Strategic Research PROGRAM

COMPREHENSIVE TRANSPORTATION AND ENERGY SYSTEMS (CTES) – STRATEGIC RESEARCH ROADMAP

November 2015
## Abstract

In recent years, the United States has experienced a boom in energy production, particularly in extraction of oil and natural gas from shale formations and wind power generation. While the energy sector has had a positive impact on the Texas and US economies, energy developments, particularly those that rely on hydraulic fracturing technology, generate enormous amounts of truck traffic on state, county, and local roads. In recent years, the Texas A&M Transportation Institute (TTI) has developed a significant amount of expertise in critical areas related to energy developments. However, many of these initiatives are single efforts responding to specific sponsor needs. There is a need for a comprehensive approach to improving the overall management of transportation systems in all areas of the state with significant energy developments. TTI’s vision is to create a world-class research environment for transportation and energy systems that provides much-needed solutions and innovation in this field. The Comprehensive Transportation and Energy Systems (CTES) initiative at TTI will provide a focal point to conduct research, technology transfer, and technical support services to address critical transportation infrastructure needs in all areas where energy development business processes interact with transportation systems. This report describes a framework to achieve the initiative’s goals in the form of a strategic research roadmap that will guide future research and technology transfer activities. The report summarizes lessons learned from three regional workshops and discussions with stakeholders, describes the themes that make up the strategic research roadmap, and provides a list of proposed research ideas along with the corresponding research need statements. The report includes a recommended $9 million plan of research expenditures over a four-year period. To put the projected expense into perspective, the $9 million research plan is only slightly more than half the cost to develop one new horizontal well in Texas. This translates to $188–$234 per new completed well, based on the number of projected well completions over the next four years.

## Key Words

Oil and Gas Energy Developments, Hydraulic Fracturing, Fracking, Drilling, Transportation Systems, Pavements, Bridges, Safety, Operations, Planning, Policy
COMPREHENSIVE TRANSPORTATION AND ENERGY SYSTEMS (CTES)

STRATEGIC RESEARCH ROADMAP

by

Cesar Quiroga, Ph.D., P.E.
Senior Research Engineer

Report 161503-1
Project 10727
Project Title: Comprehensive Transportation and Energy Systems Initiative

November 2015

TEXAS A&M TRANSPORTATION INSTITUTE
College Station, Texas 77843-3135
DISCLAIMER

The contents of this report reflect the views of the author, who is responsible for the facts and the accuracy of the information presented herein. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ACKNOWLEDGMENTS

The author recognizes that support for this research was provided by the State of Texas.

This project received internal funding through the Strategic Research Program at TTI. Jon Epps, Bill Stockton, and Katie Turnbull provided critical guidance and support throughout the project. Their help is gratefully acknowledged. Several TTI staff members provided assistance planning, conducting, and processing notes in connection with the workshops in Arlington, Midland, and San Antonio. Their help is sincerely appreciated. Particularly noteworthy was the assistance provided by Michelle Williams, David Newcomb, Edgar Kraus, Allan Rutter, Ioannis Tsapakis, Jing Li, Bill Frawley, Jolanda Prozzi, Jon Epps, Linda Castillo, and Sonia Chapa.

The North Central Texas Council of Governments (NCTCOG) hosted the workshop in Arlington. Sincere thanks go to Christopher Klaus and Lori Clark for their help in hosting the event. The Midland Center hosted the workshop in Midland. Texas A&M University–San Antonio hosted the workshop in San Antonio. Special thanks go to Charles Rodriguez and Jacquelyn Longoria for their help in hosting the event.

A total of 96 individuals representing a wide range of organizations and agencies participated in the workshops. Their travel to the workshop locations (in several cases from out of town) and active participation in the workshops helped to make those events a success.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive Summary</td>
<td>vi</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Regional Workshops</td>
<td>3</td>
</tr>
<tr>
<td>Introduction</td>
<td>3</td>
</tr>
<tr>
<td>Workshop in Arlington</td>
<td>3</td>
</tr>
<tr>
<td>Data, Policy, Economics, and Planning</td>
<td>4</td>
</tr>
<tr>
<td>Coordination, Operations and Safety, and Pavement Repair</td>
<td>6</td>
</tr>
<tr>
<td>Workshop in Midland</td>
<td>8</td>
</tr>
<tr>
<td>Policy, Economics, and Planning</td>
<td>9</td>
</tr>
<tr>
<td>Data and Communications</td>
<td>11</td>
</tr>
<tr>
<td>Operations, Safety, and Pavement Topics</td>
<td>12</td>
</tr>
<tr>
<td>Workshop in San Antonio</td>
<td>15</td>
</tr>
<tr>
<td>Data, Communications, Policy, Economics, and Planning</td>
<td>15</td>
</tr>
<tr>
<td>Operations and Safety</td>
<td>17</td>
</tr>
<tr>
<td>Pavements and Bridges</td>
<td>19</td>
</tr>
<tr>
<td>Strategic Research Roadmap</td>
<td>22</td>
</tr>
<tr>
<td>Introduction</td>
<td>22</td>
</tr>
<tr>
<td>Summary of Research Needs</td>
<td>22</td>
</tr>
<tr>
<td>Strategic Research Roadmap</td>
<td>24</td>
</tr>
<tr>
<td>Communication, Coordination, and Cooperation</td>
<td>25</td>
</tr>
<tr>
<td>Transportation and Energy Development Data</td>
<td>26</td>
</tr>
<tr>
<td>Policy and Economics</td>
<td>26</td>
</tr>
<tr>
<td>Planning and Multimodal</td>
<td>27</td>
</tr>
<tr>
<td>Operations and Safety</td>
<td>27</td>
</tr>
<tr>
<td>Environment and Sustainability</td>
<td>27</td>
</tr>
<tr>
<td>Roadside Management</td>
<td>28</td>
</tr>
<tr>
<td>Pavement and Bridge Structures</td>
<td>28</td>
</tr>
<tr>
<td>Long-Term Funding Prospects</td>
<td>29</td>
</tr>
<tr>
<td>Research Need Statements</td>
<td>30</td>
</tr>
<tr>
<td>Anticipated Costs and Benefits</td>
<td>30</td>
</tr>
<tr>
<td>References</td>
<td>32</td>
</tr>
<tr>
<td>Appendix – Research Need Statements</td>
<td>33</td>
</tr>
</tbody>
</table>
EXECUTIVE SUMMARY

In recent years, the United States has experienced a boom in energy production, particularly in extraction of oil and natural gas from shale formations, and in wind power generation. While the energy sector has had a positive impact on the Texas and U.S. economies, energy developments, particularly those that rely on hydraulic fracturing technology, generate enormous amounts of truck traffic on state, county, and local roads. Many of these roads were never designed to carry such high truck traffic volumes and heavy loads. The result has been much faster degradation of the transportation infrastructure than anticipated. The energy and trucking industries have also been affected because poor roadway conditions have accelerated truck fleet wear and tear and dramatically increased vehicle repair costs.

In recent years, TTI has developed a significant amount of expertise in critical areas related to energy developments. However, many of these initiatives are single efforts responding to specific sponsor needs. There is a need for a comprehensive approach to improving the overall management of transportation systems in all areas of the state with significant energy developments. TTI’s vision is to create a world-class research environment for transportation and energy systems that provides much-needed solutions and innovation in this field. The Comprehensive Transportation and Energy Systems initiative at TTI will provide a focal point for research, technology transfer, and technical support services to address critical transportation infrastructure needs in all areas where energy development business processes interact with transportation systems.

This report describes a framework to achieve the initiative’s goals in the form of a strategic research roadmap that will guide future research and technology transfer activities. The report summarizes lessons learned from three regional workshops and discussions with stakeholders, describes the themes that make up the strategic research roadmap, and provides a list of proposed research ideas, along with the corresponding research need statements. The three workshops were held in Arlington, Midland, and San Antonio in the spring of 2015.

This brainstorming process enabled the identification of 63 topics. There were common themes as well as unique areas of interest among the 63 topics. Together, the feedback that participants provided were combined into 19 distinct research ideas that enabled the development of the framework and strategic research roadmap. These 19 research ideas were organized into eight major interconnected themes that make up the CTES framework: (a) communication, coordination, and cooperation; (b) transportation and energy development data; (c) policy and economics; (d) planning and multimodal; (e) operations and safety; (f) environment and sustainability; (g) roadside management; and (h) pavement and bridge structures.

The synergy and interdependence among research ideas means that some of the research needs to be conducted first because the resulting products are needed for other research initiatives. The report includes a recommended $9 million plan of research expenditures over a four-year period. The anticipated economic benefits are huge, with an anticipated 20:1 benefit-cost ratio. To put the projected expense into perspective, the $9 million research plan is only slightly more than half the cost to develop one new horizontal well in Texas. This translates to $188–$234 per new completed well, based on the number of projected well completions over the next four years.
INTRODUCTION

In recent years, the United States has experienced a boom in energy production, particularly in extraction of oil and natural gas from shale formations, and in wind power generation. According to US Energy Information Administration (EIA) statistics, crude oil production in the United States reached a minimum of 1.83 billion barrels in 2008 after decades of continuous decline, but then it began to increase, reaching 3.18 billion barrels in 2014. Natural gas production remained essentially flat from 1970–2006 (fluctuating between 19.1 and 24.5 trillion cubic feet per year), but then it began to increase, reaching 31.9 trillion cubic feet in 2014. Most of this increase was due to production in shale regions. Dry shale gas production increased from 1.29 trillion cubic feet in 2007 to 11.4 trillion cubic feet in 2013. In Texas, the average number of active drilling rigs at any given time increased from 494 in 2004 to 880 in 2014. At its peak during the second half of 2014, the largest number of active drilling rigs in Texas was 906. Texas has almost half of all active drillings rigs in the United States.

