US 67 CORRIDOR MASTER PLAN

APPENDIX F

FEBRUARY 2020

US 67 CORRIDOR
MASTER PLAN

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Memorandum

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From: *CDM Smith*

Date: *February 2020*

Subject: *US 67 Corridor Intelligent Transportation Systems (ITS) Needs Assessment Technical Memorandum*

1.0 Introduction

The purpose of this technical memorandum is to provide the information necessary to develop the Intelligent Transportation Systems (ITS) Plan for the US 67 study corridor. This needs assessment technical memorandum identifies the existing and planned needs, goals, and objectives related to ITS and Transportation Systems Management and Operations (TSMO) for the US 67 study corridor; and recommends mitigation strategies and solutions to address operational issues along the corridor. Needs and goals were identified through surveys, interviews, and input collected from stakeholders and the Texas Department of Transportation (TxDOT). From these identified needs, potential ITS and operational treatments were recommended to mitigate transportation and operational concerns.

ITS is generally defined as the application of advanced technology and high-speed communications to transportation management challenges. ITS evolved as a means for highway agencies to better manage facilities and traffic congestion. While ITS has demonstrated enormous benefits in many deployments around the country, its application should be tempered with a strong operational concept and focus on functionality. ITS must be viewed as a tool to facilitate safe and efficient highway travel. Building from this logic, TSMO has evolved to encompass not just ITS, but any improvements – in the field or within an organization – that help improve management and operations of roadway facilities.

The US 67 study corridor stretches 142 miles from Interstate 10 (I-10) west of Fort Stockton to the Presidio/Ojinaga Port of Entry (POE) on the United States (U.S.)/Mexico border. US 67 provides access to the towns of Alpine, Marfa, Presidio, and surrounding communities, as well as Big Bend National Park, Sul Ross State University, the Marfa Lights, Big Bend Ranch State Park, Fort Leaton State Park, and Fort Davis attractions. This rural area has experienced growth in recent years driven by many factors, including tourism growth, international commerce, and Permian Basin oil field development. In response to these trends, TxDOT, in partnership with communities, developed a corridor master plan to help determine the current and future transportation needs along US 67. **Figure 1** shows the study corridor.

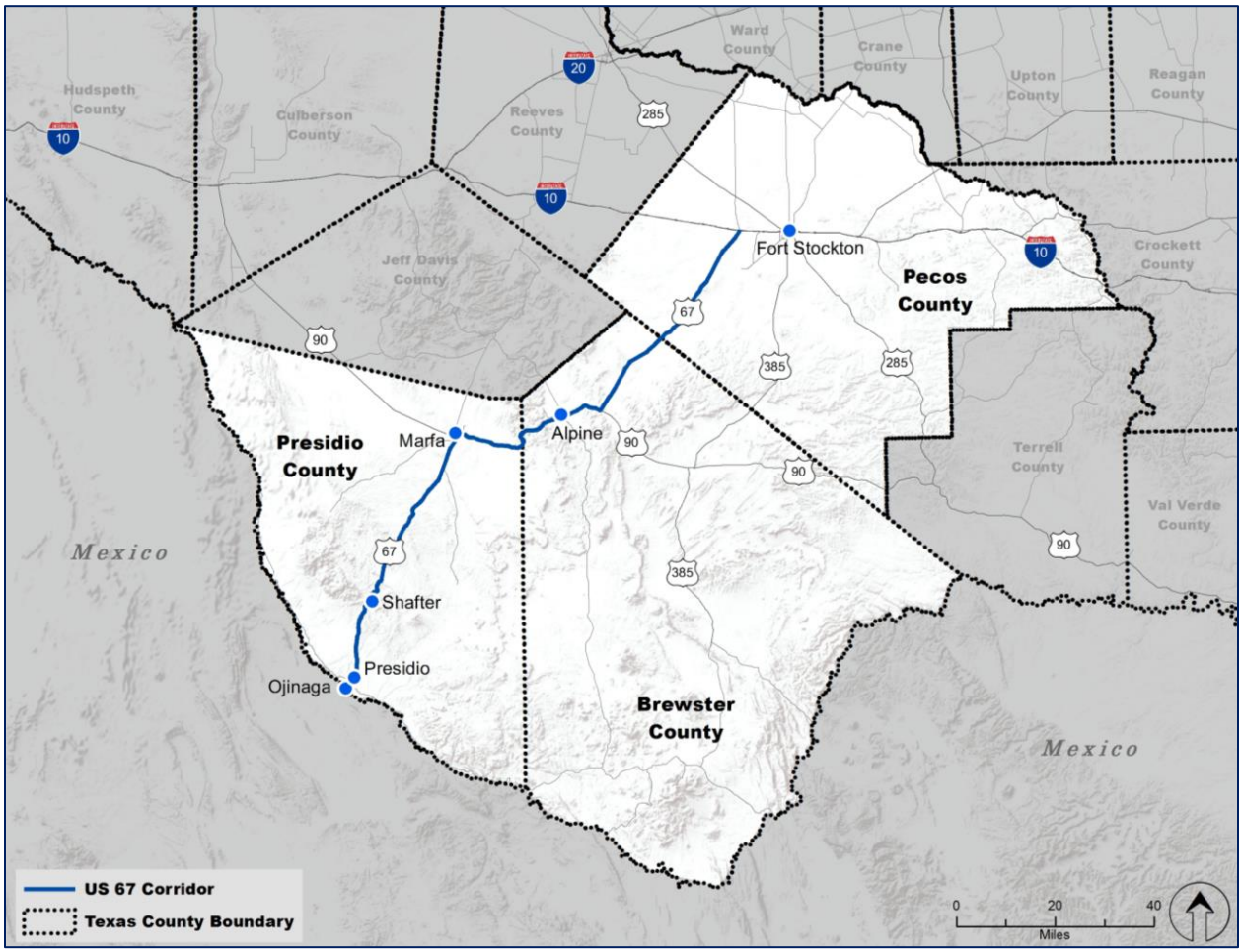


Figure 1: US 67 Corridor Master Plan Study Corridor

This document is consistent with all identified National/Regional ITS architecture, Federal Highway Administration ITS rulemaking guidelines, and TxDOT documents provided.

The remainder of this memorandum is divided into four sections:

- **Section 2** identifies the existing ITS assets and regional planned projects.
- **Section 3** identifies the study corridor ITS needs, goals, and objectives.
- **Section 4** identifies potential implementations and solutions.
- **Section 5** provides conclusions and next steps.

2.0 Existing ITS Assets and Planned Regional Transportation Projects

The following section presents the existing ITS infrastructure and discusses planned improvements. Overall, the study corridor has limited existing ITS applications or infrastructure. Existing cameras, weather sensors, and communications infrastructure are currently not used for corridor traffic operations.

2.1 Existing ITS and Transportation Systems Management and Operations Infrastructure

The US 67 study corridor falls under the rural area category, which is characterized by low traffic volumes and currently has limited ITS applications and infrastructure supporting its operation and maintenance. The ITS devices present in the corridor are as follows:

- Communications Infrastructure - Fiber optic cable and telephone lines privately owned by Big Bend Telephone Company run along the US 67 Right-Of-Way (ROW) between Presidio and Marfa and between Marfa and Alpine. Access to this communications infrastructure is through a subscription; as it is not a publicly owned asset.
- Roadway Weather Information System (RWIS) - RWIS are ITS assets that monitor pavement and weather-related information. Although, no TxDOT RWIS exists along the US 67 study corridor. Regional weather information is available from three weather stations at airports along the study corridor, including:
  - The Alpine-Casparis Municipal Airport has an Automated Weather Observing System (AWOS)[1] Level IIIP. This system measures various weather-related parameters such as visibility, wind information, temperature, dew point, barometric pressure, and precipitation.
  - Marfa Municipal Airport has an AWOS IIIP/T. The system measures all AWOS IIIP parameters, plus thunderstorm detection.
  - Presidio Lely International Airport has an AWOS IIIP/T. The system measures all AWOS IIIP parameters, plus thunderstorm detection.
- Traffic Cameras - No traffic surveillance cameras are present in the corridor. The Presidio POE has cameras that are used for internal functions including security and law enforcement. These cameras take pictures of vehicle license plates both exiting and entering the Presidio POE.

[1] National Oceanic And Atmospheric Administration https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/automated-weather-observing-system-awos

Additionally, traffic cameras are present at the Marfa Border Patrol inspection station; however, they are not available for public ITS use.

