers (SAE), and the National Marine Electronics Association (NMEA)—all incorporated through the Institute of Transportation Engineers (ITE) utilizing the Traffic Management Data Dictionary (TMDD). This TMDD data standard provides rules for communicating and vocabulary needed to permit electronic traffic control equipment from different manufacturers to operate with each other.

Outcomes

Even though the primary purpose of the snowplow data collection is to inform the state's operations and maintenance practices, other users who benefit from the data are cities and counties, Nevada DOT's 511 system, the www.nvroads.com website, the Nevada Highway Patrol, and WAZE. This IMO project has been integrated with the National Center for Atmospheric Research and FHWA's Weather Data Environment.

Nevada DOT staff stated that the technology has helped to standardize how operations staff are trained for weather-related road treatment—important in an environment where staff turnover requires training for new employees.[199]

Resources

Stakeholders involved in the technology applications and development include the University of Nevada-Reno, University of Nevada-Las Vegas, University of California-Davis, and the Desert Research Institute. The cost of implementing the Phase III snowplow sensor project was over $4,000 for each vehicle. The initial roadside equipment (i.e., radio and GPS/weather sensor) cost over $5,500 but was paid for during earlier phases of the Nevada project. In addition to one-time capital costs, the project has recurring data plan costs of $15 – $35 per month per vehicle. Additional information about costs and lessons learned are

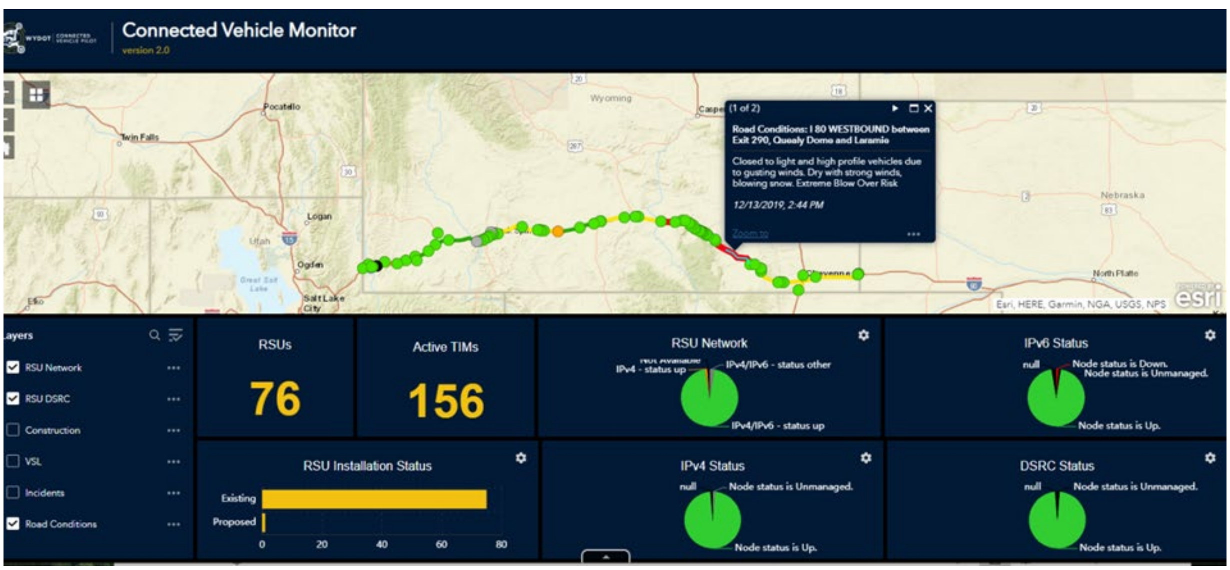
[198] FHWA (nd). Weather-Savvy Roads - Leveraging Multiple Communications Systems for Vehicle-Based Data Sharing: Nevada Department of Transportation Case Study, https://ops.fhwa.dot.gov/publications/fhwahop18030/fhwahop18030.pdf

[199] Nevada DOT (2019). Presentation at 2019 NADO Annual Training Conference

available in the Nevada DOT's Integrated Mobile Observations 3 Final Project Report prepared for the U.S. DOT.[200]

7.4 Partnerships Support Rural Technology Deployment Along Wyoming's I-80 Corridor

The Wyoming DOT was one of three agencies that was selected in 2015 by the U.S. DOT to pilot vehicle connectivity technologies. The two other agencies selected for pilots are the New York City DOT and the Tampa-Hillsborough Expressway Authority (THEA). Wyoming DOT is using connected vehicle technologies to improve safety along the I-80 corridor, which runs east-west through the southern portion of the state between Evanston and Pine Bluffs. Drivers who travel along that 402-mile segment of I-80 experience high winds throughout the year, and white-out conditions are possible during snowstorms. The state's Connected Vehicle Pilot (CVP) addresses weather and traffic through communication of messages and warnings signaled from roadside sensor units and onboard vehicle units. Both Wyoming DOT service vehicles and commercial carrier fleets are hosting onboard units as part of the pilot. Wyoming's CVP is considered critical to improve travel safety and reduce road closures due to vehicle collisions or blow overs. According to a U.S. DOT fact sheet on the CVP Deployment program, there were 1,237 reported blow overs from 2006 to 2016, and from October 2015 to September 2016, there were more than 1,600 crashes on I-80 resulting in 18 fatalities and 271 injuries. It is calculated that for the 2015–2016 period, the affected segments of I-80 were closed for over 1,500 hours.[201] Wyoming DOT's Connected Vehicle Monitor is seen in Figure 21.



Source: Wyoming DOT, 2020

Figure 21. Wyoming DOT's Connected Vehicle Monitor

[200] U.S. DOT (2018). Nevada DOT's Integrated Mobile Observations 3 Project Final Report, https://collaboration.fhwa.dot.gov/dot/fhwa/RWMX/Documents/Nevada%20DOT%20IMO%203%20Final%20Report.pdf

[201] U.S. DOT, ITS Joint Program Office. (nd) Wyoming Connected Vehicle Pilot Deployment Program, https://www.its.dot.gov/factsheets/pdf/WyomingCVPilot_Factsheet.pdf

Project Purpose

Due to limited alternate routes, I-80 truck volumes can reach 50 to 70 percent of overall traffic during seasonal travel peaks.[202] As noted, the primary purpose of the CVP is to improve travel safety and reliability and reduce crashes and delays by improving road weather information, alerting drivers to emergency situations, and providing up-to-date information about travel speeds, detours, and truck parking availability. Vehicle-to-vehicle and vehicle-to-infrastructure interconnectivity is reliant on DSRC between the 75 roadside units and 400 vehicles with on-board units. The use of short-range communication and vehicle units will enable faster information sharing in conditions when there is not enough time for road and condition messages to be relayed from Wyoming DOT's Transportation Management Center.

Interconnectivity extends beyond the technology itself. Partnerships within Wyoming DOT divisions and with external partners from the public and private sectors are driving the CVP project forward.

The CVP's systems engineering phase was completed in 2016. Design, build, and deployment testing took place between 2016 and 2019 with maintenance and operation of the pilot occurring after fall 2019. The second phase of design and deployment involved working with the Wyoming Trucking Association, third-party intermediaries, and commercial fleet partners who sign a memorandum of understanding with Wyoming DOT to participate and test the connected vehicle technology. Participating trucking fleets vary in size from small to medium regional operations (e.g., Dooley Oil, Inc.) to national fleet operators (e.g., Crete). Participants agree to have their truck cabs equipped with on-board units so that drivers and/or the units receive and relay data through one of the five onboard applications.[203] The five applications are: distress notification, forward collision warning, situational awareness (e.g., speed restriction, parking availability), spot weather impact warning, and work zone warning.