Nationwide from 2000 to 2013, wind power generating capacity increased from 2394 to 60,712 megawatts, and wind energy generation increased from 5.59 to 168 terawatt-hours. In Texas, during the same period, wind power generating capacity increased from 173 to 12,328 megawatts, and wind energy generation increased from 0.49 to 35.9 terawatt-hours. In relative terms, Texas’ share of all wind energy generation in the United States increased from 8.8 to 21.4 percent. Currently, Texas produces the most wind power of any state.

While the energy sector has had a positive impact on the Texas and US economies, energy developments, particularly those that rely on hydraulic fracturing technology, generate enormous amounts of truck traffic on state, county, and local roads. Many of these roads were never designed to carry such high truck traffic volumes or heavy loads. The result has been much faster degradation of pavement structures than anticipated, increases in crash and fatality rates, increases in congestion and air emissions, and degradation of roadside infrastructure such as shoulders, clear zones, driveways, and drainage structures. The energy and trucking industries have also been affected because poor roadway conditions have accelerated truck fleet wear and tear and dramatically increased vehicle repair costs.

Recent oil and gas energy developments are unique in many respects because of the combined use of horizontal drilling and hydraulic fracturing technologies. Historically, however, the oil and gas industry goes through wild swings between periods of intense drilling activity and periods where the level of activity is much lower. Many factors drive the occurrence and timing of these ‘boom-and-bust’ cycles, of which the price of oil and gas in international markets plays a critical role.

The number of wells completed in Texas peaked in the early 1980s at a time when oil prices were high, due in part to instability in the oil supply that resulted from the Iranian Revolution of 1979 and the beginning of the Iraq-Iran War in 1980. High oil prices encouraged energy conservation, which, in turn, resulted in lower consumption. The resulting oversupply caused a significant reduction in oil prices in the mid-1980s, which caused a corresponding reduction in the number of wells drilled. The number of wells began to increase substantially again in the early to mid-2000s thanks to increases in the price of oil and gas, as well as the combined use of horizontal drilling and hydraulic fracturing technologies.
After a period of high oil prices in the world market (at least $80/barrel for most of 2010 through October 2014, and $100/barrel or higher for most months from March 2011 to June 2014), the price of oil decreased rapidly during the second half of 2014, reaching $58/barrel in December 2014 (7). During the first half of 2015, the price of oil fluctuated between $45 and $57/barrel. It is not clear how long this trend will continue. In the short term, EIA anticipates the price of oil to vary from $40 to $52/barrel through December 2016. The number of drilling rigs has also decreased over the last few months. As of August 21, 2015, the number of drilling rigs in Texas was 383 (i.e., down from 906 in August 2014). The implications of these changes regarding the ability of agencies to operate and manage the transportation system effectively are not clear.

In recent years, TTI has been developing a significant amount of expertise in critical areas related to energy developments, ranging from pavement maintenance and repair techniques, development and assembly of massive energy-related databases, analysis of safety trends and countermeasures, commodity flows and supply chain analysis, and coordination with public-sector and private-sector stakeholders. However, many of these initiatives are single efforts responding to specific sponsor needs.

There is a need for a comprehensive approach to improving the overall management of transportation systems in all areas of the state where there are significant oil, gas, and wind energy developments. TTI’s vision is to create a world-class research environment for transportation and energy systems that provides much-needed solutions and innovation in this field. The Comprehensive Transportation and Energy Systems (CTES) initiative at TTI will provide a focal point to conduct research, technology transfer, and technical support services to address critical transportation infrastructure needs in all areas where energy development business processes interact with transportation systems. The needs are multidimensional, therefore calling for a multidimensional, multidisciplinary approach that will draw expertise from many groups, divisions, and programs across the Institute and the Texas A&M University System.

The CTES initiative will help local, regional, and state communities and industry stakeholders solve fast-growing problems using leading-edge research, technology transfer, and technical support. The opportunity for TTI will be even greater considering that many other countries are beginning to develop their own shale oil and gas fields using the same hydraulic fracturing technologies that were developed in the United States. TTI could offer research and technology transfer services to those countries, becoming in effect a world leader in this area.

This report describes the framework to achieve the initiative’s goals in the form of a strategic research roadmap that will guide future research and technology transfer activities. The report summarizes lessons learned from three regional workshops and discussions with stakeholders, describes the themes that make up the strategic research roadmap, and provides a list of proposed research ideas along with corresponding research need statements.
REGIONAL WORKSHOPS

Introduction

Three regional one-day workshops were conducted with public-sector and private-sector stakeholders to introduce the CTES initiative, discuss short-term and long-term issues, identify potential research ideas and implementation strategies, and identify potential partners:

- Arlington: Focus on North and Northwest Texas energy developments
- Midland: Focus on West Texas energy developments
- San Antonio: Focus on South Texas energy developments

A critical goal of the three regional workshops was to address the relationship between transportation networks and energy developments in a holistic manner. To achieve this goal, the workshops included breakout sessions to address topics such as, but not limited to, industry and public outreach and communication, pavement structures, operations and safety, roadside, asset management, planning, environment, and design. Table 1 shows the typical agenda at each of the workshops.

Table 1. Typical Workshop Agenda.

<table>
<thead>
<tr>
<th>Time</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30 AM</td>
<td>Registration</td>
</tr>
<tr>
<td>9:00 AM</td>
<td>Welcome and Introductions</td>
</tr>
<tr>
<td>9:15 AM</td>
<td>Texas A&amp;M Transportation Institute Overview</td>
</tr>
<tr>
<td>9:30 AM</td>
<td>Oil and Gas Developments in Texas</td>
</tr>
<tr>
<td>9:45 AM</td>
<td>Break</td>
</tr>
<tr>
<td>10:00 AM</td>
<td>Recent and Current Research and Technology Transfer</td>
</tr>
<tr>
<td>11:00 AM</td>
<td>Strategic Research Roadmap</td>
</tr>
<tr>
<td>11:30 AM</td>
<td>Lunch Break</td>
</tr>
<tr>
<td>12:30 PM</td>
<td>Breakout Group Discussions</td>
</tr>
<tr>
<td>2:30 PM</td>
<td>Breakout Group Presentations</td>
</tr>
<tr>
<td>3:00 PM</td>
<td>Next Steps and Adjourn</td>
</tr>
</tbody>
</table>

A summary of discussions and lessons learned at each of the workshops follows.

Workshop in Arlington

The North Central Texas Council of Governments hosted the workshop in Arlington. In total, 23 stakeholders representing state, regional, county, and local agencies; private industry; and academia participated in the event. Considering the level of interest expressed by participants, two breakout sessions took place:

- Data, policy, economics, and planning
- Coordination, operations and safety, and pavement repair
Participants indicated that stakeholders and agencies often have to dig through many data sources and perform cross-referencing, data cleaning, and other activities prior to conducting analyses. Federal, state, and local government agencies have data in a variety of formats, making it necessary to convert disparate data to compatible formats. This can be time-consuming, contributing to inefficiencies. Data boundary issues, particularly in the case of spatial data, also pose challenges. This makes it necessary to rectify data such as metropolitan statistical area (MSA), city, county, and other similar boundaries. A specific complaint by participants was the lack of compatibility of Texas Railroad Commission data with enterprise-level database systems at their agencies. Agencies cannot easily access well permit data in ways and formats that are suitable for analysis.

The Texas Department of Transportation (TxDOT) uses traffic count data, including data from weigh-in-motion (WIM) stations, to prepare monthly statistics. A challenge mentioned was that axle count data are available mainly on major freeways, but not on secondary roads or local streets. In some cases, classification counts have been conducted near disposal well site locations along I-35W, and changes from previous observations have been observed. A city representative expressed a need to conduct origin-destination (O-D) studies to understand traffic patterns in connection with well developments. A metropolitan planning organization (MPO) representative indicated that they conduct O-D surveys for large regional studies, but not for individual wells.

These observations led to a discussion about the potential value of a database and information clearinghouse where various agencies could enter or access data and studies, as well as look for information from similar agencies. Participants discussed how transportation planning could consider energy development data. A challenge mentioned was the lag between private-sector activity and the availability of the data, which can be months or even years.

A county participant indicated that they attempt to be proactive through the local permitting process. Some other strategies include using non-transportation-based data for transportation purposes, as well as coordinating city and county thoroughfare plans. Another issue that counties face is working with multiple cities that share boundaries in the urban/rural fringes.

TxDOT officials indicated that they spend considerable time developing projects, some of which end up staying on the books for a long time due to funding limitations. At the same time, they recognize that developing well sites can generate enormous amounts of traffic, but there is not an easy way to include those developments in the typical multi-year planning horizon for transportation projects. To a large degree, this is due to inadequate information from the oil and gas industry related to the amount of truck traffic that planned energy developments will generate. Without this information, it is difficult to identify what kind of surface transportation infrastructure might be necessary to support those developments. A related challenge is that trucking companies must be highly mobile to respond to the dynamic nature of the oil and gas industry.

One participant mentioned an issue with funding inequality related to the allocation formula that the Texas Legislature passed in 2013, in that some counties received considerable funding...
because trucking companies were headquartered there, even though the trucks actually operated elsewhere in the state.