- Rest Areas/Pull out Areas - Several traveler rest areas are present along the US 67 study corridor. At some rest areas, an overnight stay is permitted. Most pull out areas lack restrooms, green spaces/parks, or dining places. These pull out areas are essentially paved shoulders where drivers are permitted to park their vehicles. These facilities are directly connected to the highway with no exits to secondary roads. The existing rest areas along the corridor are listed below:
  - Small rest area 3.5 miles west of Alpine
  - Small rest area east of Alpine at the US 67 and US 90 intersection
  - Small rest area 15.5 miles west of I-10 and US 67
  - Marfa lights rest area near the Marfa lights viewing area
  - Small picnic area between Fort Stockton and Alpine
  - Other very small pull out areas, or areas with trash cans along highways, such as the Cibolo Creek Ranch parking/viewing area

The existing rest areas/pull out areas lack any ITS assets such as cameras or smart parking applications. Also, no designated truck parking spots exist along the study corridor. As a result, trucks must park as needed at gas stations and small pull out areas.

2.2 Planned Regional Transportation Projects

The Texas Rural Transportation Plan (TRTP) 2035[2] identifies and ranks future transportation projects in rural areas throughout the state. The projects in the TRTP within the US 67 study area are largely geometric design upgrades to address and/or enhance safety and operations. Without a particular need, ITS is not an appropriate addition at these locations. Instead, ITS assets are being proposed for implementation in areas where safety and operation can be enhanced with technology applications.

The Statewide Long-Range Transportation Plan (SLRTP)[3] 2035, Chapter 5, defines the Texas Trunk System as "a network of four-lane divided rural highways to improve rural mobility, connect major activity centers, and provide access to ports of entry into Texas." US 67 within the study area does

[2] Texas Rural Transportation Plan 2035 https://www.txdot.gov/inside-txdot/division/transportation-planning/statewide-plan/trtp-2035-report.html

[3] Statewide Long-Range Transportation Plan 2035 https://www.txdot.gov/government/reports/statewide-plan/slrtp-2035-report.html

not meet the Texas Highway Trunk System criterion. There are no planned projects identified in the SLRTP along the US 67 study corridor.

3.0 ITS Corridor Needs, Goals, and Objectives

The overall study goals and objectives for the US 67 Corridor Master Plan have already been defined. The following section reviews the ITS specific needs that have been identified, ties them back to the study goals, and then develops the ITS objectives.

3.1 Summary of Issues and Needs

Issues and needs related to ITS applications were identified from the Safety Analysis Technical Memorandum (**Appendix D – Safety Analysis**), the Bus Tour #1 (December 12, 2017) Summary, and anecdotal information provided by TxDOT during several phone and in-person conversations.

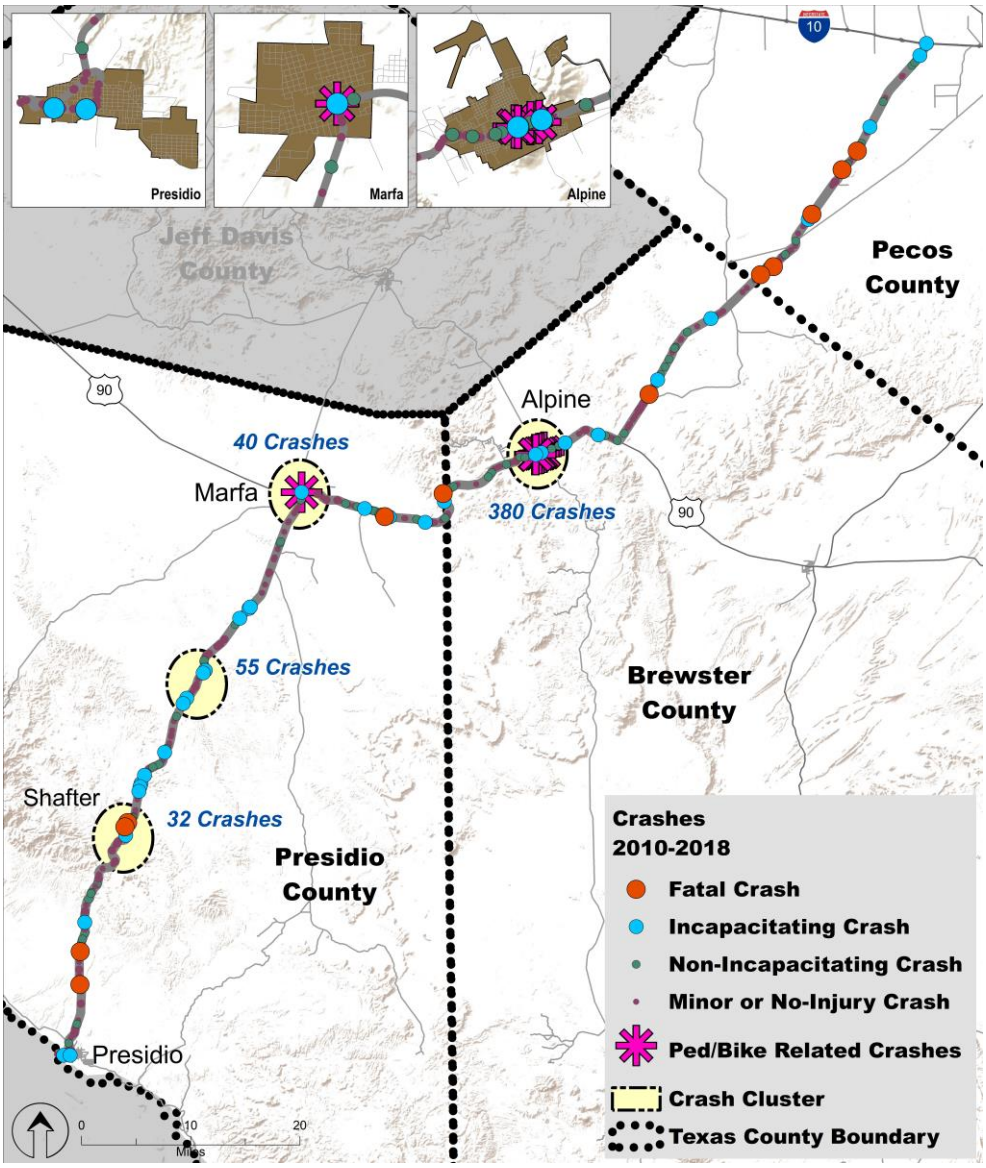
3.1.1 US 67 Safety Analysis Technical Memorandum

The US 67 Safety Analysis Technical Memorandum identifies safety and operational needs for the study corridor. ITS applications may address these safety and operational needs. Within the Safety Analysis Technical Memorandum, TxDOT Crash Records Information System (CRIS)[4] data was analyzed for the years 2010 to 2018. The Safety Analysis Technical Memorandum identified 878 total crashes along the corridor, summarized as follows:

- 731 crashes resulting in property damage only
- 100 non-incapacitating injury crashes. These are evident injuries such as bruises, abrasions, or minor lacerations which do not incapacitate.
- 35 incapacitating injury crashes. These are severe injuries that prevent the continuation of normal activities; including broken or distorted limbs, internal injuries, crushed chest, etc.
- 12 fatal crashes resulting in 15 fatalities

Figure 2 shows the 878 crashes along the US 67 study corridor between 2010 and 2018. Crashes tend to cluster in the cities of Alpine and Marfa, as well as on a few more remote segments, especially between Marfa and Presidio.

[4] Crash Records Information System https://cris.dot.state.tx.us/public/Query/app/welcome



Source: TxDOT Crash Records Information System

Figure 2: US 67 Crash Density Map for All Crashes between 2010 and 2018

The Alpine, Marfa, and Presidio communities accounted for many of the crashes; however, crash clusters exist in the areas between these communities. Highlights from the Safety Analysis Technical Memorandum are as follows:

- Out of the 878 crashes, 478 (54 percent) were roadway departure/run-off-the-road crashes resulting in 92 severe injury crashes. No clear cluster of data at specific locations is identified, as roadway departure crashes accounted for the majority of crashes. Eighty-seven crashes

involved severe injuries or fatalities that occurred between the cities (non-intersection related).

- Out of the 878 crashes, 375 (43 percent) of the crashes occurred in Alpine, compared to 58 (six percent) in Marfa and Presidio. Just over half, 445 (51 percent), of the crashes occurred between communities outside of Alpine, Marfa, and Presidio. Severe crashes in Alpine made up 31(eight percent) of the total 375 crashes. Of the 31 severe crashes, 20 occurred at intersections. Two of the eight pedestrian and bicycle-related crashes in Alpine were incapacitating injury crashes.
- Nine crashes involved a bicycle or pedestrian, with three of them being incapacitating pedestrian crashes. Eight occurred in Alpine and one in Marfa.
- There were 127 reported crashes involving animals in the roadway, with eight of them being severe crashes.
- There were 50 crashes that involved commercial motor vehicles, of which seven were severe crashes.
- There were two crashes involving a train at the Old Alpine Highway. The crashes were minor or no-injury crashes.
- Between communities, out of the 103 non-intersection related severe crashes, 87 crashes (84 percent) were run-off-the-road crashes, 11 crashes (11 percent) were head-on crashes and five crashes (five percent) were other types of crashes, such as rear-end and angle collisions.
- Out of the 87 severe non-intersection run-off-the-road crashes, 30 (34 percent) of them happened on a curve and 57 (66 percent) happened on a straight segment.