Truck fleets that participate in the pilot are expected to drive the Wyoming stretch of I-80 about three or more times per week and to continue with the pilot for a 12-month evaluation period. On-board units are purchased by Wyoming DOT and funded through the U.S. DOT. Fleet partners must agree to install on-board equipment using their own contractors with guidance from the Wyoming pilot team. Pilot fleets do not need to return the equipment. Drivers are expected to participate in periodic project surveys.[204]

As part of the partnership with commercial fleets, the University of Wyoming is providing truck simulator and online training for fleet operators. Training is required to ensure that drivers are informed about the system and its capabilities. The driver training consists of several modules that can be completed in a single training at the university's facilities in Laramie or on a computer at any location.[205]

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[202] State of Wyoming, Wyoming DOT (2017). WYDOT Connected Vehicle Pilot project website, https://wydotcvp.wyoroad.info/index.html

[203] Phoenix Contact USA. Connected Vehicle Pilot Deployment Overview – Deepak Gopalakrishna. (2018). https://youtu.be/9ScWtawAbJc

[204] Personal communication with Vince Garcia, November 2019

[205] Personal communication with Vince Garcia, November 2019

Outcomes

Real-time status of roadside units and road conditions along I-80 in Wyoming is visible on the Connected Vehicle Monitor. As depicted in a screenshot of the monitor taken on December 13, 2019, 76 roadside units are in place and 156 Traveler Information Messages (TIMs) were being shared at that moment. Segment colors indicate the quality of driving conditions and whether the road section is closed. Details identify exact conditions. An example message is “Closed to light and high-profile vehicles due to gusting winds. Dry with strong winds, blowing snow. Extreme Blow Over Risk.” Winter 2019 through 2020 will be an opportunity for Wyoming DOT, I-80 travelers, pilot participants, and partners such as the Wyoming Trucking Association to determine how traveler information is being accessed and the extent to which drivers are making travel decisions sooner than in prior years.

Resources

The U.S. DOT awarded more than $45 million in funding for the three CV Pilots Sites.[206] Wyoming DOT documented plan for each phase of the project from conception to implementation, including plans for stakeholder outreach, partnerships (i.e., fleet partners, training agreements with the University of Wyoming), and project evaluation. The content and format of these plans can be used as models for other rural ITS projects, no matter their size. Plans can be scaled to match small, localized technology partnerships and local memoranda of understanding or can be expanded for regional deployments. A downloadable list of technical assistance documents and project plans is available at https://www.its.dot.gov/pilots/technical_assistance_events.htm#t2.

7.5 Testing Vehicle and Infrastructure Connectivity in Marysville, Ohio

Union County, Ohio (population of 52,300 in 2010), and its county seat, the City of Marysville (population of 22,094) are testing vehicle and infrastructure connectivity in real-world conditions.[207] Along the U.S. 33 corridor, this area and neighboring counties are home to automotive manufacturers and research and development entities, making the area ready for innovation. At the initial publishing of this report in September 2020, the local jurisdictions were collaborating with Drive Ohio, the state’s multi-agency partnership to advance smart mobility, Honda, and other partners. The goal of this work was to deploy roadside dedicated short-range communication (DSRC), on-board units in vehicles, and other technologies through connected intersections within the City of Marysville and along the U.S. 33 corridor, which connects Marysville to destinations such as Columbus to the southeast and to the Transportation Research Center in East Liberty to the northwest.[208]

Project Purpose

The efforts occurring within Marysville, Ohio, and along the U.S. 33 corridor in Union County are interrelated but each have a distinct approach.

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[206] U.S. DOT (nd). Connected Vehicle Deployment Program: Wyoming, https://wydotcvp.wyoroad.info/assets/promotion/WyomingCVPilot_Factsheet_v2_020817.pdf

[207] Census 2010, http://data.census.gov

[208] Union County-Marysville Economic Development/CIC (2020), https://www.33smartcorridor.com/

Connected Marysville

The City of Marysville, Ohio, launched Connected Marysville, a project that equipped all 27 traffic signals with DSRC to enable communication between the signals and more than 500 planned connected vehicles in the community. This allowed the city to serve as a rural, smart mobility test site and provided automotive companies, government agencies, and academia an opportunity to develop and test connected vehicle technologies in a real-world environment.[209]

At the first intersection to receive cameras and DSRC to support connectivity (shown in the Figure 22), downtown buildings at each corner of the intersection block the driver's view, reducing their opportunity to react safely to another vehicle running the red light, an approaching emergency vehicle, or even a pedestrian crossing. These applications, along with signal phase and timing messages, alerted drivers through their on-board units to the possibility of conflict so that they could react in time.

Source: NADO Research Foundation, 2019

Figure 22. City of Marysville staff show the connected signal cabinet interior

The city hoped that up to 5 percent of traffic would ultimately be equipped with on-board DSRC units, giving a large enough sample size to study how connected vehicles and intersections work together and how technology can support the goal of reducing fatalities. The vehicles with DSRC units included city

[209] Personal communication with Mike Andrako, June 2019

and state vehicles such as government fleets and law enforcement vehicles, as well as volunteers interested in participating and local Honda employees.[210]

The city worked with key partners to move the project forward. Significant funding was provided through the U.S. DOT. Drive Ohio provided funding through ODOT, technology, and technical assistance in the project. Honda provided research, technology, and equipment, and has recruited employees to have their vehicles equipped with on-board units. Union County-Marysville Economic Development provided communications and marketing throughout the community, including in connection to other smart transportation projects, and supports the Northwest 33 Council of Governments who had partnered on the 33 Smart Mobility Corridor.

33 Smart Mobility Corridor

The 33 Smart Mobility Corridor is a 35-mile stretch of connected highway with on-the-road infrastructure that allows for the development and testing of vehicle connectivity technologies in a real-world, open and closed, all-weather environment. The corridor included 94 roadside DSRC units and more than 175 smart signals, including those in Marysville as well as other jurisdictions along the corridor. The project has allowed for testing in rural, exurban, suburban, and urban environments.