There was considerable discussion on the limitations that counties face in managing the impact from oil and gas developments within their jurisdictions. County representatives indicated that counties need additional authority or help in a number of areas, such as the following:

- **Weight limits.** A county representative witnessed a county road being destroyed in one weekend. The road had to be completely rebuilt.
- **Road damage enforcement.** Counties would like to be able to say, “If you break it, you fix it.” A practical challenge is how to know who broke it.
- **Pavement materials, standards, and construction methods.** Counties need assistance in many areas related to pavement design, construction, and maintenance (e.g., determining which byproduct or surplus materials, if any, may be acceptable for road construction).
- **Truck routing enforcement.** Counties do not have enough advance information about permitted routes and do not have enough enforcement capabilities in place.
- **Staffing and funding.** Only a few counties in Texas have staff county engineers, so many depend on outside resources. Consultants can help, but a concern is that after finishing a project, they leave because they are no longer under contract and are no longer available on an ongoing basis. One county representative stated that they paid a consultant $46,000 for a thoroughfare plan but they have not seen the consultant since the plan was delivered, raising the question whether this business model is sustainable in the end.

Participants indicated that there has been some talk about increasing the extraterritorial jurisdiction (ETJ) control for cities, although apparently there has been some effort at the state legislature to reduce ETJs by half a mile.

Participants stated that the pay structure (i.e., by the load, instead of by the hour) for truck drivers causes them to do things they should not or probably would not do otherwise. Participants suspect that one of those things is loading trucks above the legal weight limit, resulting in damaged infrastructure that cities and counties are left to repair.

An MPO representative described an initiative that involved an oil services company to connect the MPO with drivers to learn about trip chaining patterns. Participants highlighted that there is a need for more research related to this issue, including differentiating between local trips and long-distance trips. Remote sensing technologies and applications would be helpful in this regard.

There was considerable discussion about traffic safety and enforcement, in particular whether it would be feasible to build the law enforcement infrastructure necessary to address safety issues. Participants were concerned that providing funding for traffic law enforcement in energy development regions was not a high priority at the state level. Some participants highlighted that the current emphasis at the state legislature was on repairing the road infrastructure.

A representative of a small city highlighted that it was very difficult for them to get adequate funding for enforcement. Federal safety regulation enforcement is the responsibility of the Texas Department of Public Safety (TxDPS). There is a population threshold in Texas beyond which
municipalities can have vehicle inspection authority, provided municipal police officers meet certain training and certification requirements. While there is proposed legislation to lower the population threshold, the question remains whether cities have equipment and resources to do inspections. Inspection training is intensive (i.e., 8–10 months for the initial class) and continues after that.

There was some discussion about compressed natural gas (CNG) conversions. There was a reference to a study that identified problems related to CNG conversions. A challenge is the limited number of contractors who can do the work. There are also staff limitations to process applications and permits. A participant complained that the paperwork for CNG conversion grants took a long time because of all the details required.

Coordination, Operations and Safety, and Pavement Repair

TxDOT officials have difficulties dealing with and integrating multiple datasets. A reason is that they have to spend a significant amount of time and effort becoming familiar with different data dictionaries, processing raw data, and updating datasets on a regular basis. Another problem is the lack of appropriate hardware and software to facilitate the data cleaning and data mining process. This problem is more acute in district and area offices where computer infrastructure capabilities are limited. As a result, TxDOT officials have to be very selective about the datasets with which they work, limiting the usability of the data.

A strategy to address this problem would be to develop and maintain a data warehouse that provides adequate access and support to stakeholders. In order to develop and maintain a centralized database, a proper structure would need to be implemented and different stakeholders would need to provide sufficient funding (e.g., in the form of a subscription or funding from the state legislature).

A common problem mentioned by participants was limited communication and cooperation among agencies. Some agencies do not have a formal mechanism in place to facilitate a meaningful exchange of data or information among stakeholders (e.g., when a state agency issues permits but does not integrate this process with, or even provide linkages to, the permitting processes at other state agencies, resulting in redundancies and inefficiencies to all the parties involved). As a result, agencies are not aware of each other’s needs, goals, and objectives. In practice, appropriate technical knowledge and infrastructure are needed to facilitate data and information exchange, but many agencies do not have access to these resources.

Participants discussed their experience regarding the time and effort required to develop working relationships with the oil and gas industry. TxDOT officials indicated that they do not currently communicate with energy companies, and previous efforts did not have positive results. In some cases, conflicts emerged at the beginning of a working relationship, and afterward, it was difficult for both parties to build trust.

Some city officials have managed to develop a working relationship with the energy sector. Cities typically have formal or informal meetings with single operators. Gatherings with groups of company representatives are not common. Initial discussions at the management or
administration level (e.g., between city managers and energy developer district managers) are the most effective way to build a working relationship. Other participants highlighted that county commissioners should initiate communication and coordination efforts.

Industry stakeholders mentioned that confrontational relationships have become less frequent, resulting in improved communications and cooperation that are more effective. They stated that the overall culture at private companies has changed, realizing that a key factor to achieve their goals should be to maintain a positive attitude and remain friendly with local officials and the media. At the same time, they have realized that some conflicts are not region-specific, but span multiple states. Some stakeholders dislike the industry and would object to whatever the industry attempts to do, while other stakeholders tend to be supportive.

Industry stakeholders highlighted the need to access infrastructure-related data (e.g., bridge height and width) and incorporate these data into navigation tools and maps that can help truck drivers avoid certain roadway segments. The tools should contain up-to-date roadway infrastructure information and reroute drivers, as needed. Such tools can be beneficial not only for the industry, but also for TxDOT because the number of structure-related crashes would decrease, along with the cost to repair that infrastructure. Participants also noted that energy service companies increasingly use global positioning system (GPS) technologies to monitor and control their fleet.

TxDOT officials highlighted the need to obtain truck traffic data (e.g., GPS coordinates) from the private sector because the data can be useful in a variety of applications (e.g., for transportation planning and pavement design purposes). A concern discussed was that some companies might not be willing to share data with state agencies because the data contain competitive and/or confidential information. Other participants suggested that the industry could provide the data in an aggregated, anonymized format by removing personal or confidential information. An example mentioned was that of the American Transportation Research Institute (ATRI). As the research arm of the American Trucking Associations Federation, ATRI has an ongoing program that focuses on developing performance metrics from truck GPS data. The resulting data are highly aggregated. Sharing this information with transportation agencies would be highly beneficial.

There was some discussion about formal structures to facilitate communication and coordination among stakeholders (e.g., through task groups that meet on a regular basis and enable stakeholders to share ideas, discuss problems and challenges, and identify strategies for improvement). An example of effective coordination practices is the regular meetings that utility owners and TxDOT have at the district and state levels. Prior experience shows that these meetings are beneficial because they enable the industry and TxDOT to understand each other’s challenges and issues, as well as formulate specific strategies that result in improvements in coordination practices.

The group discussed examples of permit fee structures that some cities have implemented. The City of Burleson requires permits for drilling within city limits. They also have a fee structure to recoup damages to roadway infrastructure. As part of the process, well developers provide a map and a video of the routes that the trucks will follow. City officials use this information to assess the conditions of the selected routes. Depending on the type of road and its pavement condition,
city officials assign a score to every segment. The initial fee is higher if the development involves a new construction pad than when additional wells are developed on an existing pad. The City of Cleburne also has well permit fees and a bond and insurance program that enables the city to recoup damages to city streets or other city property caused by the equipment and vehicles used by operators traveling to and from well sites.

Participants mentioned that some bonding programs go beyond existing regulations for road repairs by providing opportunities for communication and cooperation, which strengthen the relationship between local jurisdictions and the private sector. At the same time, a problem that several stakeholders mentioned was that permit fees were frequently inadequate to compensate for the actual damage to the roads. Another problem was that city permits or fees were not required for wells located outside city limits, even if the trucks used to develop these wells traveled on city roads. Participants also mentioned a lack of coordination with TxDOT and indicated that appropriate communication avenues need to be established. They also stated that cities could share some of the information they have with TxDOT.

There was some discussion about the correlation between oil and gas developments and vehicle crashes. Participants highlighted that conclusions drawn solely on the number of crashes can be misleading, highlighting the need to use crash rates in the calculations. Some participants also cautioned that some of the truck traffic in energy regions is not associated with oil and gas developments but with other industries. There was some anecdotal information that in some areas of active energy developments, heavy truck traffic has increased but annual average daily traffic (AADT) numbers have decreased, suggesting the possibility of local drivers trying to avoid driving on those corridors.

Participants indicated that traffic engineers review crash data and trends and, to the extent possible, implement safety countermeasures to address specific issues. However, a common problem across agencies is that engineers do not have the time or the resources to deal with and analyze crash data and trends to the desired extent. Some attendees also mentioned that some trucks do not meet oversize/overweight (OS/OW) vehicle regulations. Unfortunately, TxDPS does not have enough resources to increase enforcement. A suggestion made was to process and analyze TxPROS data systematically to address some of the existing needs.

Participants also mentioned that the coverage of the network of permanent traffic volume recorders was limited in areas of active energy developments. This limitation is seriously affecting the capability of state, county, and local agencies to determine typical truck traffic volumes in connection with energy developments.