3.1.2 Bus Tour #1 and Corridor Working Group meetings

The second source of operational and safety issues was identified through the Bus Tour #1 (conducted on December 12, 2017) Summary. The summary provided a range of operational observations from local officials and stakeholders within the study corridor. **Table 1** summarizes the issues identified from Bus Tour #1 and the Corridor Working Group meetings summaries.

Table 1: Issues Identified along the Corridor

	Issues	Location
1	Short and limited number of passing lanes and no signage	Along the corridor
2	High crash frequency. Boredom, fatigue, distraction, and wildlife were the primary issues	Between Marfa and US 90 in Alpine
3	High fatalities. Many of the motorists were not using seatbelts	At the intersection of US 67 and US 90 (east of Alpine)
4	Motorists must make a complete stop on the railroad crossing coming from 75-mph curves on both sides of the track. Also, there is no advance warning before the curves	South of I-10 (parallel to Old Alpine Hwy) in Pecos County
5	Lack of pull-over areas and shoulders	Alpine to I-10 segment
6	Low clearance bridges (railroad and others) for mobile homes and trucks	West of Alpine
7	Icy road conditions. Paisano Pass 15-20 degree drop in temperature, recent snow events, and rockslides in some locations	Paisano Pass
8	Blind curve/limited sight distance	Along the corridor/Elephant curve (east of Marfa)
9	Drop in speed limits	Between Marfa Lights and City of Marfa
10	Four-way intersection with flashing red-lights	Marfa
11	Steep drops and no guardrails	Marfa to Presidio
12	High speed at curves	Along the corridor
13	Alpine and Marfa have noted bicycle and pedestrian safety issues	Downtown areas

Some of the issues noted in the bus tour can be addressed through ITS applications. For example, systems to enhance bicycle and pedestrian safety in the urbanized areas, warn motorists of icy or foggy conditions, and advise drivers of sharp curves or drops in speed limits. These solutions will be explored further in **Section 4.0**.

3.1.3 Other Needs

On the surface, the operational issues identified in the Safety Analysis Technical Memorandum and the bus tour can be generally categorized as safety-related. However, the ITS tools that address many of these issues often fall into two other categories: traveler information and incident management. For example, an icy road is a safety issue, but some of the tools used to address the condition could be defined as traveler information.

Traveler information can be tourism-related, weather-related, work zone related, or traffic condition related. In today's world, there are more options to communicate with motorists, such as smartphone applications. However, for applications that depend on crowd-sourced data, accuracy and availability in rural areas are more limited. In addition, as identified through public input, there are segments of the US 67 study corridor that lack cell phone coverage. Although traditional methods such as Dynamic Message Signs (DMS) are more expensive and point-specific, it is often important to provide services

that are sufficient in coverage and are provided in such a manner that all motorists can benefit from the information.

Incident management is an ever-present need that is rarely identified directly by the user but can be critical to emergency response. The medical industry refers to the "golden hour," i.e., if a person can get proper medical treatment in the first hour after sustaining an injury, his or her chance of survival increases dramatically. In rural areas, this can be challenging when the nearest emergency responder may be 20 miles away. Reducing notification time, providing an accurate assessment of conditions, and ensuring timely emergency response are all needs for the study corridor.

3.2 ITS Goals and Objectives

The needs defined in **Section 3.1** must be formally translated into goals and objectives. A set of goals and objectives have been established for the overall US 67 Corridor Master Plan. Aligning the ITS goals with these overarching goals of the corridor master plan is important. The seven overall goals for the US 67 Corridor Master Plan are:

- Improve Safety
- Improve Emergency Response
- Promote Sustainability
- Maintain a State of Good Repair
- Support Economic Development
- Enhance Multimodal Connectivity
- Improve Mobility

Each corridor goal is matched with a set of objectives. The ITS needs align well with several of the corridor goals. In addition, applications of Transportation Systems Management and Operations (TSMO) can address many of these goals. However, the overall corridor goals that are typically best addressed using ITS are the goals related to safety, emergency response, enhanced connectivity, and improved mobility. These goals are broad enough that some ITS efforts cut across more than one goal area. For example, one project alone can address safety, emergency management, enhanced connectivity, and improved mobility simultaneously.

A considerable amount of public outreach and internal needs assessment was completed for the study prior to developing the ITS needs. The notes and results of those meetings have been used along with the goals, issues, and needs identified in the previous section to identify the following high-level objectives specific to ITS.

3.2.1 Improve Safety

According to the Federal Highway Administration, "In 2012, 19 percent of the U.S. population lived in rural areas, but rural road fatalities accounted for 54 percent of all fatalities. Even with reductions in the number of fatalities on the roadways, the fatality rate in rural areas is 2.4 times higher than the fatality rate in urban areas[5]." Safety was identified as a major focus of the US 67 study corridor Master Plan through public outreach and crash data analysis. For more detail on crash trends on the study corridor including comparative statistics for similar rural routes, please see the US 67 Safety Analysis Technical Memorandum (Appendix D – Safety Analysis).

Capacity is not usually a primary issue for rural areas as compared to urban areas. However, the impact of growing traffic, motorists unfamiliar with the area, distracted driving due to long trips, and other risks are present on the US 67 study corridor. The crash rate on US 67 has varied slightly over the years, trending upwards from 2016 to 2018. It has surpassed the rural statewide crash rate for five of the nine years from 2010 to 2018. The following are the objectives that will assist the achievement of the goal to improve safety:

- Enhance travel safety along the study corridor through identified crash reduction measures.
- Enhance travel safety along the study corridor through public outreach campaigns.
- Provide advance warning of events to reduce secondary incidents.
- Provide safe travel in work zones.
- Provide enhanced pedestrian safety features in urban areas.
- Reduce road departure crash occurrence.
- Minimize the number of non-recurring incidents.
- Minimize the duration of incidents, expediting the response and clearance of incidents.
- Provide advance warning of lane-blocking events to reduce secondary incidents.

3.2.2 Improve Emergency Response

Providing timely and appropriate responses to incidents enhance safety and improve mobility along the corridor. The following are the objectives that will assist in the achievement of the improved emergency response goal:

- Provide means to notify authorities of new incidents.
- Provide means to verify the incidents to authorities.

[5] National Highway Traffic Safety Administration https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812050

- Expedite the clearance of hazards.
- Provide advance warning of lane-blocking events to reduce secondary incidents.
- Improve capabilities of local emergency responders.
- Coordinate with other agencies on incidents.

As important as having assets for incident management is the continuous Traffic Incident Management (TIM) training of emergency responders to make use of those available assets. In rural settings, in particular, incident response has unique challenges in preplanning, communications, scene assessment, advance warning, blocking, and clearance. Applying best practices in each stage and situation can have impactful results.

One example is providing positive protection for emergency responders at the scene of an incident. This practice is often accomplished with DOT maintenance vehicle support at an incident including the use of arrow boards and Portable Changeable Message Signs (PCMS). Alternatively, the fire department can provide their own protection with the proper training and meeting the proper standards of the state. As successfully done in Irving, TX, old fire trucks that would have been typically sent for auction, are turned into blocker trucks by adding arrow boards on each side and the rear of each vehicle. The control panel for the amber LED light arrow sticks can be programmed to flash in the desired direction of travel. These revamped trucks can be instrumental in alerting motorists of an incident or major event along the US 67 study corridor.

3.2.3 Enhance Multimodal Connectivity

In a rural corridor, transit service is generally limited; however, commercial vehicle traffic is often higher than most urban corridors. In rural corridors, connectivity for transit and commercial vehicles is typically less focused on new systems or infrastructure, but rather focused on information and operations. To successfully promote connectivity, the operations of the corridor must be considered as a whole, not isolated by mode. The purpose of improving transportation system operations is to maximize the safety, reliability, and efficiency of the transportation system, thereby increasing the benefits of the existing infrastructure and assets which improves operational performance and reduces long-term costs. The following are the objectives that will assist the achievement of the Enhance Multimodal Connectivity goal for US 67 study corridor:

- Collect and share current travel conditions data with other agencies.
- Increase availability and access to data for planning, operations, and programming purposes.
- Integrate operational improvements into capital project planning and design.
- Provide improved commercial vehicle service.