The City of Marysville, Union County, and Union County-Marysville Economic Development have been players in the 33 Smart Mobility Corridor as well as in the Connected Marysville project. Since the 33 Smart Mobility Corridor spans a larger geography, other key partners have included the City of Columbus, City of Dublin, National Highway Traffic Safety Administration, Transportation Research Center, The Ohio State University and Center for Automotive Research, Honda, ODOT and Drive Ohio, JobsOhio, Battelle, and Logan County. The Mid-Ohio Regional Planning Commission has played a role in convening partners and supporting the project as a benefit to the entire central Ohio region, as the staff to the area's MPO and the Central Ohio Rural Planning Organization. These entities work together either as members of the Northwest 33 Council of Governments or as external partners, and together have focused the efforts of working groups on infrastructure, vehicles, smart network, engagement, and funding and finance.[211]

Outcomes

Innovation in transportation technologies is emerging around Ohio in a variety of rural, suburban, and urban locations, and in various types of technologies and applications across modes. The data and information gathered from both Connected Marysville and the 33 Smart Mobility Corridor has been important for research, manufacturing, transportation planning and operations, and more. At the time of initial publishing, lessons learned from the rollout of these projects included the amount of time and engagement needed for volunteers to sign on to install on-board units in their vehicles and receive the benefits of intersection conflict warnings and other alerts. Project participants also had not anticipated the pace of change of technology and adaptations that need to be made over time, even as some locations for roadside units needed to install adequate power supply.[212]

These and other investments in advanced transportation technologies sparked interest in workforce development. A Smart Workforce Committee was established including state and local government

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[210] Drive Ohio (2019) "Connected Marysville," https://drive.ohio.gov/wps/portal/gov/driveohio/know-our-projects/projects/07-connected-marysville

[211] Personal communication with Mike Andrako, June 2019

[212] Personal communication with Mike Andrako, June 2019

partners, educational institutions, and private sector partners. With a significant presence in the region of automotive and other advanced manufacturing as well as research sites, Union County-Marysville Economic Development anticipated future growth in jobs and investment made in the area. A program was created to train high school students in this field, with local private sector partners offering the students hands-on experience through internships.[213]

As of May 2023, efforts have been largely focused on coordinating and conducting the installation of on-board units in both city public agency fleet vehicles and private citizen volunteer vehicles. The latter are part of a research project led by DriveOhio, focused on driver interactions with and behavior in relation to connected vehicle (CV) technology. The hope of this project is to increase saturation of CVs on the road network, expanding sample size and allowing greater data collection. Noting the FCC ruling to sunset DSRC technology, the 33 Smart Mobility Corridor and its partners are actively planning for the transition. They continue to study the effectiveness of CV technology and the use of transportation technology to improve roadway safety.[214]

Resources

The ability to test out new technologies in Marysville and Union County has been the result of significant investments by multiple partners. The NW 33 Innovation Corridor Partnership was the recipient of a $5.9 million grant from the U.S. DOT in 2016.

ODOT funded the installation of a fiber network at a cost of approximately $15 million in support of the investments along the corridor, along with local public match of $400,000. Local public and private sources matched these state and federal investments with nearly $3.5 million. Another $45 million has been invested to establish a dedicated connected and automated vehicle testing facility at the Transportation Research Center, which is an enclosed vehicle proving ground situated along U.S. 33 in East Liberty, Ohio.[215]

Maintenance and operation costs for the connected infrastructure roadside units and signals were noted as expected to be minimal. Typically, the cost to install a roadside unit at an existing traffic signal ranges from $5,000 to $10,000 including installation. On-board units to retrofit vehicles that are not currently connected cost $5,000 including installation. For more information about these projects and others around Ohio, visit https://www.33smartcorridor.com and https://drive.ohio.gov.

[213] Personal communication with Mike Andrako, June 2019

[214] Personal communication with Marc Dilsaver, May 2023

[215] Union County CIC (2020). “Smart Mobility,” https://www.33smartcorridor.com/mobility

8 Smart Infrastructure Case Studies

Smart infrastructure offers opportunities to build connectivity directly into transportation facilities. Although such implementations are more common in urban areas, the case studies in this chapter explore rural implementations of smart infrastructure.

8.1 Modular Smart Pavement Slabs

Smart Pavement is a technology capable of providing simple, compact deployment of various smart systems along roadways. The technology is typically made up of precast concrete slabs intended to replace and outlast more traditional asphalt. Modular systems embedded inside have the capacity to receive software upgrades and an expansion port (described as the size of a soda can) that allows a new technology to be integrated.

Project Purpose

The slabs currently produced allow for wireless EV charging; use of in-road sensors and antennae systems to locate vehicles in two distinct ways, improving accuracy and reliability while eliminating the latency inherent when relying on distant satellites for A-PNT; and sensors of sufficient sensitivity to provide anonymous real-time traffic data on speeds, lane usage, make, model, year, weight, and more of each passing vehicle.[216] A-PNT is a global navigation satellite system (GNSS) adjacent to GPS. PNT can be labeled as Assured when their signals are technologically safeguarded from both natural and human-caused disruptions. Latency or delay is inherent given distance.[217]

Beyond providing data on pavement conditions to allow timely repair or enabling immediate accident response, these sensors have considerable utility for research on the impact on traffic conditions of local events, changing weather conditions, and more. Ongoing testing in Denver, Colorado has attracted interest from academics hoping to make use of collected data, while a demonstration for the Kansas DOT (KDOT) has emphasized potential cost-saving benefits. Rather than fronting the complete cost of “at the edge ITS integration” for one component or desired benefit, the technology’s creators speak of a model where distinct benefits for the public and private sectors from different components or data could see partnerships to invest in the system. For DOTs and transportation agencies, embedded sensors could allow efficient and cost-effective remote access to data used in ITS, avoiding the need to work from a transportation management center.[218]

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[216] Personal communication with Tim Sylvester, January 2023

[217] Oscilloquartz. (nd). “What is assured PNT?” https://www.oscilloquartz.com/en/products-and-services/technology/what-is-assured-pnt

[218] Personal communication with Tim Sylvester, January 2023

Outcomes

In 2017, the Colorado DOT (CDOT) contracted the deployment of a segment of Smart Pavement on Route 285, a rural stretch from the New Mexican border through the San Luis Valley to Denver, as well as a demonstration site within Denver, seen in Figure 23. This contract was ended in 2019 due to changing priorities, with subsequent testing and deployment based on a private financing model with little to no government funding.[219] Without local, state, or federal government funding to facilitate more widespread deployment, early usage of Smart Pavement and similar technologies may be concentrated in urban areas.[220]

Source: Integrated Roadways, 2019

Figure 23. A screenshot of the installation of Smart Pavement on Brighton Boulevard at 39th St in Denver, Colorado, completed in collaboration with CDOT's RoadX program, the City and County of Denver, and other public and private sector partners

Traffic and population density make this a matter of economics for many such technologies. Given time, growth, and increased production capacity, expansion into rural areas will grow more cost effective, with or without government involvement. There are benefits of such technologies to rural communities which may warrant investigation or public-private partnership to accelerate that process.[221]

Beyond providing broadband access which could better facilitate remote work in low cost-of-living areas, Smart Pavement’s creators cited a potential use for the rural bridges that often serve as chokepoints for agricultural traffic. In edge cases where a trailer nears or exceeds a weight limit, a bridge instrumented to give reports on its own condition could allow companies to efficiently determine if an additional trailer or alternate route is warranted or enable an overweight fee to be assessed based on the weight of the load and the bridge’s condition. This integration would bring both passive efficient improvements to nationwide logistics and avoid a potential infrastructure failure with all the safety and economic consequences that

[219] Personal communication with Tim Sylvester, January 2023

[220] Personal communication with Tim Sylvester, January 2023

[221] Personal communication with Tim Sylvester, January 2023

brings. Redeveloping the existing information tech systems to facilitate this service and serve rural regions is within producers' existing technological capacity, but it would again require government or private funding to facilitate development and deployment until a clear market justifies a for-profit entity taking such action.[222]