**Workshop in Midland**

The Midland Center hosted the workshop in Midland. In total, 35 stakeholders representing state, regional, county, and local agencies; private industry; and academia participated in the event. Considering the level of interest expressed by participants, three breakout sessions took place:
Policy, Economics, and Planning

Counties have interagency agreements with cities that can be useful to address certain types of road maintenance issues. However, counties frequently face challenges related to completing road projects, including limited time windows to spend available funds; cash flow restrictions (e.g., some counties do not have the cash to front expenses); and labor shortages (i.e., limited ability to get people and equipment to accomplish the work).

One county representative stated that they have outsourced much of their road improvement process because of internal resource limitations. However, another county (with about the same population as the previous county) considered outsourcing, but decided that they could make their limited funds go further by not outsourcing. The same county that reported outsourcing some of its work has also taken advantage of the transportation reinvestment zone program, which was possible because of the increase in property values resulting from the energy boom over the past few years. A risk of depending heavily on property values is that property values can decrease substantially during the ‘bust’ part of the cycle, highlighting the need for policies or programs that keep property values from dropping too quickly. County representatives stated that having best practices from other counties around the state would be helpful. An idea for future action is to develop an innovative funding toolbox for counties.

One city representative complained that trucks repeatedly use minor streets that were not designed for heavy trucks. There have also been numerous cases of over-height trucks striking bridges, in some cases causing severe damage. Another challenge mentioned was the multiplicity of policies that cities have implemented related to impact fees that require truck operators to pay for damages to infrastructure, including roadways. Many cities do not have impact fees. Other cities have plat processing fees, but these fees typically only pay for the administrative effort to review the plats.

There was some discussion on the feasibility of designating roads for drilling and related uses. Cities have truck routes, but additional regulations might be necessary. Counties do not have the authority to establish truck routes or prohibit truck traffic on specific roads, but would need such authority. A concern mentioned was how to ensure the safety of county maintenance workers on roads with no regulations and whether the level of safety would be the same as for workers on state roads. One suggestion was to extend truck route designation authority to ETJs. A study would be necessary to analyze the benefits of extending city authority related to truck traffic to their ETJ.

An issue that affects rural areas in West and South Texas is that land is often owned as large ranches and is not frequently divided. Oil and gas developments in these areas use large networks of access roads within the ranches, but when the trucks enter county and state roads, the impact of the resulting traffic volumes at those locations can be larger than in other parts of
the state with a denser network of public roads. This issue can also affect land and infrastructure development in small urban and urbanized areas.

The oil boom has affected transportation planning in metropolitan areas. One MPO representative stated that they struggle to balance all the needs, while working with limited financial resources and the rapid growth in all traffic types. Rapidly growing metropolitan areas face dynamic project priorities in response to various traffic demands. There is also confusion among stakeholders about roadway funding categories and their applicability. A city representative mentioned that there is an issue of agencies and departments operating in isolation, which results in inefficiencies.

Another issue related to land development practices is not properly accounting for well site locations and mineral rights as part of the planning, platting, and development processes. An example mentioned was that some developers who are not familiar with the area submit master development plans prior to talking to land owners or without becoming familiar with land ownership issues such as large tracts of land tied up in family trusts.

Participants expressed a desire to obtain more information on public-private partnerships to address transportation challenges in cities and counties in West Texas. There was also discussion about experiences in other states, such as Pennsylvania, where energy developers are required to procure performance bonds. The performance bonds ensure that road maintenance issues related to petroleum exploration and production can be addressed without overburdening local governments. One county representative stated that, after complaining for a long time, energy developers agreed to repair some of the roads with their own equipment and resources. However, some of the companies expressed concern about potential liabilities in case of incidents after working on the road.

Rural planning organizations (RPOs) were briefly discussed. At this time, there is not an active RPO in the Permian Basin region, so there are no coordination issues at this time.

The Texas Legislature authorized La Entrada al Pacifico Rural Rail District to improve rail freight transportation along a corridor that stretches from the Mexican coast of the Gulf of California to the West Texas plains, via Presidio and Midland-Odessa (8). The rail district proposed to connect the South Orient Railroad with a rail facility in Seagraves. Anticipated benefits include a reduction in truck traffic and truck-related crashes and fatalities. The rail district anticipates a demand for 40,000 carloads, including fracking sand, drilling pipes, and cement (delivered to the region) and crude oil (shipped to refineries). As infrastructure in Mexico is improved, additional products and commodities could be transported to and from the Permian Basin region. Rail improvements would be at least partially privately funded, but would need help from the state acquiring right-of-way. The rail district has the authority to issue bonds and has the power of eminent domain. A question that participants asked was whether rural rail districts would need to have additional powers and authority to make those districts more effective.
Data and Communications

A county representative indicated that communications between state agencies and local jurisdictions were frequently inadequate. A recommendation made was to reestablish the annual coordination meetings that TxDOT and local jurisdictions held until a few years ago. An example of the critical need for coordination was a problem with heavy trucks in energy development areas that pass school buses at high speed on roads without shoulders. An effective communication channel between the county and TxDOT would have potentially enabled all stakeholders to analyze and resolve the issue quickly.

Participants highlighted that communication and coordination problems affect other stakeholders as well. For example, the MPO has regular campaigns to engage the public in a variety of ways. However, it is challenging to obtain meaningful feedback from citizens. One of the reasons is that the public usually does not have a good understanding of the roles of organizations such as the MPO. There was some discussion about the need to engage and promote RPOs as a mechanism to gather local input into the rural decision-making process. Getting energy developers involved in the communication and coordination loop is also challenging because the energy industry does not easily respond to requests for participation and involvement. In 2014, the Federal Highway Administration (FHWA) added a new emphasis area to the planning process, which aims to address communication inefficiencies. As part of this initiative, one of the MPO strategies is to reach out to individual stakeholders in an effort to improve communications and develop a better understanding of their needs and concerns.

A critical issue discussed was that energy developments frequently affect areas far away from where drilling is taking place. The reason is that truck traffic needed to develop sites frequently involves long-distance traveling using a variety of transportation modes. A recommendation made was to document supply chains, O-D patterns, and typical routes needed for energy developments in order to develop a reliable picture of the real magnitude of the impact.

Participants also highlighted that energy developments have altered traffic circulation patterns in the region, and that such changes have happened extremely fast. For example, there has been a significant increase in traffic volumes on US 285 over the last few years, which took state, county, and local officials by surprise. Part of the reason was a lack of coordination between energy developers and those agencies. Participants highlighted the critical importance of documenting traffic patterns on the routes of interest on a regular basis. Participants also highlighted the critical need for the industry to participate in the process by providing relevant traffic data to state and local agencies. In turn, agencies can consolidate traffic pattern and permit data to identify fast-growing road sections with heavy truck use and make that information available to all stakeholders.

There was some discussion about the need to encourage and promote technologies and strategies resulting in increases in efficiency and a corresponding reduction in truck traffic or impact to local infrastructure. For example, an energy developer is experimenting with a process to clean well flowback water to reuse in hydraulic fracturing operations instead of dumping the water into the city’s wastewater system. Another idea mentioned was to build water storage facilities at truck stops to balance water consumption along designated routes.
Workshop participants voiced concern that some traffic data estimates that TxDOT districts and local agencies receive from the Transportation Planning and Programming Division (TPP) are much lower than anticipated traffic conditions. Part of the problem is that the network of traffic count stations is not enough to cover all locations. For example, only about 30 WIM stations may be actively collecting axle weight data in Texas at any given time. One strategy to address this issue would be to use portable WIM stations that can be moved easily from one location to another at relatively low costs (compared to permanent WIM stations, which typically involve high installation and maintenance costs) to supplement the number of permanent WIM stations. A concern with portable WIM stations is that they are not as accurate as permanent WIM stations, which limits the range of applications for the portable stations (e.g., they would not be suitable for enforcement—unless a secondary inspection is part of the process). Another concern is that portable WIM stations would likely have a limited life span because of the harsh environment in which they would need to operate, particularly on secondary roads characterized by uneven pavement surfaces and a lack of adequate lane control. An advantage of portable WIM data collection devices is that they only collect axle weight and spacing data, limiting the perception that some energy developers might have that these devices collect all kinds of vehicle data.

Some participants were not aware of data sources that were readily accessible online, highlighting the need to raise awareness about those data sources. For example, TxDOT has an online platform based on a geographic information system (GIS) that shows different types of data, such as AADT and truck percentages, which can be useful for planning and pavement design purposes. However, several county officials had never heard of or used this online tool.

One of TxDPS’ missions is to communicate and educate local communities and the industry (e.g., energy service companies) about traffic safety and the impact local drivers have on the transportation system. However, an ongoing issue is limited funding. TxDPS would like to increase enforcement levels but has budgetary constraints. Safety training programs are also not targeting all driver groups. Drivers are typically required to attend these programs only after receiving a traffic ticket. Prior experience has shown that when companies provide safety training, employees receive traffic tickets less frequently. Participants agreed that educating drivers, raising awareness, and establishing effective communications among all stakeholders have positive impacts on traffic safety.

Funding for safety programs also affects the private sector. TxDPS’ experience is that small service companies typically do not have the resources to educate their personnel as much as large service companies. Some companies invite TxDPS to provide safety training. Other companies require employees and subcontractors to attend internal safety training programs. Some companies have a key point of improvement (KPI) program with subcontractors, which includes checkpoints to ensure that subcontractors meet safety standards, policies, and procedures, and align with day-to-day operations. Some large companies are proactive by conducting audits that take into account crash rates, traffic safety violations, roadside inspections, and other relevant factors. They also conduct surveys and follow-up questionnaires. Some companies conduct regular meetings with stakeholders to discuss safety and traffic issues.
Frequent discussions among stakeholders can raise safety awareness. Participants highlighted the need to establish working groups where people get together on a regular basis and discuss problems and strategies for improvement. A recommendation made was for each county to have an energy liaison who would be responsible for communicating and coordinating with all stakeholders within the county.