3.2.4 Improve Mobility

Armed with timely traffic information such as warnings for lengthy travel times, road work, incidents, and weather information, motorists can make informed decisions to plan their trip. Providing accurate information helps satisfy motorists and encourages compliant behavior to laws and regulations. The following are objectives that will assist in the achievement of the goal to Improve Mobility for the US 67 study corridor:

- Provide non-recurring and recurring event-related information to motorists.
- Provide advance warning of lane-blocking events so motorists can change or plan their trips.
- Provide real-time travel time and congestion limits for travel in work zones.
- Provide advance notice prior to environmental impact: snow/ice, rockslides, and dust storms.
- Provide information to travelers on congestion/incidents prior to reaching decision points.

4.0 Implementation of ITS and Transportation Systems Management and Operations

A wide variety of potential solutions have been identified in other reports as part of the US 67 Corridor Master Plan (Safety Analysis Technical Memorandum [Appendix D – Safety Analysis], summaries from the Corridor Working Group meetings, public meetings, and the Bus Tour #1). Many potential countermeasures were also identified in the Safety Analysis Technical Memorandum. Many stakeholders have offered suggestions on specific and general improvements. Some treatments have been investigated over the years including striping, geometric concerns, and rumble strips on the centerline, among other treatments. Most of these treatments are lower-cost physical treatments. These lower-cost Transportation Systems Management and Operations' treatments, however, are not ITS applications.

This section identifies potential ITS solutions for the issues identified in **Section 3.1.2**. The study team used several resources to identify potential ITS solutions for the US 67 study corridor:

- **National Center for Rural Road Safety Rural ITS Toolkit.** The Rural Intelligent Transportation Systems Toolkit was recently updated by the National Center for Rural Road Safety, which is a center funded by the FHWA.[6] The toolkit provides basic information about a selected set of advanced technology tools, in the form of individual fact sheets. There are a total of 42 rural transportation critical need fact sheets focused on the most common critical needs in rural areas today, including (1) Crash Countermeasures (CC); (2) Traffic Management (TM); (3) Operations & Maintenance (OM); (4) Emergency Services (ES); (5) Surface Transportation & Weather (STW); (6) Rural Transit & Mobility (RTM); and (7) Tourism & Travel Information

[6] National Center for Rural Road Safety https://ruralsafetycenter.org/resources/rural-its-toolkit/

(TTI). Each fact sheet provides detailed information including a description of the solution, applicability in a rural area, key components of the system, tips, examples of implementation, considerations before implementing, cost information, and additional resources.

- **US 67 Safety Analysis Technical Memorandum (Appendix D – Safety Analysis)**. Some of the safety concerns identified in the study may have ITS solutions, such as enhancing static wildlife crossing signs with active warning systems. The Safety Analysis Technical Memorandum also recommends some ITS countermeasures that include curve warning systems and treatments at railroad crossings and urbanized area intersections. These recommendations are discussed with the Rural ITS Toolkit solutions since the toolkit identifies technology applications that address those issues. The ITS tools that can address these treatments are the Road Geometry Warning System, Highway-Rail Crossing Safety Systems, and the Bicycle and Pedestrian Safety Systems.

- **Solutions developed by the study team**. The final source includes solutions developed by the team that are outside of conventional isolated systems. These are typically back-end communications and power infrastructure required to enable other ITS solutions.

The study team assessed potential ITS solutions for their applicability to the US 67 study corridor, based on the needs discussed in **Section 3.0**. Applicability to the study corridor was evaluated qualitatively with ratings of Low, Medium, and High. The study team also assessed the expected planning-level capital cost of each solution, using the same categories as the Rural ITS Toolkit:

- Low - $0 to $50,000
- Medium - $50,000 to $100,000
- High - $100,000 to $250,000
- Higher – Above $250,000

High capital cost was not used to eliminate potential solutions at this point in the study (although it may be a consideration later, as conceptual alternatives for the corridor are developed and evaluated). However, only solutions with at least medium level of applicability to the US 67 study corridor are presented below, with the exception of Vehicle Detection which is regarded as an enabling technology for several ITS applications relevant to the corridor.

Based on this evaluation and the issues already identified in previous sections, the ITS and Transportation Systems Management and Operations concepts shown in **Table 2** are proposed for consideration. The complete list of ITS solutions, including those with low or no applicability to the US 67 study corridor, is provided in **Attachment A**.

Table 2: Potential ITS Solutions for the US 67 Study Corridor

Tool #	Tool Name/Description	Capital Costs	US 67 Applicability
CC1	Animal Warning Systems	High	High
CC2	Automated Visibility Warning Systems	Medium to High	High
CC3	Bicycle Safety Systems	Low	Medium
CC6	Highway-Rail Crossing Safety Systems	Low to Higher	Medium
CC7	Intersection Collision Warning System (ICWS)	Medium to High	Medium
CC8	Pedestrian Safety Systems	Low	High
CC9	Road Geometry Warning System	Low to Higher	High
CC11	Speed Warning Systems	Low	Medium
CC12	Work Zone Safety Systems	Low to Higher	Medium
TM2	Variable Speed Limit (VSL)	Low to Higher	Medium
TM5	Vehicle Detection	Low	Low*
TM8	Planned Special Event Management Systems	Low to Higher	High
OM2	Site Management During Rockslides	High to Higher	Medium
ES1	Next Generation 911	Higher	Medium
ES2	Smartphone Applications for First Responders	Higher	Medium
ES3	Crash Reporting	Low to Higher	Medium
ES4	Automatic Crash Notification Systems	Low	Medium
STW1	Integrated Weather Monitoring/Prediction Systems	Low to Medium	High
TTI3	Dynamic Message Sign (DMS)	Low to Higher	Medium
TTI4	Integrated Traveler Information Systems	Higher	High
TTI5	Social Media	Low	Medium
Other	Power and Communication	High	High
Other	Traffic Surveillance	High	High

***** Retained because vehicle detection is an important enabler for other ITS applications.

Legend:

Capital Costs: Low ($0 to $50,000), Medium ($50,000 to $100,000), High ($100,000 to $250,000), Higher (Above $250,000) (Source: Rural ITS Toolkit)

US 67 Applicability: Low, Medium, High

Detailed descriptions of these solutions are provided in the following sections. Note that the Rural ITS Toolkit includes all the ITS applications that were identified in the Safety Analysis Technical Memorandum. Those applications are discussed in **Section 4.1**. Solutions included in the 'Other' category are best thought of as enabling infrastructure for potential future ITS applications.

The intent of this memorandum is to identify the tools that could apply to provide a more complete description of potential solutions. In the next step of the study, these tools were discussed with the stakeholders. As a result, some tools were superseded due to low applicability to the US 67 study corridor. The most relevant tools were further refined and are presented in the ITS Plan Technical Memorandum (**Appendix G – Intelligent Transportation Systems (ITS) Plan**).

4.1 Rural ITS Toolkit Solutions for the US 67 Study Corridor

The following sections describe the Rural ITS Toolkit solutions identified through the process described above. Potential solutions recommended by the Safety Analysis Technical Memorandum (Appendix D – Safety Analysis) are also included.

4.1.1 Crash Countermeasures (CC)

This category includes tools that are focused on reducing crash frequency and severity. The tools identified as relevant to the US 67 study corridor operations for short- and mid-term implementations are listed below:

- Animal Warning Systems (CC1)
- Automated Visibility Warning Systems (CC2)
- Bicycle Safety Systems (CC3)
- Highway-Rail Crossing Safety Systems (CC6)
- Intersection Collision Warning System (CC7)
- Pedestrian Safety Systems (CC8)
- Road Geometry Warning System (CC9)
- Speed Warning Systems (CC11)
- Work Zone Safety Systems (CC12)

CC1 Animal Warning Systems

This system helps to mitigate vehicle collisions with large animals using electronic sensors to detect animals. The animal warning system is a signboard that activates flashing lights when an animal is detected (see **Figure 3**).

http://tranbc.ca/wp-content/uploads/2016/02/H3-WDP-Sign-ACTIVATED.jpg

Figure 3: Animal Warning Systems

These systems generally have inconsistent success across the country. Some common problems are related to false detections, lack of driver compliance, and high maintenance costs. They often work best when isolated to a specific location rather than applied over a larger length of road. In locations with known issues, benefit-cost analysis is recommended to determine if detection or a different countermeasure like fencing is more suitable.

One hundred and twenty-seven (14 percent) of the crashes on the US 67 study corridor involved an animal. Most animal collisions along the corridor occur between Presidio and Marfa. If this

technology is proposed for the corridor, it should probably be installed at a few known animal crash hotspots since these treatments tend to be expensive and localized.