Resources

Modular production and installation of smart pavement slabs assists with managing the costs involved in deploying and maintaining the infrastructure. Smart Pavement slabs (which are horizontal, whereas panels are vertical) are designed for quick engineering and fabrication, with a standardized design capable of being customed to local specifications. Installation is described as simple, with the slabs raised or lowered to a needed height by an internal leveling system. Maintenance of these slabs is largely identical to that of standard concrete pavement, with the largest warning being to treat each unit as such and avoid dismantling or sawing through them. While the vendor presently operates all the systems it delivers, this is not a necessity beyond the limited knowledge about their utilization. In the future, an easy-use software package would enable clients to manage and replace slabs, or similar compact ITS deployments, fully self-sufficiently.[223]

8.2 The Ray Highway in West Georgia

The Ray is an independent nonprofit entity operating on the Ray C. Anderson Memorial Highway, which spans an 18-mile stretch of interstate between LaGrange and West Point on Interstate 85 in Troup County, Georgia. The name is well-chosen, honoring Anderson as a champion of industrial sustainability and alluding to the energy-charged solar rays which offer sustainable energy and support The Ray's mission: zero carbon, zero waste, and zero deaths. This mission connects and sustains communities in a way that moves toward net-zero goals, supports wildlife and safety, and saves or even generates resources.[224] The Ray partners with the Georgia Department of Transportation (GDOT) and other public, private, and academic entities to test smart and sustainable transportation technologies. There are eleven technologies currently being tested by The Ray, with more waiting in the wings.[225]

There are substantial benefits to approaching highways as a focus area in improving safety and sustainability. NHTSA estimates point to 31,785 deaths in traffic crashes during the first nine months of 2022, with ITS offering safety improvements and more efficient incident response.[226] The IEA estimated that transportation accounted for 37% of end-use sector CO_2 emissions in 2021, highlighting the significance of the sector's transition toward decarbonization. The Ray's data points to 52,000 acres suitable for solar development at interstate exits in the contiguous United States, capable of generating 36 terawatt hours of energy a year and powering 12 million passenger EVs.[227] Rather than specifying

[222] Personal communication with Tim Sylvester, January 2023

[223] "What is assured PNT?" Oscilloquartz. https://www.oscilloquartz.com/en/products-and-services/technology/what-is-assured-pnt

[224] The Ray C. Anderson Foundation, The Ray. https://www.raycandersonfoundation.org/the-ray

[225] The Ray. https://theray.org

[226] "NHTSA Estimates for First Nine Months of 2022 Suggest Roadway Fatalities Beginning to Level Off After Two Years of Dramatic Increases." National Highway Traffic Safety Administration. https://www.nhtsa.gov/press-releases/nhtsa-estimates-traffic-deaths-2022-third-quarter

[227] The Ray. https://theray.org

exclusively in traffic safety systems, vehicle electrification, or any single technology, The Ray has embraced the concept of a regenerative mobility ecosystem. Their work supports a diversification of smart and sustainable technologies that will build the confidence of public and private entities who are weighing the urgency with which to transition to new systems amidst the confines of their operational realities.[228]

Project Purpose

To avoid tech exclusivity, The Ray Highway hosts a broad range of roadside technologies. These include a system that allows for tire pressure and tread depth readings as well as tire sidewall readings, allowing drivers to obtain information about tread depth and pressure specific to their vehicle, identify how much usable life is left on the tire, and where to find a suitable replacement; solar-powered EV charging that provides drivers a free 175kW charge for their electric vehicles; roadside vegetation and wildflowers to beautify, improve agricultural wellbeing, and fortify soil against stormwater; a rubber-added asphalt mix that reduces road noise and increases durability; and others.[229] A tire safety check sensor is visible in Figure 24.

[228] Personal communication with Allie Kelly, January 2023

[229] The Ray. https://theray.org

Source: The Ray, 2022.

Figure 24. The Ray's tire safety check station alerts passing drivers of information on any of their tires via printed slip.

Outcomes

Beyond the technical improvements enabled by testing in areas with industrial and civilian traffic, The Ray's emphasis on diverse technology ecosystems has shown that those ecosystems help fuel the future development and implementation of new technologies. A representative of The Ray spoke on the need to assure both the private sector and state or local government agencies of the certainty of operations in a very low infrastructure reality.[230] The resources invested into one sector of intelligent transportation—be it EVs, CVs and AVs, or real-time logistic and diagnostic data—strengthen the shared ecosystem and create a gravity that draws in funding, scientific interest, and confidence in embracing a new way of doing things. For rural communities, the earliest developments in these ecosystems may be charging infrastructure to meet demand from freight EVs, with roadside data gathering and other ITS systems to follow.[231] Charging infrastructure can be seen in Figure 25.

[230] Personal communication with Allie Kelly, January 2023

[231] Personal communication with Allie Kelly, January 2023

Source: The Ray, 2022.

Figure 25. The Ray's free solar-powered EV charging station.

Resources

For an ecosystem of ITS and EV, CV, and AV support systems, communities must invest in a broad array of technologies with their own costs and requirements for upkeep. The Ray has seen a rural success story in Troup County paving its first rubber road even prior to their own experiments and cites collaborations between local governments and private entities as bringing and maintaining digital and physical infrastructure in impoverished or low-population communities. The model which has enabled much of this success, particularly for states and locales which lack the money to commit large infrastructure investments is the public-private partnership.[232] The Ray is a public-private partnership (P3) and even considers itself a P4 through adding a philanthropic dimension to the partnership. With the help of these connections, carefully negotiated and comprehensive contracts bring private sector investment potential—domestic and international—to public infrastructure needs, the private party or parties paid, possibly in part or in full, with value generated by the developed infrastructure. By including philanthropy, The Ray adds tremendous value to partnerships by leveraging specialized knowledge, skill sets, and connections unique to nonprofits.

The Ray's spokesperson described P3s and P4s as a great opportunity for states and communities, calling the agreements a land use solution. Here a government with limited funds but with potential projects expected to generate value can contract a P3 or P4 and navigate issues such as including land fees or power purchase deals, requiring pollinator friendly spaces, private handling of upkeep for the duration, and more. Georgia's legislature and governor have taken steps to update P3 laws, providing in

[232] Personal communication with Allie Kelly, January 2023

appropriate cases one potential solution to the unique infrastructure needs and funding challenges faced by rural areas.[233] Determining when a partnership contract is the optimal solution, selecting the partner offering the best value for money, and negotiating a successful contract will require localized governments to study past successes and failures. As infrastructure needs are met, the stage will be set for what The Ray considers the coming challenge in transportation: updating fundings system as new technologies make existing systems for funding transportation infrastructure obsolete.[234]

For more information about The Ray, visit the organization's website at https://theray.org.

8.3 Smart Railroad Ties for Energy Harvesting

Rectangular railroad ties (also called crossties) serve an important role in the function of rail transportation without incorporating advanced technologies. That may change due to ongoing research from the Railway Technology Laboratory at Virginia Tech's Center for Vehicle Systems and Safety (CVeSS). Their smart tie concept, seen in Figure 26, places a generator inside of the tie, the weight of a passing train turning its internal gears and producing electricity. This track harvester is distinct from previous concepts for using only downward motion, which its creators note as simplifying installation and increasing reliability.[235] Its creation was enabled by U.S. DOT funding through the Virginia Tech University Transportation Center.