There was some discussion on what to do with habitual violators. A potential strategy would involve TxDPS identifying and focusing on habitual violators. Participants also suggested that state laws might need to become more stringent to deal with repeat offenders more effectively.

A critical safety issue mentioned was oversized trucks hitting bridges. In general, TxDPS’ perception is that trucks with annual permits and small motor carriers are more frequently involved in this type of incident. Participants mentioned that there are cases where vehicles hit bridges and leave the crash scene before police arrive. One strategy is to widen or re-build some bridges proactively (e.g., in the case of narrow bridges located along frequently used routes). Another strategy is to raise awareness about maximum legal vehicle dimensions; bridge clearance heights, signs, and advance warning systems; the importance of following the designated route in single-trip OS/OW permits; and the potential implications if a vehicle hits a bridge. Education and awareness campaigns would need to include both energy developers and service companies. To this end, some companies use agreements with subcontractors to control the operation of oversized vehicles more effectively. Several participants highlighted that the cost of OS/OW permits in Texas is very low and does not reflect the additional cost to use the transportation infrastructure. There is also no correlation between the cost of the permit and the cost to repair roadway damages caused by oversized or overweight vehicles.

There was an overall agreement among participants that some traffic safety problems in energy development areas are related to poor infrastructure conditions. Counties and municipalities cannot easily improve existing infrastructure due to funding and resource limitations. County officials often have a good idea about their hot spot areas and the type of roadway improvements that have worked over time and those that have failed. However, they have limited experience with unconventional energy developments and have limited knowledge about best practices and lessons learned in pavement maintenance and roadway improvements in other parts of the state. This lack of communication and cooperation within TxDOT or among different agencies needs to be improved.

Participants agreed on the need to educate the legislature on the magnitude of roadway issues at the county level. One strategy would involve identifying specific local issues that need to be addressed, gathering relevant data, and providing the resulting information to the legislature. TxDOT could provide counties with data (e.g., traffic, pavement conditions, WIM data) and information (e.g., guidance and pavement engineering methodologies) to help them develop a better understanding of traffic patterns and trends, which in turn, would allow counties to address relevant challenges and problems.

An ongoing challenge is the lack of funding to rebuild or widen narrow roads. Participants stated that they could commonly afford only two-foot shoulders, which quickly become ineffective. Wider shoulders would be preferable but are not affordable.
There was considerable discussion about the lack of knowledge on pavement design and pavement performance, as well as a lack of awareness of the correlation between energy developments and pavement deterioration. Pavement failures are often the result of this lack of knowledge, even on roadways that have been repaired multiple times in the recent past. Part of the problem is that agencies often repair damaged roads using the same guidelines they used decades ago, relying on old pavement structures that cannot carry significant axle loads and fail quickly. A strategy to deal with this problem is to develop a tool or guidance that uses updated pavement design parameters that take into account the axle loads that are most likely to happen using current oil and gas development technologies. Based on these input parameters, the tool would provide guidance on maintenance strategies and pavement design characteristics (e.g., type of pavement and thickness of layers and sublayers).

Another problem that some participants raised was the lack of adequate funding for transportation projects. Insufficient funding often results in project construction delays. This problem is more acute in areas that experience sudden increases in traffic volume (e.g., where energy developments are active). Participants also mentioned that, in some cases, depending on the funding source, the funding must be spent within a certain window of opportunity. In these cases, engineers might need to make rushed or uninformed decisions in the absence of reliable data or appropriate planning and design tools.

One such challenge is how to quantify existing traffic patterns and how to prepare reliable forecasts considering that energy developments are highly dynamic in both space and time. The selection of maintenance projects relies on historical traffic data that do not always capture actual or future traffic conditions. These issues highlight the need for reliable prediction and analytical tools to support planning and decision making.

Related to the difficulty to analyze and predict truckloads is the lack of a robust, data-driven methodology to identify, prioritize, and select maintenance projects. One strategy would be to develop an asset management–driven, user-friendly tool (e.g., web-based) that officials can use to review and overlay different types of data (e.g., pavement condition scores, geometric characteristics, work history, traffic data, and maintenance expenditures). This platform would allow officials to identify, prioritize, and select roadway maintenance projects, enabling them to allocate funds more efficiently. It would also allow officials to respond to funding releases in a timely manner without making rushed and uninformed decisions. Officials at various levels would use the tool, ranging from field engineers who identify and recommend strategies to mid-level and executive managers who would play a role in the project selection process.

A problem that resonated with participants was that the revenue from severance taxes goes to the general fund and is allocated without necessarily tackling surface transportation issues effectively. To address this issue, local agencies would need to identify their local needs and communicate them effectively to the appropriate instances, including the legislature, TxDOT, and other agencies that manage the funds.

Participants also highlighted that the formulas used to distribute available funds need to account more effectively for variables that affect pavement conditions. An example of this need is that the allocation formula only considers the number of wells drilled, but not the relative impact on pavement structures due to horizontal wells versus the impact due to vertical wells.
A challenge that affects rural corridors in energy development areas is litter control. Picking up litter is very expensive. Public awareness could be one way to alleviate the problem in the long term. In the short term, TxDOT is exploring ways to reduce this type of maintenance expense.

**Workshop in San Antonio**

Texas A&M University–San Antonio hosted the workshop in San Antonio. In total, 38 stakeholders representing state, regional, county, and local agencies; private industry; and academia participated in the event. Considering the level of interest expressed by participants, three breakout sessions took place:

- Data, communications, policy, economics, and planning
- Operations and safety
- Pavements and bridges

**Data, Communications, Policy, Economics, and Planning**

Counties feel that they do not have enough political power to deal with energy developments and impacts. Participants also expressed concern that the sense of working together and the spirit of cooperation among agencies are frequently lacking. Counties indicated that they would like to have guidelines on how to use available resources effectively to improve their infrastructure. For example, in some cases, counties have been hesitant to invest in transportation infrastructure, but, at the same time, they have used available funding on other projects (e.g., expanding water and wastewater utilities to serve lodging facilities). Counties have also noticed that most of the transportation funding from the legislature has flown to TxDOT. However, most of that funding must be spent on the state highway system.

There was considerable discussion on the need to document commodity flows, supply chains, and routes used for energy developments. TxDOT focuses on the evaluation of needs at chokepoints and other critical locations throughout the transportation network. However, the data that TxDOT uses to conduct the analysis are not necessarily up-to-date and lack context (because traffic data are not connected to individual energy developments). In practice, partly because of budget limitations and lack of information from the industry, TxDOT frequently finds itself in a reactive mode instead of anticipating and planning for the impact that might result from upcoming energy developments.

Databases that show both existing and anticipated energy developments would help TxDOT and other agencies develop a better understanding of locations where activity is likely to happen. A logical data source is the industry, but a frequent complaint by agencies is that energy developers are not willing to provide this information. Some partial information might be available through other sources (e.g., from county appraisal districts or through discussions with trade organizations).

Participants highlighted the need to improve travel demand forecasting practices by accounting for energy sector trends and needs. Transportation planning is already challenging under
‘normal’ conditions given the unpredictability of transportation funding sources. Including energy sector trends and needs would result in additional challenges because of the dynamic nature (in both space and time) of the oil and gas industry. One of the difficulties is trying to obtain reliable traffic data from the industry. Sometimes, planners are able to obtain some data indirectly (e.g., number of bank loans and plats for mineral leases), but this is not always feasible. Obtaining information directly from the industry would be the most cost-effective way to gather data needed to improve travel demand forecasting practices.

There was some discussion on how to develop funding strategies for counties and municipalities. Most counties have a limited capability to attract funding. In some cases, counties have been able to hire consultants who have experience in this area. However, other counties have been hesitant to hire consultants due to their high cost. Participants highlighted that RPOs could play a role in this process.

Participants discussed their experience with the provisions in Senate Bill 1747 (83rd Legislature) and the County Transportation Infrastructure Fund Grant Program. Some counties were disappointed that all counties in the state were eligible for funding even if they did not have energy developments. Counties were also concerned about the short turnaround time for the submission of grant proposals and the difficulty in preparing baseline reports, including a reliable inventory of roadway conditions.

Participants discussed the feasibility of public-private partnerships to optimize the development and use of transportation infrastructure. These partnerships could help to alleviate the impact resulting from the lag between the time that energy developments take place (which place all kinds of demands on existing infrastructure) and the time that agencies begin to receive economic benefits. Cities have more flexibility enacting regulations on land use, but counties do not have the same authority.

There was some limited discussion on the feasibility of energy developments at the Burgos Basin in Northern Mexico. At this point, it is not clear how or when those developments might take place or what kind of implications there might be for the Texas economy or transportation infrastructure. At the very least, additional activity would be expected at border crossings in connection with the transportation of drilling rigs, drilling and fracking equipment, pipelines, and fracking sand.

TxDOT officials highlighted that one of the limitations in transportation planning is that projects must be financially constrained. Planning for transportation projects is particularly challenging in shale play areas. The usual transportation planning process involves identifying projects based on where the need is most acute, but identifying where pavements will suffer the most is very difficult in energy development areas. In other cases, project prioritization is based on traffic safety or mobility considerations. However, TxDOT is often operating in a reactive mode, trying to respond to problems that are critical instead of planning proactively in order to anticipate where problems might occur. In addition, TxDOT is responsible for on-system roads, but not county or local roads.