CC2 Automated Visibility Warning Systems

This system warns drivers by providing severe weather conditions information like fog, snow, dust, smoke, etc. (see **Figure 4**). The sensors required are typical of standard RWIS systems. The Automated Visibility Warning Systems also require Dynamic Message Signs (DMS), flashing lights and a traffic management center. Flashing lights will activate or messages will display on the DMS when severe weather conditions are detected. DMS is also coordinated with the traveler information system to spread the message.

https://encryptedtbn0.gstatic.com/images?q=tbn:ANd9GcRWR7hdeL6lRo0gDdSJhV5KlNUZM25SKQ-X3TbjOCE3jkoY_HO7yw

Figure 4: Automated Visibility Warning Systems

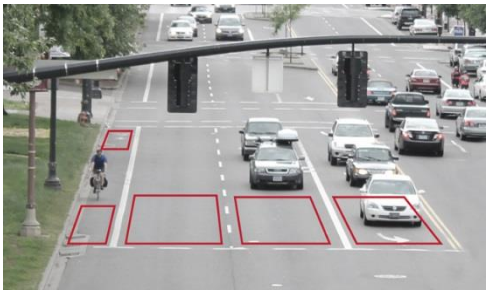
Three issues have been noted along US 67: snow/ice, rockslides, and dust storms. From the Bus Tour #1 notes, various local agencies have an established procedure for addressing snow events. Fog is generally an issue in the mountainous curves between Presidio and Marfa. Automated Visibility Warning Systems (AVWS) will rely on weather stations. The crucial step is obtaining the information in advance. Even though the weather stations are likely to be located away from the US 67 study corridor, the AVWS are monitored by one or more agencies along the corridor. This low visibility technology allows an agency to identify when parameter values for wind speed or visibility are exceeded, and then monitor and send alerts or notifications to various stakeholders. These stakeholders could be TxDOT maintenance, dispatch staff, and/or law enforcement. These notifications are useful to place responders into high alert on the potential for severe weather events. In the event of severe weather, this system would disseminate real-time information to motorists in or approaching the corridor via DMS, and 511[7] phone/website and network surveillance systems at pre-determined closure points.

A fog detection system may be an appropriate solution for Paisano Pass, where fog and low visibility are often a concern. Such a system could use sensors to detect low visibility conditions and flashers to warn motorists.

[7] The 511 system is a national traveler's resource set up and run by the U.S. Department of Transportation's (DOT) Federal Highway Administration (FHWA). The system allows drivers in participating states/cities to dial "511" on their phones and receive real-time traffic information. https://www.dmv.org/travel/511.php#What-Is-the-511-Traffic-System

CC3 Bicycle Safety Systems

This tool helps to identify/detect the presence of a bicycle and increases the safety and visibility of a bicyclist. This system can be installed at crossings as an automated or pushbutton device (see **Figure 5**). Some of the bicycle safety systems are as follows:



https://nacto.org/wpcontent/uploads/gallery/2012_detectionactuation/videodetection_portland_or.jpg

Figure 5: Bicycle Safety Systems

- Protected yet concurrent signal phasing
- Red-light cameras
- Automated speed enforcement systems
- Green wave programs (corridor signal coordination)
- Bicycle warning systems (tunnels, bridges, roadway crossings)

As noted above, nine crashes involved a bicycle or pedestrian with three of them being incapacitating pedestrian crashes. All of them occurred in Alpine and Marfa. Currently, there are no bicycle lanes in these areas. Based strictly on total numbers, the data indicates that bicycle/pedestrian safety is not an issue. However, with almost one-third of the bicycle/pedestrian crashes resulting in severe injury, the concept warrants investigation. In addition, there is an active bicycle group in Marfa (http://www.bikemarfa.com/) that runs several events throughout the year, and a lot of tourists take bicycle rides in the mountains. The need exists to maintain the safety record and make the study corridor safe and friendly for cyclists.

Overall, the available data suggests that these systems should be targeted towards a few strategic locations in Marfa and Alpine and supplemented with public awareness and education campaigns.

CC6 Highway-Rail Crossing Safety Systems

This system notifies the train operator of a delayed vehicle on the tracks and informs motorists of an oncoming train using a DMS or Blank Out Signs (BOS) (see **Figure 6**). This system can use any of the following to support its operation: access control gates, flashing lights, DMS, vehicle detection, in-vehicle sensing, traffic signal preemption, and integrated traveler information systems. It improves safety and communications and reduces congestion.

https://www.mobility.siemens.com/mobility/global/SiteCollectionImages/rail-solutions/rail-automation-new/level-crossing-protection-systems/simis-lc-large.jpg

Figure 6: Highway-Rail Crossing Safety Systems

At the railroad crossing south of I-10 in Pecos County, buses must make a complete stop at the railroad crossing coming from 75-mph curves on both sides of the track and lacking adequate sight distance. As traffic volumes increase in the future, a system could be implemented that provides warning flashers when vehicles are

stopped (or slow) near the railroad crossing. Advance railroad crossing warnings before the curves are also suggested. Other locations may need similar stand-alone treatments.

CC7 Intersection Collision Warning Systems (ICWS)

This tool is useful at intersections where one direction is stop-controlled and the other direction is uncontrolled. It informs drivers about an approaching vehicle at crossings (see **Figure 7**). This tool uses DMS to display the details of approaching vehicles to the drivers approaching or waiting at the intersection.

http://www.itsinternational.com/_resources/assets/inline/custom/72/105115.jpg

Figure 7: Intersection Collision Warning Systems

Rural area intersections with stop-controlled and uncontrolled intersections will be the most challenging due to the high-speed nature of through traffic in rural areas.

Intersections are a safety issue for the corridor. For example, of the 31 severe injury crashes in Alpine, 20 occurred at an intersection. However, the majority of the ICWS systems are more applicable for intersections at divided rural expressways, or in dense urban areas with limited visibility. Therefore, additional investigation is needed to determine appropriate locations for these systems in the rural sections of the corridor. The US 67 Safety Analysis Technical Memorandum (Appendix D – Safety Analysis) presents additional analysis at intersections.

CC8 Pedestrian Safety Systems

These systems alert motorists of the presence of pedestrians to improve pedestrian safety while crossing roads (see **Figure 8**). This system has multiple options to choose from:

http://www.floriance.eu/wp-content/uploads/2017/08/APL-Smart.gif

Figure 8: Pedestrian Safety Systems

- Red-light enforcement cameras or no-turn-on-red signals.
- Variable speed limit.
- Countdown signals/illuminated walk signal pushbuttons.
- Flashing crosswalk lights/pedestrian hybrid beacon/road lighting technology.
- Automated pedestrian detection systems for traffic signals.

Over the past eight years along the US 67 study corridor, eight crashes involved a pedestrian and one crash involved a bicycle. One crash occurred in Marfa and the other eight in Alpine. None of them were fatal. A simple safety improvement is to enhance striping for the crosswalks in the downtown Alpine area. These systems work well when combined with bicycle safety systems and are recommended for the urbanized areas of the corridor.

CC9 Road Geometry Warning System

This system warns road users of ramp rollover risks, sharp curves, steep downhills and heights of structures/over-height vehicles. This system primarily benefits heavy vehicles by warning them in advance using signboards/flashing beacons. These could be supplemented with traffic sensors. (see **Figure 9**).

https://www.tapconet.com/solar-led-division/overheight-warning-system

Figure 9: Road Geometry Warning System

Signals can take the form of single or multiple flashing displays. They may be installed by themselves, in conjunction with a traffic sign, or as an integral part of a warning sign. Overuse of advance warning flashing signals may reduce their impact and effectiveness; therefore, they should only be used when other alternatives (i.e., traditional signage) have been exhausted.

The system could be installed on the right side of the road, or both sides of the roadway, in sections with difficult alignments. They may flash permanently, for certain periods of the day, or only when triggered by an event. Some recommended applications along the US 67 study corridor are:

- At skewed intersections (intersection angle greater than 15 degrees), improvements could include installing flashing beacons at the intersection approach and providing an Automated Real-Time System to inform drivers of the suitability of available gaps for making turning and crossing maneuvers. However, due to the cost of the ITS technology, it may be more feasible to physically improve the intersection.

- At the two low-clearance rail bridges, both west of Alpine (13-feet 7-inches and 14-feet 9-inches in clearance height), truck warning systems can be deployed in advance of these locations to warn over-height vehicles to stop and turn around.

- Nineteen percent of the segments between communities consist of curves. Out of the 87 severe roadway departure crashes occurring in the segments between communities, 30 crashes (34.5 percent) occurred on curves. It is likely that more traditional treatments like static signage, striping, and rumble strips are more effective for these locations. Where safety issues persist, dynamic curve warning systems and interactive truck rollover advisory systems can be provided.