[233] Personal communication with Allie Kelly, January 2023

[234] Personal communication with Allie Kelly, January 2023

[235] Pan, Y., Zuo, L., Ahmadian, M. (2020). "Design and Bench Tests of a Smart Railroad Tie for Energy Harvesting." Proceedings of the 2020 Joint Rail Conference, St. Louis, Mo, April 20 – 21, 2020. https://doi.org/10.1115/JRC2020-8133

Source: Virginia Tech Center for Vehicle Systems and Safety, 2023

Figure 26. An example of machinery incorporated into the smart ties to generate electricity from the movement of a passing train

Project Purpose

With each axle or wheelset passing over the current iteration of the generator producing in the range 5 to 10 W, the passage of a train with tens or hundreds of cars could see the device harvest kilowatts of power, particularly on high-traffic lines or areas where multiple devices are installed.[236] This power can be stored in batteries for use by trackside smart equipment, supporting efforts to improve safety and efficiency through technology.

The potential benefits of this method of generation are greatest in rural America. The Federal Railroad Administration reports that nearly three quarters of track is in rural areas.[237] Harvested electricity allows greater use of technology in remote areas which may lack convenient power infrastructure to rely upon—with one application being to power Many existing systems rely on either solar panels, which can be damaged, stolen, or rendered useless by lack of sunlight; or propane-powered generators, which require their own service and fuel replenishment.[238] A track harvester draws power from the motion of a train, which will otherwise go to waste as the train continues onward. This power can be applied to new ITS

[236] Personal communication with Dr. Mehdi Ahmadian, February 2023

[237] United States Department of Transportation, Federal Railroad Administration. https://railroads.dot.gov/rural

[238] Personal communication with Dr. Mehdi Ahmadian, February 2023

tools such as sensors—temperature, humidity, accelerometer, acoustic, LIDAR, radar, or others—that flag potential hazards and monitor train and track condition.[239]

Outcomes

The idea for the track harvester began as a generator built into an electrical damper, tested at the U.S. DOT's Transportation Technology Center (TTC) test facility in Pueblo, Colorado. The idea was found workable but its overall harvested energy too small, which led the researchers turning their focus to the track and its potential to safely house otherwise delicate equipment. Over a two-year period, the smart tie was conceived, a prototype was produced and tested in the Railway Technology Laboratory, that prototype was improved, and it began its current testing in collaboration with Norfolk Southern—a Class I railroad—on their revenue-service track.[240]

Private parties doing business in rail or in tie manufacturing have reportedly expressed enthusiasm for the smart tie concept, recognizing the potential benefit of generating electricity from a process that their work already interfaces with regularly.[241] Rural regions seeking to improve safety with technologies deployed in urbanized areas will benefit from additional power reducing costs or allowing additional hardware to be deployed.

As a prototype undergoing testing, the current smart tie design has recently undergone design improvements based on the lessons learned while testing. With confidence expressed in future improvements as the testing process continues, the harvesting potential of this technology could increase meaningfully, strengthening the incentive for future adoption while planning new track infrastructure or performing upkeep on existing track.[242] Like many largely novel technologies, increased awareness of its utility will translate into more minds and resources seeking to improve upon the design. Potentially 4,000 Watts per train per device is not insubstantial and may be a milestone before even greater harvest potential.

Resources

A notable benefit to the smart tie is that its installation process is currently as simple as standard tie installation, as seen in Figure 27. CVeSS noted that the railroad crew installing the test tie were seeing it for the first time, yet crew members were able to install it in a similar length of time to one without an energy harvester.[243] The smart tie takes up no more space than a standard tie, and the durable substance of the tie avoids the need for regular maintenance on the internal components.

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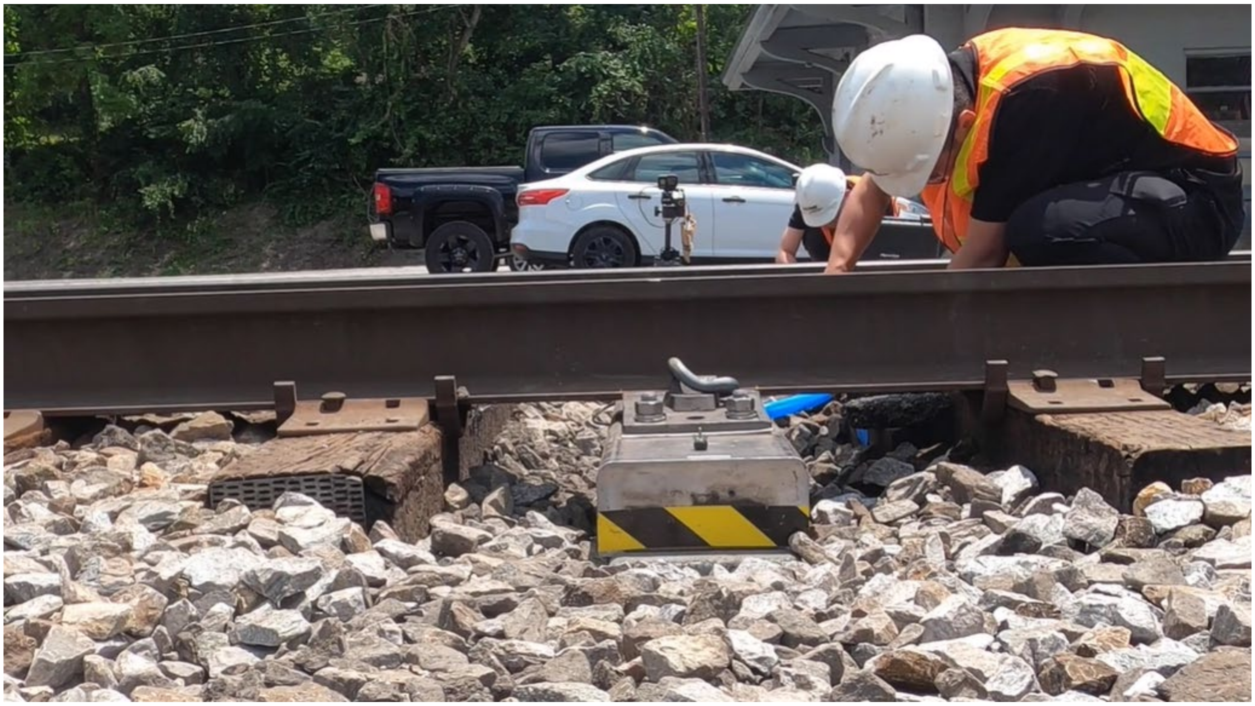
[239] Institution of Mechanical Engineers. (2021). "Energy harvesting powered rail track sensor technology is becoming a reality." https://www.imeche.org/news/news-article/energy-harvesting-powered-rail-track-sensor-technology-is-becoming-a-reality

[240] Personal communication with Dr. Mehdi Ahmadian, February 2023

[241] Personal communication with Dr. Mehdi Ahmadian, February 2023

[242] Personal communication with Dr. Mehdi Ahmadian, February 2023

[243] Personal communication with Dr. Mehdi Ahmadian, February 2023



Source: Virginia Tech Center for Vehicle Systems and Safety, 2023

Figure 27. Workers install the smart tie on the track for testing

Where more consideration may be necessary is for the generated electricity once it has left the harvester. Wires from the smart tie will connect to some manner of battery bank or energy storage device, the specifics of which will likely depend on each rail operator and the smart equipment they wish to operate trackside. Any battery bank or other linked components will benefit from being installed either between the tracks or some distance from them so as to avoid serious damage, this being the greatest change from what conventionally exists on a railroad track.[244] Such installations may require their own expertise and upkeep, beyond the costs of smart ties intended to ultimately save more money than they cost.