There was some limited discussion about environmental issues. The San Antonio region is currently in attainment for air quality standards, but is in danger of losing this status. Participants
expressed some concern that emissions from Eagle Ford Shale energy developments might accelerate air quality degradation in the region. However, the potential magnitude of the impact is not clear, which prompted participants to continue to monitor the situation and explore partnership opportunities with agencies such as the Texas Railroad Commission and the Texas Commission on Environmental Quality (TCEQ).

Participants expressed concern about the use of limited water resources to support energy developments. Landowners in the Eagle Ford Shale region have benefitted financially from energy developments in the area, but there is growing concern that groundwater management has not been a top priority. There are also initiatives to transport water from counties where there is relative surplus to regions where water may be needed for oil and gas developments (e.g., water from the Edwards-Trinity Aquifer in Val Verde County to the Permian Basin). However, there is little coordination among regions.

There was some discussion about the willingness of energy developers to pay for some road improvements. Some participants indicated that agencies and developers sometimes use donation agreements, but the nature and extent of these agreements are unknown. The potential for this type of instrument to pay for improvements such as acceleration and deceleration lanes, turn lanes, and new signals would need to be evaluated.

There was also some limited discussion about additional topics, including the use of abandoned rail right-of-way for new roadway corridors and strategies for agency knowledge management and succession planning. Some participants indicated that agencies are losing expertise and the question was what kind of strategies might be implemented to address this issue.

**Operations and Safety**

Participants indicated that acquiring reliable data to understand truck traffic routes and patterns is critical. The traffic count program that TxDOT has used for decades is inadequate for documenting truck traffic patterns in energy regions. Participants discussed the feasibility of acquiring data using technologies such as Bluetooth or cell phone signals, as well as acquiring data from commercial data aggregators. Participants mentioned ATRI as a potential data source, but highlighted that there is currently not an effective mechanism to acquire data through this organization. Acquiring data from the oil and gas industry was also discussed. In this regard, participants agreed that there is the need to have better communication and coordination with the industry.

Participants emphasized the need for more effective communication and coordination among state agencies. Currently, information such as TxDOT work zone updates helps TxDPS to make decisions on patrolling schedules. Some information about highway construction projects and crash locations is available through services such as [http://drivetexas.org](http://drivetexas.org). In some cases, TxDOT involves TxDPS in relation to new construction projects. Through its Highway Safety Operations Center, TxDPS conducts data analyses and disseminates information to other stakeholders and the public. TxDOT could potentially assist by providing locations where energy sector trucks drive the most so that TxDPS can focus enforcement activities more effectively. TxDOT could also provide information as to the suitability of certain locations for pulling over heavy vehicles.
Participants indicated that having access to current information about anticipated oil and gas well locations is critical. One of the reasons is that using existing driveways as the only visual cue for energy development activity is both limiting and misleading.

There was some discussion about the difficulty in identifying long-term needs and project allocations. TxDOT officials mentioned that each district has a four-year plan that includes a list of roadway segments that are scheduled for repairs or improvements in the short term. However, it is considerably more challenging to identify long-term improvement needs (e.g., which corridors would need additional capacity in 10 years). For rapidly changing conditions such as what happens when energy developments are executed, a major concern is whether to invest on certain corridors only to find later that the roadway is not used as originally predicted. Districts need assistance in predicting how much and where traffic might happen in the future, including the ability to play what-if scenarios. Participants also highlighted that long-term traffic analyses of energy sector activities should be at the regional and/or statewide levels, not just district levels.

There was considerable discussion about traffic safety issues related to energy sector activities. The discussion focused initially on identifying what causes crashes and what kind of strategies might be appropriate to address those issues. Participants suggested that driver fatigue might be a major contributing factor and that strategies such as rumble strips should be used more often. Another factor is that local rural area residents, who for decades drove on roads with very little traffic, now have to share the road with a large number of heavy trucks. Some participants suggested that overloading trucks might be a factor considering that truck drivers are frequently paid by the load, not by the hour. A critical issue that resonated with participants was what to do with commercial drivers who receive too many traffic tickets. Although existing regulations help to some degree, it appears that too many of these drivers are involved in crashes.

The discussion then focused on who should be responsible for safety issues: the trucking company, the driver, or the energy developer. Some participants thought that energy developers should be more responsible for the trucking companies they hire, and that drivers should share more responsibility. Some energy companies are proactive and want to do the right thing (e.g., by joining task forces with local communities and law enforcement). This kind of involvement by the industry is usually considered helpful and welcome.

Participants highlighted the need for a database containing up-to-date posted speed limit information. Two issues in particular were discussed. The first issue was that posted speed limits along certain corridors change across TxDOT district boundaries, but there are no signs alerting drivers about the change, causing driver confusion. The second issue was that agencies change posted speed limits in response to fast-growing energy developments and changes in land use, but these changes are not communicated to all affected stakeholders, including TxDPS. TxDOT keeps track of posted speed limit changes, but the official roadway inventory database is not updated with the same frequency as the changes that take place in the field.

There was considerable discussion about the need for guidance to improve safety in work zones in areas of active energy sector developments. Participants highlighted issues when energy sector trucks enter the road in the middle of a work zone, especially at night. In many cases, traffic is limited to one-lane operations with a one-lane, two-way control zone. The problem arises when
trucks enter the road from driveways located between the two control zone ends but the drivers do not know which of the two directions is active at that time. This issue is particularly critical at night. There are general guidelines for one-lane, two-way control zones, but participants indicated there is a need to update current methodologies to properly account for situations such as those that occur in energy development areas. Some participants suggested the use of technologies such as arrow boards or flashing signs to alert drivers about which direction is active at any point in time.

Work-zone speeding was also discussed, particularly in relation to challenges that affect the feasibility and effectiveness of law-enforcement activities and campaigns. Portable speed trailers can be used as a mechanism to alert drivers about their actual speed, but the effectiveness of those devices is limited, particularly without the support of adequate law enforcement presence in the field.

Participants also discussed the need for more effective traffic-control signage along truck routes. Some TxDOT districts are evaluating or improving signage on narrow bridges. Other examples include using flashing traffic signs that are actuated when speeding occurs on curves, or chevron arrow lights that flash when trucks enter the roadway. Participants discussed the wrong-way detection system in San Antonio and the possibility that this system could be adapted for use along energy sector corridors. There was also some discussion about engaging the industry to help pay for these devices using donation agreements.

**Pavements and Bridges**

TxDOT would like some assistance in determining the allocation of resources for maintenance activities. Many roads in the Eagle Ford Shale region were not designed for the heavy loads that they now carry, and, as a result, they deteriorate at a very fast pace. Maintenance engineers have several options, from full rehabilitation to overlays and seal coats, but it is not always clear which option to choose or which roadways to prioritize. A major concern by TxDOT is to rehabilitate a pavement with an upgraded pavement structure that can withstand the heavy loads, only to find out that heavy trucks are no longer in the area and are not using the roadway. Maintenance support takes into account different functional classifications of roadways, which impacts TxDOT’s ability to use maintenance funds.

There was some discussion about the need for a simplified decision tree or process for the design of pavements in energy development areas. Currently, TxDOT has tools to determine loads to failure and remaining life. The process involves determining what kind of pavement structure is needed, but this requires a detailed understanding of current and expected future use of the roadway, including current and expected traffic use and economic development. Questions that TxDOT often deals with are the required width of the roadway (i.e., 28, 30, or 32 feet) and whether the pavement depth can be reduced if the roadway width is increased. TxDOT would like to have a tool or process to determine the necessary type of pavement repairs, including minimum depth (i.e., shallow repair versus deep repair). The tool should help TxDOT determine what the agency can do to maintain a roadway in the short term (i.e., one to two years) before starting a full rehabilitation. Participants also discussed the need for guidance to select the most critical pavement distress factor that pavement design should address.
Related to this subject was a discussion of how heavy and super-heavy trucks can be included in pavement design using equivalent single axle loads (ESALs). It was unclear to what degree this was an issue because the AASHTO pavement design guide accounts for ESALs up to 90-kip axle loads, and many super-heavy trucks distribute very heavy loads over many axles. A comment made was that there are limitations on the use of ESALs and that a mechanistic stress analysis might be more suitable.

Additional discussion focused on pavement tie-ins at bridges. There is a need for best practices to mitigate issues on approaches to bridges (e.g., longitudinal cracks).

There were also questions related to the management of floodplain changes and their impact on pavement maintenance, design, and construction. TxDOT cannot raise a profile too much because of the risk of causing drainage pattern changes that alter the local hydrology, increasing the level of liability for the department.

Participants highlighted the need to better research and validate the impacts of all energy-related traffic on the transportation network. Traffic patterns in South Texas are also likely to change because of the upcoming Mexican oil reform. For example, some participants expect Eagle Pass to experience a significant increase in staging and oil storage in the near future. Other traffic impacts might be those resulting from new plants or plant expansions (e.g., liquefied natural gas [LNG] facilities in Corpus Christi). This starts with getting better information about traffic weights for all truck traffic. Currently, there is too much guessing when it comes to estimating truck weights, particularly on secondary roads. Better weight information would result from an expansion of the WIM system. In this regard, there should be a better process to determine the location of new WIM stations.