CC11 Speed Warning Systems

This system informs motorists about the speed of their vehicles, weather conditions, road geometry, and other factors. Various speed warning systems include:

- Road geometry speed warning systems.
- Speed detection and enforcement.
- Variable speed limit/dynamic speed feedback signs (see **Figure 10**).
- Dynamic curve/downhill speed warning systems.
- Vehicle-based monitoring and feedback systems/commercial vehicle operations speed warning systems.

https://safety.fhwa.dot.gov/roadway_dept/horicurves/fhwasa15084/ch4.cfm

Figure 10: Speed Warning Systems

Speeding is a contributing factor to some crashes along the US 67 study corridor. Rapid and unexpected speed limit drops have also been noted, for example when approaching Marfa from all directions. One potential application is to improve speed limit signage with flashers and possibly a speed curve warning system in advance of unexpected changes in horizontal alignment. Such a system could also be deployed before the curves near the railroad crossing in Pecos County. These applications could be part of a fog or dust storm detection system or a curve warning system.

CC12 Work Zone Safety Systems

This system enhances safety in and around work zones by alerting construction workers of any vehicle coming nearby and alerting motorists about the ongoing changes on a roadway such as a lane configuration change, congestion, alternative routes, and change in speed limit (see **Figure 11**). This system uses various ITS applications like speed compliance systems, dynamic late lane merge systems, queue detection systems, cameras, and Bluetooth detectors to monitor traffic. DMS and integrated traveler information systems can also be used.

https://www.srfconsulting.com/wp-content/uploads/2016/02/intelligent-work-zone.jpg

Figure 11: Work Zone Safety Systems

The system could include a vehicle detection and dynamic speed feedback system. These types of systems are available to most contractors who perform road construction or maintenance work. Smart work zone systems should be considered as part of any major construction project along the study corridor.

4.1.2 Traffic Management (TM)

This category provides tools that facilitate the identification of congestion and the management of traffic. Some of the tools identified as relevant to the US 67 study corridor operations for short- and

mid-term implementation are listed below. In addition, other ITS tools have been described for consideration in future efforts as the needs and demands of the corridor change.

- Variable Speed Limit (TM2)
- Vehicle Detection (TM5)
- Planned Special Event Management Systems (TM8)

TM2 Variable Speed Limit (VSL)

VSL is a tool used to lower the speed of vehicles traveling at high speed. VSL can be used in special circumstances (e.g. school zones, inclement weather conditions, poor pavement conditions, high traffic volume and operation speeds) and allows the operating agency to balance between the needs of safety and efficiency. VSL uses DMS (see **Figure 12**) to display the roadway conditions and can coordinate with RWIS and work zone safety systems.

VSL has been very successful in the U.S. when related to isolated weather conditions for specific sections of roads such as fog and snow for bridges or passes. Fog is a common problem at some locations along the US 67 study corridor.

VSL can also be used in congested areas. While there is minimal congestion in general on the corridor, congestion can also consist of cross-street traffic, specifically during special events.

VSL could be deployed as part of a fog or dust storm detection system or curve warning system.

https://k2radio.com/wydot-installs-variable-speed-limit-signs-on-part-of-i-90/

Figure 12: Variable Speed Limit (VSL)

TM5 Vehicle Detection

This tool allows agencies to identify vehicle presence, speed, weight, direction, and occupancy (see **Figure 13**). This tool enhances safety, provides travel-time information, reduces congestion, monitors travel flow, counts vehicles, detects queues, and identifies pedestrians/bicyclists. Vehicle detection can be installed in-road or over the road and it consists of various sensors.

https://cdn-images-1.medium.com/max/1200/0*D00EZ6px0y-ss4dd.pnghttps://www.verc.com/imports/medias/produits/photos/pcms-1210-portable-changeable-message-sign-ver-mac.jpg

Figure 13: Vehicle Detection

There are several different data items that may be collected, including counts, speeds, occupancies, and classifications. There are numerous different detectors on the market that address some or all of these items. In almost all cases, external power and communications are required to receive the data.

For the purposes of this study, vehicle detection systems are best viewed as an enabler for other desired applications. Therefore, there are no isolated vehicle detection projects. Rather, they are part of several other applications, including pedestrian and bicycle warning systems.

TM8 Planned Special Event Management Systems

This tool allows road users to obtain information about upcoming events through social media, traveler information systems, DMS (see **Figure 14**) and 511. It uses vehicle detection and cameras during the events to monitor traffic conditions and informs both road users and the authorities. It helps road users by instructing them to use alternative routes, times or transportation modes to avoid congestion. It also informs authorities about traffic conditions so that law enforcement personnel can be deployed to direct traffic.

https://www.verc.com/imports/medias/produits/photos/pcms-1210-portable-changeable-message-sign-ver-mac.jpg

Figure 14: Planned Special Event Management Systems

This application is potentially useful for the many special events in the region such as the Marfa Lights Festival, various county fairs, the TransPecos Festival, and various bicycle and running races. The ITS devices can be permanent or portable depending on the number of events per year. Existing social media and travel information sites should also be used to disseminate the information.

4.1.3 Operations & Maintenance (O&M)

This category includes tools that facilitate operations, enhance maintenance, or extend the longevity of transportation assets. Only one tool was identified as relevant for the US 67 study corridor operations:

- Site Management During Rockslides (OM2)

Note that this application has been adapted from the Rural ITS Toolkit's 'Site Management During Avalanches' tool. Avalanches are not an issue in the US 67 study corridor, but rockslides have been noted in some sections. The technologies used to detect the two events are similar.

OM2 Site Management During Rockslides

This tool informs the authorities and public of rockslide conditions within the rockslide prone areas (see **Figure 15**). Various sensors, access control gates, and DMS are used in this tool. Sensors like ultrasonic, geophones, tilt sensors, and environmental sensor stations are used to identify the risk of rockslides; vehicle detection sensors identify the number of vehicles in the rockslide prone areas. These sensors send a warning message to the authorities or maintenance staff. Access control gates will activate to stop the public from entering the risk area. DMS conveys the road conditions to the public.

https://upload.wikimedia.org/wikipedia/commons/c/c3/Falling_rocks_sign.jpg

Figure 15: Site Management During Rockslides

Rockslides are an issue at a few points along the US 67 study corridor. They generally occur at specific locations before and after Shafter and near the Paisano Pass. An ITS solution could be the addition of a monitor on cliffs and slopes to determine when rockslides occur. The system would then trigger warning signs to alert motorists until cleanup is complete.

4.1.4 Emergency Services (ES)

This category includes tools that support, facilitate, and expedite emergency response efforts. Some of the tools identified as relevant to the US 67 study corridor operations for short- and mid-term implementation are listed below:

- Next Generation 911 (ES1)
- Smartphone Applications for First Responders (ES2)
- Crash Reporting (ES3)
- Automatic Crash Notification Systems (ES4)

ES1 Next Generation 911 (NG911)

NG911 is an updated version of 911 services. In addition to 911 services, it allows the public to send photos, videos, and text messages (see **Figure 16**). This tool allows the dispatcher to identify the caller's location and sends the response teams, thereby providing faster response times. NG911 allows information sharing, and call rerouting with other 911 call centers. This tool requires computer hardware and software improvements and coordination with emergency response agencies (911 call centers, first responders, local hospitals, and others) combined with GIS mapping technology.

http://www.fedeng.com/images/911-mobile-phone.jpg

Figure 16: Next Generation 911 (NG911)

ES2 Smartphone Applications for First Responders

This tool improves the communication between the hospital and the Emergency Medical Technicians (EMTs) in the field when an incident occurs. EMTs can send photos, videos, and audio files to the nearest hospitals from the incident and can also receive the patient's records from the hospital. This tool can improve the response time by up to 50 percent and expedite the treatment process in rural areas. This project is more applicable to first responders.

ES3 Crash Reporting

This tool is an updated electronic version of regular crash reporting (handwritten on paper) in the field. The benefits of this tool include improved data accuracy, reduced time to fill out the report, better reporting consistency, and the ability to identify the location of an incident with coordinates. It provides detailed and accurate data to data analysts and traffic engineers. This tool uses hand-held or in-vehicle computers (see **Figure 17**). The Crash Records Information System (CRIS) data is compiled based on records sent to TxDOT from local law enforcement and could be either electronic or on paper, depending on the jurisdiction. CRIS data is used to compile and track crash data statewide in Texas.