For more information, visit the CVeSS website at https://cvess.me.vt.edu.

[244] Personal communication with Dr. Mehdi Ahmadian, February 2023

Appendix A. Additional Resources

The research, guides, toolkits, and other resources summarized below contain additional information on ITS applications in rural and small metropolitan areas.

Multimodal ITS Applications and Issues

National Center for Rural Road Safety. (2018). *Rural Intelligent Transportation System Toolkit*.
https://ruralsafetycenter.org/resources/rural-its-toolkit/

The toolkit includes fact sheets on 42 types of ITS technology. Fact sheets outline the technology, partners or jurisdictions involved, components involved in installing the technology, examples of how the technology has been implemented, considerations, resources, and capital and operations costs.

U.S. Department of Transportation, ITS Joint Program Office. (2018). *Intelligent Transportation Systems Benefits, Costs, and Lessons Learned: 2018 Update Report.*
https://rosap.ntl.bts.gov/view/dot/36236

The report contains summaries of applications in the areas of crash prevention and safety, accessible transportation, mobility on demand, and information management, connected vehicles, and automated driver assistance. The report includes overviews of U.S. DOT-funded Connected Vehicle Pilots in New York City, Wyoming, and Tampa. The Wyoming DOT Connected Vehicle Pilot is a safety and weather information project that incorporates V2V and V2I technology through roadside units and onboard communications units along rural segments of I-80. Specific applications within the pilot pertain to forward collision warning, infrastructure-to-vehicle situational awareness (e.g., weather alerts, parking, and road closures), work zone warning, and spot weather impact warning. Other projects identified in the report include a Vermont statewide trip planner that incorporates alternative modes and a section on truck platooning through V2V connectivity.

National Operations Center of Excellence. (2021). 2nd Transportation Systems Management and Operations (TSMO) Workforce Development Summit Proceedings.
https://transportationops.org/2ndworkforcesummit

Summit discussions identified that a key TSMO workforce challenge is finding talent, including at technical schools, colleges, and universities, as well as among incumbent workers. This can be difficult due to relative lack of visibility of TSMO, hiring practices, and organizational silos. Difficulties in updating position descriptions, challenges sharing positions to leverage needs across an agency, competition for workers with the technology sector, and a lack of understanding about TSMO all can make up the set of issues that an agency must work within to manage its TSMO workforce, which can include managing ITS to support operations.

Career tools for professional positions are available through the National Network for the Transportation Workforce and the ITS JPO ITS Professional Capacity Building (PCB) Program. These can be beneficial to academic partners, workforce development agencies, and transportation agencies. The summit participants also discussed paraprofessional positions supporting TSMO, including jobs supporting transportation management center (TMC) operation services and TSMO field operations.

Rural Highway ITS Applications

U.S. Department of Transportation, Intelligent Transportation Society of America. (2017). *Rural Connected Vehicle Gap Analysis: Factors Impeding Deployment and Recommendations for Moving Forward*. https://rosap.ntl.bts.gov/view/dot/34723

This document is based on interviews with subject matter experts. One-on-one interviews were conducted with 11 state DOT, federal, university, or consultant representatives who work in rural transportation. In addition, 20 rural emergency response and ITS practitioners were interviewed at the National Rural ITS Conference in 2015. Rural-specific issues discussed include lower traffic volumes, lower tax base, and less funding to support projects. Rural areas do experience a higher level of fatal crashes. Extreme weather conditions, severe vehicle crashes, and a lack of operational data about roadways are other areas of concern.

Interviewees noted that there can be misconceptions about connected vehicle technologies in rural areas. The perceived primary benefit is addressing rural crashes and related factors of high speed, roadway curves, weather conditions, and animal collisions. Interviewees mentioned that rural congestion is difficult to predict and is often the result of crashes, stalled vehicles, road construction, weather, tourism, and special events. Limited alternative routes mean it may take longer to clear congestion or provide effective emergency response times. These are issues that could be addressed by connected vehicle technology, yet rural areas have concerns about the clear demonstration of benefits and return on investment; lack of funding to implement projects; and physical barriers of rugged terrain, extreme weather, and the environment. Other areas of concern mentioned include backhaul capacity (connection from node/vehicle to central network) and cellular capacity. Rural areas have lower smartphone ownership and internet use combined with a higher percentage of older and low-income residents. Interviewees mentioned that rural residents may raise more concerns about government intervention through technology applications.

Recommendations from the interviews include developing a connected vehicle sustainability plan that uses data from pilots to demonstrate technology usability and to encourage future deployments, deploying freight supply chain movement projects, exploring innovative funding beyond traditional grant programs, and conducting outreach and public engagement programs as well as identifying champion agencies or individuals who can support projects and promote their use in rural areas.

U.S. Department of Transportation, ITS Joint Program Office. (n.d.) *Rural Safety Initiative: The Approach*. https://www.its.dot.gov/research_archives/rural/rural_approach.htm#co

The U.S. DOT awarded Rural Safety Innovation Program (RSIP) funding to nine agencies in 2008 to develop 11 projects. ITS elements include the use of changeable message signs and smart work zone cones that track vehicle speed in California, use of augmented LED lighting in the U.S. 160-Wolf Creek Pass tunnel in Colorado, and installation of speed-actuated truck tip-over warning signs on U.S. 50 in Colorado. In Illinois, safety countermeasures include vehicle detection before curves that triggers LED-flashing beacons to warn drivers. Illinois also implemented flashing beacons to warn drivers of an upcoming two-way stop. Iowa established a web-based Traffic and Criminal Software program to improve accuracy and completion of traffic crash data and load data into the statewide crash report system. Kansas DOT entered a partnership with the Prairie Band Potawatomi Nation to deploy ITS at intersections that provide access to the reservation. The technologies include a roadway weather information system station, a closed-circuit television camera, portable DMS, flashing beacons, and traffic queue detection at two other locations along U.S. 75. Minnesota DOT implemented a speed measuring device tied to a DMS with a message "Slow Down" to address the statistic that 27 percent of crash fatalities in the state between 2001 and 2005 were along rural curves. Variable speed limit signing was implemented in South Carolina to reduce speeds in wet conditions on U.S. 25 in the mountainous region of the state near.

Additional funded projects include development and implementation of driver feedback signs that use vehicle detection technology and display vehicle speeds. The Wisconsin DOT used RSIP funds to implement a Rural Intersection Collision Avoidance System (RICAS). The RICAS technology provides real-time warnings to drivers to help prevent [vehicle] gap selection errors for drivers attempting to turn at unsignalized medians. The 2010 pilot location for the project was the intersection of U.S. 53 and State Trunk Highway 77 west of Minong in Washburn County, Wisconsin. In the RICAS implementation, sensors are used on U.S. 53 to determine the lane of travel, position, and speed of vehicles approaching the intersection. Loop detectors installed in the intersection median activate a Driver Infrastructure Interface (DII) that relays alerts and warnings to the vehicle attempting to turn from the intersection median. The DII sends its alerts through a variable message sign alerting the crossing driver that a vehicle is approaching. When a vehicle is not sensed, the alert system remains inactive. *[Note: Wisconsin DOT is no longer using this technology at the pilot location.]*

Rural Public Transportation ITS Applications

U.S. DOT, John A. Volpe National Transportation Systems Center (2020). Intelligent Transportation Systems: Findings from the 2019 Small Urban and Rural Transit Provider Survey, https://rosap.ntl.bts.gov/view/dot/50549

U.S. DOT conducted an ITS survey specifically for small urban and rural transit providers in 2019. The results of that study showed: High usage of security cameras and systems (83% of respondents) and automatic vehicle location (75%); Moderate usage of computer-aided dispatch (56%), Geographic Information Systems (54%), and traveler information systems (51%); Low usage of maintenance management systems (27%), electronic fare payment (20%), automatic passenger counters (16%), and transit signal priority (3%). Across all types of ITS included in the survey, respondents from small urban programs were more likely to respond that they were using ITS than rural transit agencies were. Costs, perceived need, and technical expertise were among the barriers that agencies cited for not further implementing ITS.