The use of local resources and/or recycling for pavement management has been studied before, but TxDOT is still unsure about how to implement results on a case-by-case basis. Using fewer natural resources and more of what is available at the site is more cost-effective and safer, but project managers need guidance and solutions. It is especially difficult to mix recycled materials with new materials. For example, the mix may be designed in a laboratory setting but the cement used in the lab is different from the cement delivered to the job site. A member of the discussion group mentioned the use of a pavement maintenance product called “mechanical concrete,” which uses recycled tires tied together and filled with aggregate base. This method could be an alternative for rehabilitation.

There is an ongoing issue with the release of traffic at the end of the day to travel on the surface of an unfinished pavement structure. This practice is not always suitable for heavy traffic. In some cases, there is simply not enough pavement structure to open the road for traffic before the roadway is finished. Participants expressed interest in research to develop a stable platform that can withstand truck traffic. For example, cement-treated base does not hold up to traffic well. Some area engineers now add six inches of untreated base or foamed asphalt, but more guidance is necessary. There were also questions about international roughness index (IRI) requirements for the base layer. TxDOT might use a seal coat, but if the top inch is very dusty, the seal coat will peel off. Alternatively, a thin overlay might be used to level the surface.
Participants also discussed the feasibility of closing roadways completely for the duration of the rehabilitation if the result is significant time savings. A concern discussed was whether adjacent roads, including FM and county roads, would be able to absorb the additional truck traffic transferred from the road that is undergoing rehabilitation.

Participants discussed the need for guidance related to specific pavement design and construction practices (e.g., how to incorporate the subgrade into the design). Lime and cement stabilization are options, but TxDOT is noticing failures even though tests were passed. There were some questions regarding intelligent compaction, and basing design on probabilities of areas with failures.

TxDOT needs assistance with testing for pavement maintenance. Checks on a subgrade can result in savings if the result is that the subgrade does not need replacement. However, gathering the necessary data is not easy because it requires traffic control and specialized equipment. As a result, some of the data are not obtained. There was a comment that uniform density control might be helpful.

Participants discussed the need to review and update current bridge inspection practices. Currently, TxDOT inspects all bridges every two years, with a very crude ‘maintenance’ inspection every other year. Some TxDOT officials voiced concern that this procedure might not be sufficient in light of the dramatic increase in the number of heavy trucks. TxDOT officials were also not sure that the ‘maintenance’ inspection was sufficiently thorough.

Participants highlighted the need for better coordination between the energy industry and highway agencies. A fundamental problem is that oil and gas companies do not want their development plans to be made public because of the fear of liability and loss of competitive edge. However, agencies cannot plan for and develop the transportation infrastructure the industry needs without information from the industry. Nevertheless, agencies should reach out to energy companies more often (e.g., through trade associations such as the South Texas Energy and Economic Roundtable [STEER]). As an illustration, TxDOT could come up with an analysis of expected future developments based on drilling permit data from the Railroad Commission and then share that information with STEER. STEER could then gather feedback from its member companies and provide consolidated information back to TxDOT.

Coordination with the industry could go beyond obtaining basic information about energy development timing and phasing. It could include obtaining information about typical routes the industry uses as well as information that could have an impact on the estimation of truck volumes (e.g., the use of new fracking technologies that reduce the amount of water).
STRATEGIC RESEARCH ROADMAP

Introduction

The three regional workshops and discussions held with individual stakeholders allowed for the identification of areas where research is necessary or strategic and where TTI could play a significant role. This chapter describes the framework to achieve this goal in the form of a strategic research roadmap to guide future research and technology transfer activities.

Summary of Research Needs

In total, 16 ideas were identified at the workshop in Arlington, as follows:

- Identify best practices and develop strategies to improve communication, coordination, and cooperation among stakeholders.
- Develop and maintain a centralized database to ensure coherence and compatibility among disparate data sources.
- Develop strategies and information infrastructure to facilitate data exchange among stakeholders.
- Develop guidelines on how to improve traffic counts on secondary corridors.
- Analyze OS/OW permit data to extract information about truck traffic trends in energy development regions.
- Develop guidelines to improve transportation planning processes to account for oil and gas energy development locations and trends.
- Develop guidelines for transportation project selection in energy development areas.
- Identify best practices for permit fee structures and performance bonding programs.
- Identify best practices for ETJ boundaries and interactions.
- Document issues and develop recommendations for CNG conversions.
- Develop recommendation for improvement of the funding allocation formula (SB 1747).
- Identify best practices for counties on topics such as weight limits; road damage enforcement; pavement materials, standards, and construction methods; truck routing enforcement; and staffing and funding.
- Document impact of truck-driver pay structure on operations and safety.
- Review guidelines and thresholds for vehicle inspection authority at municipalities.
- Document correlations between energy developments and crash data and trends.
- Develop program to make crash and safety data in energy development areas available to all stakeholders.

In total, 23 ideas were identified at the workshop in Midland, as follows:

- Develop guidelines to improve communication and coordination among state, county, and local agencies.
- Develop guidelines to improve traffic data collection practices, including volumes and weights, in areas where energy developments take place.
• Develop a methodology to forecast and quantify the magnitude and impact of energy developments at different levels of spatial and temporal aggregation.
• Develop a data-driven methodology to identify, prioritize, and select maintenance projects.
• Document and evaluate the destination of different revenue sources to address transportation infrastructure issues in energy development areas.
• Identify and develop strategies for counties to improve how they react to and plan for energy developments within their jurisdiction.
• Develop a catalog of best practices for counties and local agencies.
• Document practices at the local and county levels in areas related to permit fees, recouping of damages to public infrastructure, and donation agreements.
• Prepare briefings, reports, and presentations to educate the legislature on the magnitude of roadway issues at the county level.
• Assess the feasibility of designating certain roads for drilling and related uses.
• Evaluate the impact of land ownership trends on traffic circulation and impacts to public transportation infrastructure.
• Evaluate feasibility of public-private partnerships to address transportation challenges in cities and counties in energy development areas.
• Develop strategies to address the lack of funding to rebuild or widen narrow roads.
• Document highway/railroad integration strategies to optimize transportation needed for energy developments.
• Document impact in areas that are far away from where drilling is taking place.
• Document changes in traffic patterns due to oil and gas well developments.
• Document and test strategies to reduce the use of water for energy developments.
• Develop strategies to improve safety funding capabilities at state and local agencies.
• Develop a tool to analyze and document the relationship between traffic safety problems and poor transportation infrastructure conditions.
• Establish interagency working groups to raise safety awareness.
• Develop strategies to deal with habitual traffic-law violators.
• Develop strategies and recommendations to reduce the number of hits to bridges and other structures by oversized trucks.
• Develop a tool or guidance to design and build pavement structures, taking into account loads that are likely to happen in energy development areas.

In total, 24 ideas were identified at the workshop in San Antonio, as follows:

• Develop strategies to improve communication, coordination, and cooperation between public-sector and private-sector stakeholders.
• Develop guidelines for interagency cooperation among counties.
• Develop data-driven processes to document commodity flows, supply chains, and routes.
• Develop and maintain robust geodatabases that enable the correlation of energy development data and trends and transportation system data and trends.
• Develop and disseminate information products to a wide range of stakeholders.
• Evaluate the feasibility of acquiring truck traffic data using remote sensing technologies and from commercial data aggregators.
- Develop funding strategies for local, regional, and state agencies.
- Develop guidelines for public-private partnerships to optimize the development and use of transportation infrastructure.
- Develop guidelines for more effective transportation project selection and allocation to address energy sector needs.
- Provide assistance in determining the allocation of resources for maintenance activities.
- Improve transportation demand forecasting processes to include energy sector needs.
- Promote public awareness about best practices for water conservation in energy development areas.
- Quantify crash-contributing factors that are driver-related and develop strategies to improve safety trends.
- Develop technologies and guidance to improve safety in work zones in areas of active energy sector developments.
- Develop technologies and guidance to address work-zone speeding problems.
- Provide guidelines for deploying traffic control signage along truck routes in energy development areas.
- Develop a simplified process for pavement design in energy development areas.
- Develop guidance to select the most critical pavement distress factor that pavement design should address in energy development areas.
- Develop guidelines to mitigate issues on approaches to bridges.
- Develop a simplified process to select strategies for pavement repairs and minimum depth.
- Develop more effective tools to predict impacts on pavements and bridges.
- Develop guidelines for more effective use of local resources and recycling for pavement maintenance and access roads.
- Develop technologies and methods to open roads under reconstruction to heavy traffic.
- Review and update current bridge inspection practices.

There were several common themes among the 63 ideas that were identified at the workshops in Arlington, Midland, and San Antonio. There were also unique areas of interest. Together, the feedback provided by participants resulted in 19 different ideas that enabled TTI to develop a framework and strategic research roadmap, as described in the following section.

**Strategic Research Roadmap**

As Figure 1 shows, the strategic research roadmap was organized into eight major interconnected themes that address a wide range of topics where energy developments and transportation systems interact. A short description of each theme follows, including major goals and research ideas that were identified during the research. Readers should note that there is considerable synergy and interdependence among research ideas. One of the implications is that the research ideas should not be viewed in isolation. In fact, a number of research ideas depend on information or results generated by other ideas, making it critical to view all ideas as components of the larger research roadmap.
Communication, Coordination, and Cooperation

The goal of this research theme is to identify, test, and document strategies for effective communication, coordination, and cooperation (i.e., the 3Cs) among public-sector and private-sector stakeholders. The strategic need for this theme is the recognition that different stakeholders frequently operate in silos, resulting in inefficiencies and negative impacts and costs to all parties involved. This theme covers communication (which is related to industry and public outreach), coordination (which is related to synchronization and harmonization of business processes among stakeholders), and cooperation (which is related to the idea of working together to achieve a common goal).
Identified research ideas in this theme include the following:

- Identify best practices and develop strategies to improve communication, coordination, and cooperation among public-sector and private-sector stakeholders.
- Identify best practices for counties and municipalities on topics related to weight limits; road damage enforcement; pavement materials, standards, and construction methods; truck routing enforcement; and staffing and funding.