Source: https://ruralsafetycenter.org/resources/rural-its-toolkit/

Figure 17: Crash Reporting

ES4 Automatic Crash Notification Systems

This tool conveys incidents like crashes and breakdown of vehicles to the appropriate vehicle response team (see **Figure 18**). It uses GPS receivers and a mobile phone installed in a vehicle to transfer the incident data to the response team (crash information, speed of a vehicle, airbag deployment, and direction of impact). This tool can be activated by a driver during breakdown or it can send the data automatically to the response team when a crash occurs. The US 67 study corridor is already added to the El Paso District TransVista Traffic Alerts System, where notifications are sent out as emails to users.

Source: https://ruralsafetycenter.org/resources/rural-its-toolkit/

Figure 18: Automatic Crash

4.1.5 Surface Transportation & Weather (STW)

This category includes tools that monitor weather conditions on the transportation network and mitigate weather-related impacts. There is a single tool that is relevant to the US 67 study corridor:

- Integrated Weather Monitoring/Prediction Systems (STW1)

STW1 Integrated Weather Monitoring/Prediction Systems

Integrated Weather Monitoring/Prediction Systems (see **Figure 19**) represent a combination of technologies that collect, transmit and disseminate weather and road condition information. This tool is also coordinated with the National Weather Service to predict inclement weather conditions. The component of an Integrated Weather Monitoring/Prediction System that collects weather data is an Environmental Sensor Station (ESS). The ESS measures real-time weather-related conditions, including pavement temperature, wind speed and direction, precipitation, water level conditions, humidity, and visibility. This data is transmitted to automated warning systems, the traffic operations center, and other maintenance/operations facilities for decision support.

http://media2.govtech.com/images/940/404/VAISALA_IDAHO_RWIS_TOWER.jpg

Figure 19: Integrated Weather Monitoring/Prediction Systems

Snow/ice and dust storms are sometimes present along the US 67 study corridor, and the safety analysis found nine severe roadway departure weather-related crashes along the corridor. As noted previously, it appears the various agencies have a good procedure for addressing snow events. Dust storms are generally an issue in the mountainous curves between Presidio and Marfa. These systems will rely on weather stations.

4.1.6 Tourism & Travel Information (TTI)

This category includes tools that expand or enhance the dissemination of travel conditions and tourism opportunities in the surrounding region. Some of the tools identified as relevant to the US 67 study corridor operations for short- and mid-term implementation are listed below:

- Dynamic Message Sign (DMS) (TTI3)
- Integrated Traveler Information Systems (TTI4)
- Social Media (TTI5)

TTI3 Dynamic Message Sign (DMS)

DMS usually displays short information on roadway conditions to motorists using a large electronic screen either installed as a portable, semi-permanent or permanent sign along the road (see **Figure 20**). DMS can be mounted on overhead gantries or located alongside the roadway as a separate mount. This tool coordinates with other ITS applications to display distance and/or travel times, traffic conditions, road incidents and safety/public service information. These signs are intended to change driver behavior, provide traveler information, and encourage motorists to choose alternate routes if applicable.

http://www.skylineproducts.com/wp-content/uploads/2016/07/Walk-In.jpg

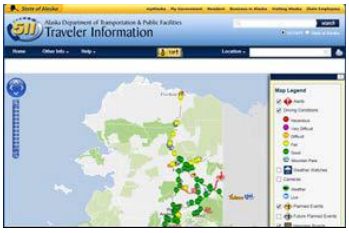
Figure 20: Dynamic Message Sign (DMS)

There is an overarching need for better traveler information and driver safety campaigns along the US 67 study corridor. DMS could be used to help meet this need. DMS placed before the access ramps to the rest stop areas/pull out areas can provide real-time parking, safety, and travel time information. These locations could also include cameras for incident and operations monitoring. This improvement will enhance safety by providing drivers with access information to rest areas, in particular to commercial vehicles that may need appropriate rest areas.

Another recommendation is to add small DMS approaching and leaving Presidio, Marfa, and Alpine. These DMS would be controlled by TxDOT but local authorities may be granted control. The DMS entering the communities can be used to inform travelers of incidents ahead in the urban area such as crashes and special events. The DMS leaving the towns should default to travel time information but can also be used for incident information, work zone information, or weather-related information–, and recommendations on variable speed limits.

TTI4 Integrated Traveler Information Systems

This tool helps travelers plan their trip before it begins or en route from origin to destination with more efficiency and safety. It collects all types of roadway information (e.g., road and weather conditions, congestion, tourism, real-time transit information) through various devices and transmits the information to the public using various means such as websites (see **Figure 21**), 511, DMS, social media, and radio.



Source: https://ruralsafetycenter.org/resources/rural-its-toolkit/

Figure 21: Integrated Traveler Information Systems

511 is a national traveler's resource initiated by the Federal Highway Administration. While the 511 term is a legacy of the initial desire to communicate with cell phones, the term is used to apply to any regional system that assembles and provides traveler information to motorists. 511 provides real-time traffic information such as road closures, accidents, weather alerts, and highway conditions along with other traveler information to drivers in participating states or cities, who can dial 511 on their mobile phones or use mobile phone applications. In Texas, the 511 system is only available in the Dallas-Fort Worth Metroplex area.

The key to many of the concerns on the US 67 study corridor is traveler information. TxDOT Intelligent Transportation Systems website[8] (also referred to as TransVista) provides traffic information (travel times, incidents, lane closures, cameras, DMS, border wait times) and emergency alerts (AMBER alerts, weather, and homeland security alerts) in Texas. The El Paso District is part of this system. On the US 67 study corridor, border wait times in the City of Presidio are available through the site. The US 67 study corridor does not have travel times, cameras and DMS available as part of this system. Any ITS device deployment should be interfaced with the TxDOT ITS website to allow for coordination and information dissipation within and outside the district. Also, with advances in social media, the use of statewide resources relative to traveler information can help to push information to travelers in the corridor. This applies to environmental, congestion, crash, and special event information.

TTI5 Social Media

Social media (see **Figure 22**) uses websites or mobile phones to share roadway information with users. This tool is growing rapidly and can provide roadway information faster.

Source: https://ruralsafetycenter.org/resources/rural-its-toolkit/

Figure 22: Social Media

4.2 Other ITS Improvements

This section briefly describes two technologies that may not be ITS solutions in and of themselves, but are important for providing the communications, power, and visual detection required for other potential solutions.

4.2.1 Power and Communications

All ITS depends on power and communications. Fiber optic cable is a technology that allows for the transmission of communications over large distances. Fiber optic infrastructure is generally used as the backbone for CCTV surveillance cameras, DMS, traffic sensors, and other ITS devices.

As noted above, private fiber is available along most of the study corridor. At certain spots, the provision of Wi-Fi/WiMAX might be easier along the corridor as that could be vendor independent. The addition of Wi-Fi/WiMAX would allow both for emergency communications from vehicles and pushing data/notices to vehicles.

Wireless communications can be accomplished through several standards or systems. Dedicated Short-Range Communications is an advanced technology that allows automobiles to communicate with other automobiles or the infrastructure using a wireless communications channel. Corridor communications can be through private cellular systems (e.g., 5G) or microwave backhaul.

New solar-powered equipment is constantly improved. CCTV, mobile technology, rural road traffic data collection systems and signage (both temporary and permanent) can all be run using solar-

[8] Texas Department of Transportation http://www.transguide.dot.state.tx.us/ELP/elp.htm

powered technology. In areas where solar power is the only viable source, it has proven to be invaluable, as the equipment does not need a utility power drop, which can be highly expensive and includes recurring costs. Additionally, solar power technology provides a cleaner and sustainable option.

Some of the challenges with solar-powered systems are the operations disruptions due to inadequate solar power configurations. For example, during mid-winter in Minnesota, annual sunlight hours are limited, and the cold weather deteriorates battery life. Cold weather climates are a challenge to the viability of solar-powered systems. Texas benefits from 135 clear days per year and is ranked 16 out of 50 states based on the annual sunlight hours in the US. Solar power is a viable source of electricity in Texas. Any design should look at local conditions.

Along a rural corridor, it is not practical to have frequent access to power and communications. Each connection is expensive. Therefore, to best take advantage of these connections when they are established, consolidation of many of the recommended systems into one "total station" is recommended. Since RWIS will likely be required at a few places along the system, cameras and traffic sensors should be co-located with those systems. This should minimize costs and improve maintainability.

The locations and details of the total stations are presented in the ITS Plan Technical Memorandum (Appendix G - Intelligent Transportation Systems (ITS) Plan). Total stations will be generally located between the cities of Presidio, Marfa, Alpine, and Fort Stockton to ensure coverage for efficient and prompt incident detection, management, and response. The locations were also chosen based on the proneness to weather impacts.