Shared-Use Mobility Center. (2019). *Case Study: Vermont Flexible Trip Planner: Bringing Fixed and Flexible Transit Together on a Single Platform.* https://learn.sharedusemobilitycenter.org/casestudy/vermont-flexible-trip-planner-bringing-fixed-and-flexible-transit-together-on-a-single-platform/

The Vermont Agency of Transportation (VTrans) has developed an online trip planning tool that includes all available options including flexible ride and dial-a-ride. Funded as a Mobility-on-Demand Sandbox project, the tool increases access to traditional fixed-route transit and alternative transportation. A project case study is available on the Shared-Use Mobility Center website. The case study explains that in 2014, all of Vermont's transit agencies adopted the Google Transit platform that publishes their public transit data; however, the Google Transit platform shows fixed-route transit and does not include dial-a-ride, hail-a-ride, and deviated fixed-route services. Responding to the issue, open-source software developers created GTFS-Flex providing information about flexible services. At that time, the Shared-Use Mobility Center's case study was completed, and Google Transit could not consume the GTFS-Flex information. VTrans applied to the 2016 Federal Transit Administration Mobility-on-Demand Sandbox opportunity in order to create mobile and desktop versions of OpenTripPlanner.

In spring 2018, the Go! Vermont Trip Planner was launched for statewide use. With the Trip Planner, travelers could see hail-and-ride stops, deviated fixed-route transit, and ADA-accessible transportation. The platform is also capable of listing carpools, hotel shuttles, and ride sourcing. In 2019, the planner was updated to include carpooling and vanpooling services. The trip planner platform is owned and managed by VTrans. To increase usage by the general public in addition to call center staff, VTrans scheduled a marketing campaign for 2019. State associations and departments that serve individuals who are blind or who have disabilities were engaged in testing the trip planner for accessibility. Transportation agency contact information is provided as appropriate; however, the planner does not include eligibility details or trip-booking/ticket purchasing capabilities.

United States Government Accountability Office. (2016). *Intelligent Transportation Systems: Urban and Rural Transit Providers Reported Benefits but Face Deployment Challenges* https://www.gao.gov/assets/680/677919.pdf

To prepare this report, the U.S. Government Accountability Office (GAO) reviewed DOT's ITS deployment data and ITS studies, interviewed U.S DOT officials and public transit stakeholders, conducted three site visits to Pittsburgh, Pennsylvania; Portland and Eugene, Oregon; and Tampa and Orlando, Florida. GAO interviewed 31 transit providers from across the country. For rural and small urban areas, GAO used a web-based survey that received 233 responses. The sample excludes transit systems with 10 or fewer vehicles.

The report includes a background overview of the types of transit service provided in urban and rural areas and the general types of ITS applications (e.g., communications, GIS and data management, maintenance management, and weather information systems). In 2016, small urban and rural transit agencies were primarily using four ITS-related technologies: security systems, computer-aided dispatch, automatic vehicle location, and GIS. If smaller systems were not using a specific ITS technology, it was due to costs or perceived lack of need. The most commonly used applications for smaller systems were maintenance management systems, traveler information systems, automatic passenger counters, electronic fare payment, and transit signal prioritization. The top five benefits of ITS that small and rural operators identified are: improvements in record keeping, enhanced safety, more efficient scheduling and routing, improvements in one-time performance and schedule adherence, and increased customer satisfaction. Interviewees indicated that the indirect benefits of ITS such as operator satisfaction and improved marketing are difficult to quantify. Technical expertise and connectivity were two challenges identified by the rural and small urban providers interviewed.

The final section of the report explores the extent to which local transit systems use federal resources, training, or funding, especially resources of the U.S. DOT's ITS Joint Program Office, to implement ITS systems.

Transportation Research Board, Transit Cooperative Research Program. (2005). *TCRP Report 84, e-Transit: Electronic Business Strategies for Public Transportation Volume 6 Strategies to Expand and Improve Deployment of ITS in Rural Transit Systems.*

https://www.nap.edu/catalog/23315/strategies-to-expand-and-improve-deployment-of-its-in-rural-transit-systems

The report summarizes interviews with rural agencies who had implemented or were planning to implement rural ITS strategies. The agencies are the Kansas DOT, Community Action Partnership of Mid-Nebraska, Iowa DOT, California DOT (Caltrans), and Oregon DOT. Each agency had a similar goal: to reduce the time to schedule trips and streamline the process of planning trips.

Kansas had a statewide ITS plan in place that focused on traveler information, and KDOT wanted to enhance traveler information, automatic vehicle location (AVL), and increased dispatch to driver communication. Mid-Nebraska focused on automated dispatch and scheduling, online ride schedule and ride request for travelers, and use of global positioning systems (GPS) for vehicle deployment and tracking. Iowa DOT had a statewide ITS plan in place with the goal of improving transit service. Iowa wanted to establish a statewide architecture for ITS and recommendations for the transit agencies related to fleet management systems, operational software and computer-aided dispatching, electronic fare payment systems, advanced traveler information systems, and transit intelligent vehicles. Caltrans' focus was on identification and field testing of potential low-cost rural transit technologies. Technologies explored include AVL and GPS, DMS for real-time information, dispatch software and real-time web maps for bus locations, silent alarms for emergencies, radio frequency modems, driver mobile data terminals (MDTs), and card reader inputs. Oregon DOT wanted to use ITS to address the needs of transportation users who are identified as transportation disadvantaged. Oregon, in coordination with Washington State DOT, decided to deploy a regional trip planning website. The service—which still exists as www.tripcheck.com—allows users to schedule trips in rural and urban areas using a variety of modes.

The report emphasizes that web-based technologies are just part of ITS infrastructure. Other technologies that play a role in the systems discussed include wireless communications, computer-aided design, AVL, MDTs, accounting and reconciliation, online customer service centers, and electronic fare collection. The Analysis of Solutions section of the report identifies funding and levels of staff technical expertise as barriers to rural ITS implementation. Barriers may be overcome by partnering with a state DOT and other agencies within the state to deploy a seamless, comprehensive system.

Altman, S. & Bregman, S. (2019). Reaching Rural Transit Riders, Presentation at ITS America, June 14, 2019.
https://static1.squarespace.com/static/5b44befeb98a780957982bf3/t/5d274f28a9a3290001b6c9ef/1562857256318/16627_Presentation.pdf

Scott Altman and Susan Bregman researched the challenges that rural transit agencies have in providing up-to-date information to transit customers and best practices that can improve the timeliness of the information shared. Their ITS America presentation is based on interviews with transportation agency managers in Chemung County, Clinton County, and Suffolk County, New York, and C Tran in Elmira, New York.

According to the authors' research, providing real-time information is affected by whether a transit schedule is published in the GTFS so that Google Transit and third-party apps can list the data. In rural areas, types of services can include a mix of fixed route, ADA-complementary service, fixed-route service with flag stops, and on-demand service. These services may have published schedules. The agencies interviewed noted that limited staff and financial resources, the digital capabilities of customers, and procurement processes affect the ability to share information about transportation services. Staff members have limited time to update websites and social media posts or must rely on county IT staff to update travel or weather information. Customers may not use social media to receive updates. Transit agencies interviewed in New York mentioned continued use of flyers or newspaper notices to reach customers. Agencies expressed concern about inflexible procurement processes that affect the agency's ability to update technology. In addition, agencies noted that a lack of research and data to illustrate that technology-based improvements will bring in revenue to offset the cost of investment surfaces in discussions and affects decisions to invest in technology.

Best practices recommended for rural systems include thinking like a customer and providing up-to-date schedule and service information by a variety of media; knowing the customers and how they prefer to receive information; leveraging existing technology to provide at a minimum static schedules, maps, and service alerts; using forward thinking for technology systems by watching trends in technology (e.g., rise in smartphone ownership); and leveraging existing technology where its available (e.g., statewide 511 network or state DOT assistance or consultant support to upload schedules into GTFS format).

Vehicle Connectivity, Automated Vehicles, and Smart Infrastructure

AASHTO/ITE/ITSA Joint Task Force. (2020). Infrastructure Owner Operators Guiding Principles for Connected Infrastructure Supporting Cooperative Automated Transportation.
https://systemoperations.transportation.org/wp-content/uploads/sites/22/2020/02/GuidingPrinciples_Feb2020-1.pdf

Infrastructure Owner Operators Guiding Principles for Connected Infrastructure Supporting Cooperative Automated Transportation (Feb 2020). Cooperative Automated Transportation (CAT) envisions all stakeholders and elements of the transportation system collaborating to improve safety, mobility, equity, and operations through interdependent vehicle, infrastructure, and systems automation enabled by connectivity and information exchange. Intentionally expansive concept, built on work by public, private, and academic. Five Guiding Principles (GP)s of CAT: 1) Automation of vehicles and infrastructure that vehicles share with users, 2) Data enables automation, 3) Communications enables data interactions between vehicles, infrastructure, and users, 4) Operations capture and enact decisions about how the systems are automated, and 5) Collaboration creates an environment that values and incorporates the needs of all participants. These support the work of Infrastructure Owner/Operators (IOOs).

U.S. Department of Transportation, Federal Highway Administration. (2018). *Effects on Intelligent Transportation Systems Planning and Deployment in a Connected Vehicle Environment*.
https://ops.fhwa.dot.gov/publications/fhwahop18014/fhwahop18014.pdf

This report provides an overview of what ITS technologies are, explains connected vehicle technology and automated vehicle technology, and describes U.S. DOT categories of ITS. The ITS categories listed are traveler information, freeway management and arterial management, archived data management, public transportation, emergency management strategies, construction and maintenance strategies, construction and maintenance management, other types of traffic management, vehicle safety, and connected vehicle technology. A chapter highlights how connected vehicle technology may impact core ITS functions and direct delivery of traveler information into vehicles. Several case studies related to connected vehicle technologies are identified including a Maricopa County, Arizona, mobile pedestrian signal system that activates extended cross times and the Wyoming DOT Connected Vehicle Pilot. Connected vehicle impacts on peripheral ITS are addressed (e.g., electronic toll collection, truck parking information systems). The report concludes with key findings and recommendations. The technologies discussed may be deployed in rural areas or involve the participation of rural agency stakeholders.

Transportation Research Board, National Cooperative Highway Research Program. (2017). ***NCHRP Research Report 845 Briefing Document: Strategies to Advance Automated and Connected Vehicles.*** **https://www.nap.edu/catalog/24873/strategies-to-advance-automated-and-connected-vehicles**

This document summarizes the key findings of *NCHRP Research Report 845: Advancing Automated and Connected Vehicles: Policy and Planning Strategies for State and Local Transportation Agencies* and is designed to help decision makers identify and leverage policy tools they have in place and consider how to align with emerging automated vehicle and connected vehicle technology. The document outlines how vehicle technology is tied to existing transportation planning issues: traffic crashes, congestion, pollution, land development, and mobility. The report identifies strategic goals tied to addressing these issues through implementation of vehicle connectivity projects and provides a menu of strategies for policy makers to consider based on the outcomes they want to achieve. Outcomes may include mitigating safety risks through testing, training, and public education; encouraging shared automated vehicle use; addressing liability issues that may impact market development; enhancing safety, congestion, and air quality benefits by influencing market demand. An example strategy under the Encourage AV Use outcome is "subsidized shared AV use." For each strategy, there is an overview page with assessment or rating of a viability, including how the strategy has geographic impact statewide or in urban, suburban, and rural areas. Other viability criteria include effectiveness, efficiency, political acceptability, operational feasibility, geographic impact, level of government affected, and hurdles or barriers to implementation.

Federal Lands

U.S. Department of Interior, National Park Service. (2014). ***Congestion Management Toolkit.*** **https://www.nps.gov/orgs/1548/upload/NPS-CMS_Toolkit.pdf**

The Congestion Management Toolkit provides a list of congestion mitigation solutions or tools that can be applied to address specific congestion problems and issues in National Park Service settings. Key features include implementation considerations, cost and financial information, examples of where these tools have been used, and expected outcomes based on previous applications. The toolkit contains an overview of the congestion and the specific steps that can be taken to address the issue. The tools that can be used are broken into five categories: additional capacity to existing system and infrastructure, intelligent electronic systems, public transportation, traffic operational improvements, and visitor demand management that can include electronic systems. Other features of the toolkit include a chart with a comprehensive list of tools, strategies that can be achieved by each tool, physical locations and emphasis areas where tools should be deployed, estimated capital costs for the tool, and timing to implement the project (e.g., near term to long term). The toolkit offers an extended profile of each tool including a description, photo, a list of where the tool can be used, which strategies it achieves, the pros and cons of implementation, whether the tool requires partnerships, estimated time for implementation, examples of where the tool is currently being used, suggested performance measures, and additional resources. The last section of the toolkit is an index list of tools categorized by the locations where they are used within a national park.

U.S. Department of Transportation, John A. Volpe National Transportation Systems Center. (2011). ***Intelligent Transportation Systems in the National Parks System and Other Federal Lands.*** **https://rosap.ntl.bts.gov/view/dot/9554**

This report discusses the state of ITS deployments on federal lands through 2011 and updates an earlier 2005 report. In 2011, use of DMS was continuing to increase, and social media to provide traveler information was experiencing the most growth activity among ITS applications. The report covers considerations and challenges surrounding deployment of ITS in rural locations and rugged terrain. Types of technologies evaluated include travel and traffic management, incident management, park or facility entry management, and public transportation management. The five technologies that the Volpe Center found to have promising results in 2011 are DMS, highway advisory radio, 511 system integration, traffic counters and loop detectors, and social media tools. Volpe provides ITS implementation recommendations for the park of federal land unit level and the national level and technology-deployment guidance. The report appendices offer a detailed inventory of ITS technology in use for each park and technology-deployment guidance that charts the type of ITS recommended for each park or federal land area.