4.2.2 Traffic Surveillance Cameras

Traffic surveillance cameras are a major part of most intelligent transportation systems. On surface roads, they are typically mounted on high poles or masts, sometimes along with streetlights. Cameras permit the operating agency to view traffic conditions, such as congestion, crashes and other events. Cameras can be panned, tilted, or zoomed to provide operators with the best possible view of the roadway. Cameras assist operators and, ultimately, emergency responders with confirming, locating, and managing incidents, construction zones, and congested areas. Higher-end cameras may be able to see over a mile. Infrared cameras can also be used to see better in the dark and over longer distances. Cameras can be used in other applications, such as license plate recognition or stopped vehicle detection systems, but these cameras are serving more like a sensor than a surveillance tool.

5.0 Conclusions and Next Steps

At this time the US 67 study corridor has relatively few ITS assets, which is not unusual given its rural nature. However, some of the operational needs and concerns that have been identified in other tasks and through public outreach may have ITS solutions, including many that enhance safety, mobility, emergency response, and connections between travel modes.

The Safety Analysis Technical Memorandum for the corridor notes several geometric deficiencies and areas of concern throughout the study corridor. Most of these issues are best addressed either through geometric improvements or static signage. ITS solutions can be considered for those issues that remain, or where safety issues persist after physical treatments have been implemented.

The key step for the study effort overall was to define conceptual alternatives for the US 67 study corridor. Some of the conceptual alternatives involved ITS components. Once the conceptual alternatives were better defined, the team developed the US 67 ITS Plan Technical Memorandum. This plan identified the ITS strategies and applications that are applicable to the corridor, including a timeline for implementation and an assessment of the level of integration necessary to make the ITS strategies interoperable with the existing TxDOT ITS program.

Attachment A: Rural ITS Toolkit Applications

The table below presents a list of all the applications from the Rural ITS Toolkit as well as those generated by the study team, with their estimated capital costs and relevancy to the US 67 study corridor. The intent of this table is to identify the tools that could apply to provide a more complete description of potential solutions. In the next step of the study, these tools were discussed with the stakeholders. As a result, some tools were superseded due to low applicability to the US 67 study corridor. The most relevant tools were further refined and presented in the ITS Plan Technical Memorandum.

Tool #	Tool Name/Description	Capital Costs	US 67 Applicability	Notes
CC1	Animal Warning Systems	High	High	About 14 percent of the study corridor crashes involve an animal. These treatments are expensive and localized, so they should probably be limited to major crash hotspots (two to three locations).
CC2	Automated Visibility Warning Systems	Medium to High	High	Fog detection may be useful for the Paisano Pass or other mountainous areas. Dust storm detection could be implemented corridor-wide and linked to relevant Road Weather Information Systems and national weather stations.
CC3	Bicycle Safety Systems	Low	Medium	This should be supplemented with awareness and education campaigns.
CC4	Connected Vehicles	Low to Medium	Low	Studies are required to identify potential applications for Connected Vehicles along the corridor.
CC5	Wrong-Way Driver Detection & Warning System	Low	Low	The corridor is generally not divided by a median, so this application is probably of limited use.
CC6	Highway-Rail Crossing Safety Systems	Low to Higher	Medium	Applicable to the Texas-Pacifico rail crossing south of I-10. The system would include train detection systems and DMS at track for warning messages.
CC7	Intersection Collision Warning System (ICWS)	Medium to High	Medium	Generally, less applicable to urbanized areas. More investigation is needed to determine ideal rural locations. The US 67 Safety Analysis Technical Memorandum presents additional analysis at intersections.
CC8	Pedestrian Safety Systems	Low	High	There were two severe injury pedestrian crashes in Alpine and one in Marfa.
CC9	Road Geometry Warning System	Low to Higher	High	Nineteen percent of the segments between communities consist of curves. Thirty-four and a half percent of severe roadway departure crashes along the corridor occurred on these curves. The low bridges in west Alpine are a hazard for trucks.

Tool #	Tool Name/Description	Capital Costs	US 67 Applicability	Notes
CC10	Smart Trucks	Low	Low	Adoption is most likely to be driven by the private sector.
CC11	Speed Warning Systems	Low	Medium	High speeds at curves are an issue. There are also unexpected speed limit drops, for example, when entering towns.
CC12	Work Zone Safety Systems	Low to Higher	Medium	These systems are common and available to most contractors.
TM2	Variable Speed Limit (VSL)	Low to Higher	Medium	These systems are already part of other treatments, namely Automated Visibility Warning System and Road Geometry Warning System.
TM4	Interconnected Signal Systems	Low to Medium	Low	Applicability is limited since there are no traffic signals along the study corridor.
TM5	Vehicle Detection	Low	Low*	Enabling application for other systems including bicycle and pedestrian safety systems.
TM6	Monitoring Travel Times and Speeds	Low to Higher	Low	Congestion is generally not much of an issue in the corridor.
TM7	Parking Management Systems	Low to Higher	Low	There is a general lack of reasonable commercial vehicle accommodations at rest stop and pull out areas.
TM8	Planned Special Event Management Systems	Low to Higher	High	Marfa Lights Festival, County fairs, Trans-Pecos Festival, various bicycle, and running races.
TM9	Rural Traffic Management Center (TMC)/Traffic Operations Center (TOC)	Higher	Low	Given the high capital cost and low applicability to this corridor, using statewide traveler information would be more cost-effective.
OM2	Site Management During Rockslides	High to Higher	Medium	Rockslides have been noted as an issue.
OM3	Global Positioning System (GPS) Data	Low to High	Low	Would require ongoing data purchases; may not be justified given the low volumes.
ES1	Next Generation 911	Higher	Medium	Could improve emergency response, especially if coordinated between TxDOT, law enforcement, first responders, and private collision notification services.
ES2	Smartphone Applications for First Responders	Higher	Medium	Could expedite medical treatment for injury crashes.

Tool #	Tool Name/Description	Capital Costs	US 67 Applicability	Notes
ES3	Crash Reporting	Low to Higher	Medium	Provides efficiencies in crash reporting and may improve the accuracy of records.
ES4	Automatic Crash Notification Systems	Low	Medium	Can reduce response times, but gaps in cellular service (which are present in the corridor) will cause communications issues.
ES6	Unmanned Aerial Systems (UAS)	Low to Higher	Low	The regulatory environment for UAS is still uncertain.
STW1	Integrated Weather Monitoring/Prediction Systems	Low to Medium	High	Nine severe weather-related crashes. Snow/ice and dust storms are noted issues along US 67.
TTI2	Crowdsourced Data	Low to High	Low	Most applicable to larger cities and likely to be private-sector driven.
TTI3	Dynamic Message Sign (DMS)	Low to Higher	Medium	There are no existing DMS in the corridor, but they could be used to deliver traveler information at strategic locations.
TTI4	Integrated Traveler Information Systems	Higher	High	Social media can be used to enhance traveler information.
TTI5	Social Media	Low	Medium	Use to enhance other traveler information sources.
Other	Power and Communication	High	High	Further study is required to understand coverage gaps and the feasibility of tapping into existing private infrastructure.
Other	Traffic Surveillance	High	High	Several projects needed in the short-, mid-, and long-term. Infrared cameras are recommended. Snapshots can be used if communication is an issue.
TM1	Access Control Gates	Low	N/A	N/A
TM3	Geographic Information Systems	Low	N/A	N/A
TM4	Interconnected Signal Systems	Low to Medium	N/A	N/A
TM10	Adaptive Signal Control Technologies (ASCT)	Low to Higher	N/A	N/A
OM1	Weigh-in-Motion (WIM) Systems	Low to Higher	N/A	N/A

Tool #	Tool Name/Description	Capital Costs	US 67 Applicability	Notes
OM4	Fixed Automated Spray Technology (FAST)	Higher	N/A	N/A
ES5	Emergency Vehicle Traffic Signal Pre-emption	Low	N/A	N/A
RTM1	Coordinated Rural Transit Service	Higher	N/A	N/A
RTM2	Automated Stop Announcement Systems	Low	N/A	N/A
RTM3	Automatic Vehicle Location (AVL) on Agency and Public Vehicles	Low to Medium	N/A	N/A
TTI6	Public Transportation Trip Planner	High to Higher	N/A	N/A

N/A: Not Applicable

* Retained because vehicle detection is an important enabler for other ITS applications.

Legend:

Capital Costs: Low ($0 to $50,000), Medium ($50,000 to $100,000), High ($100,000 to $250,000), Higher (Above $250,000)

US 67 Applicability: Low, Medium, High

13 FT 7 IN
Texas Department of Transportation
PRESIDIO TEXAS
CITY of ALPINE
BREWSTER COUNTY
1882
THE CITY OF MARFA
MARFA TEXAS
OUR 67
US 67 CORRIDOR
MASTER PLAN