Transportation and Energy Development Data

The goal of this research theme is to develop the information infrastructure needed to document, understand, and forecast trends and the multidimensional relationships between energy developments and transportation systems. The strategic need for this theme is the recognition that access to robust, integrated information is a fundamental requirement to support the other themes and for the development and implementation of sound transportation and energy development policies.

Identified research ideas in this theme include the following:

- Develop and maintain a centralized database and information infrastructure to facilitate data exchange among stakeholders.
- Develop guidelines to improve traffic data collection practices in energy development areas, including traffic volumes, origins and destinations, supply chains, and vehicle axle weights.
- Analyze OS/OW permit data to extract information about truck traffic trends in energy development regions.
- Develop data-driven tools to forecast and quantify the location, magnitude, and impact of energy developments at different levels of spatial and temporal aggregation.

Policy and Economics

The goal of this research theme is to develop, investigate the feasibility of, and promote policies and strategies to achieve the goals of efficient, sustainable, and safe transportation systems in areas where energy developments take place or where energy developments affect transportation systems. The strategic need for this theme is the recognition that traditional transportation policy approaches are inadequate to address or anticipate issues that affect the ability of jurisdictions at various levels (e.g., state, regional, and local) to manage transportation systems effectively.

One identified research idea in this theme is the following:

- Evaluate the use and effectiveness of different revenue and funding sources to address transportation infrastructure issues in energy development areas.
Planning and Multimodal

The goal of this research theme is to develop and recommend business processes and strategies to plan and program transportation infrastructure that anticipates and takes into account the location and characteristics of energy developments. The strategic need for this theme is the recognition that, historically, there have been gaps between the process to develop energy projects and the traditional process to plan, program, and develop transportation projects.

Identified research ideas in this theme include the following:

- Develop guidelines to improve transportation planning processes to account for oil and gas energy development locations and trends.
- Develop highway/railroad integration strategies to optimize the transportation system in energy development areas.

Operations and Safety

The goal of this research theme is to develop and test technologies, standards, specifications, and business processes that contribute to an effective, safe use of the transportation infrastructure by all users of that infrastructure, including the general public and energy developers. The strategic need for this theme is the recognition that dramatic increases in truck traffic in areas where energy developments take place have resulted in additional congestion and significant increases in crash rates.

Identified research ideas in this theme include the following:

- Document correlations between energy developments, crashes, and transportation infrastructure conditions.
- Develop guidelines to improve driver safety in energy development areas.
- Develop technologies and guidance to improve work zone safety in areas of active energy sector developments.
- Provide guidelines for traffic control signage along truck routes in energy development areas.

Environment and Sustainability

The goal of this research theme is to develop and test technologies, protocols, and procedures to facilitate the implementation of strategies that contribute to sustainable transportation systems and energy developments, while minimizing detrimental environmental impacts and footprint. The strategic need for this theme is the recognition that energy developments, particularly those that rely on techniques such as horizontal drilling and hydraulic fracturing, tend to be resource intensive and result in impacts such as increased emissions, risk of spills, and hazmat operations.
One identified research idea in this theme is the following:

- Develop strategies to reduce the use of water and promote public awareness about best water conservation strategies in energy development areas (see Roadside Management).

**Roadside Management**

The goal of this research theme is to develop and test technologies, standards, specifications, and business processes that contribute to an effective management of the transportation infrastructure right-of-way. The strategic need for this theme is the recognition that energy developments frequently have a significant impact on roadside components of the transportation infrastructure, affecting the capability of the agencies responsible for managing those transportation assets.

Identified research ideas in this theme include the following:

- Develop strategies to reduce the use of water and promote public awareness about best water conservation strategies in energy development areas (see Environment and Sustainability).
- Develop guidelines for more effective use of local resources and recycling for roadway maintenance and energy developments (see Pavement and Bridge Structures).

**Pavement and Bridge Structures**

The goal of this research theme is to develop and test technologies, standards, material and construction specifications, and business processes to design, build, and maintain a surface transportation system that anticipates and takes into account the location and characteristics of energy developments. The strategic need for this theme is the recognition that traditional approaches to design, build, and maintain pavement and bridge structures are not adequate to support the extraordinarily high volumes of truckloads that characterize most unconventional energy developments.

Identified research ideas in this theme include the following:

- Develop a data-driven methodology to identify, prioritize, and select maintenance projects.
- Develop a simplified process to select strategies for pavement repairs and minimum depth.
- Develop guidelines to mitigate impacts to bridges and other structures in energy development areas.
- Develop guidelines for more effective use of local resources and recycling for roadway maintenance and energy developments (see Roadside Management).
- Develop methodologies to partially open roads under rehabilitation or reconstruction to heavy traffic.
Long-Term Funding Prospects

There is a significant potential to generate long-term research opportunities resulting in tangible benefits to the transportation system in Texas. At the same time, there is uncertainty because of the substantial decrease in the price of crude oil over the last 12 months. The implications are not clear. However, horizontal drilling and hydraulic fracturing technologies are a paradigm shift, so even under depressed crude oil price conditions, the use of these technologies is likely to continue. Furthermore, oil prices tend to follow a cycle of increases and decreases, and current prices are now at the lowest levels in 10 years. If oil prices increase again in the future (and there is every reason to believe they will), new oil developments and increased impacts to transportation infrastructure can be expected to follow.

To fund the research ideas identified in this report, it would be strategic to pursue a number of partnering and funding opportunities, including, but not limited to, the following:

- TxDOT.
- Other state agencies, such as the Railroad Commission, the Texas Department of Motor Vehicles (TxDMV), TxDPS, TCEQ, and the Texas Department of Information Resources (DIR).
- County and city associations. Examples include the County Judges and Commissioners Association, the Texas Municipal League, and the Eagle Ford Shale Consortium. Similar associations in other states could also be considered.
- Regional agencies, such as MPOs and councils of governments (COGs).
- Federal government, such as FHWA, the Pipeline and Hazardous Materials Safety Administration (PHMSA), the Federal Motor Carrier Safety Administration (FMCSA), the National Highway Traffic Safety Administration (NHTSA), Federal Railroad Administration (FRA), and the Department of Energy.
- Relevant Transportation Research Board (TRB) and American Association of State Highway and Transportation Officials (AASHTO) committees.
- Other states. TTI could provide expertise to a variety of stakeholders based on the lessons learned in Texas. Strategic partnerships could also be developed.
- Other countries. Unconventional energy development techniques are in the beginning stages in many other countries. Local stakeholders probably know very little about all the implications associated with this type of technology. TTI could provide critical assistance.
- Private sector and trade associations. Examples at the national level include the American Society of Civil Engineers (ASCE), the American Petroleum Institute (API), America’s Natural Gas Alliance, and the Railroad Research Foundation (RRF). Examples in Texas include STEER, the Texas Alliance of Energy Producers, the Texas Oil and Gas Association (TXOGA), the Association of Energy Service Companies (AESC), the Texas Trucking Association (TXTA), the Panhandle Producers & Royalty Owners Association (PPROA), the Texas Independent Producers & Royalty Owners Association (TIPRO), and Midland-Odessa Transportation Alliance (MOTRAN).
Research Need Statements

The appendix includes research need statements for the 19 research ideas listed in the previous section. Each research need statement includes the following elements:

- Title.
- Background and research need.
- Objective.
- Estimated time and funding requirements.
- Potential funding and partnership opportunities.

As mentioned, the synergy and interdependence among research ideas means that some of the research needs to be conducted first because the resulting products are needed for other research initiatives.

Anticipated Costs and Benefits

Table 2 shows a suggested $9,000,000 plan of research expenditures over a four-year period that takes into account the synergy and interdependence among research ideas: $2,000,000 (year 1); $2,850,000 (year 2); $3,100,000 (year 3); and $1,050,000 (year 4). Depending on the availability of funding, the plan could be modified accordingly.

Using benefit/cost (B/C) ratios that have been measured for other high-profile transportation research initiatives in the past, a B/C ratio between 5:1 and 20:1 for the CTES initiative would be realistic. The anticipated economic benefits, which would benefit all the citizens of the state, are huge. At the same time, the $9,000,000 research plan is only slightly more than half the cost to develop one new horizontal well in Texas. In 2013, there were some 23,000 well drilling permits in the state, of which close to 16,000 wells were completed. When the price of crude oil was between $90 and $100 (in August 2015 dollars), the total number of wells completed per month could be around 1500. At this point, the Energy Information Administration anticipates the price of crude oil to remain $40–$50 per barrel through 2016. Under these conditions, a preliminary statistical analysis suggests that the total number of completed wells could be 800–1000 per month. Over a four-year period, this would translate to 38,400–48,000 new wells. In other words, the $9,000,000 research plan proposed here would cost $188–$234 per new completed well, based on the number of projected well completions over the next four years.
Table 2. Suggested Plan of Research Expenditures over Four Years.

<table>
<thead>
<tr>
<th>Research Idea</th>
<th>Duration (months)</th>
<th>Total Funding</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify best practices and strategies to improve communication, coordination, and cooperation among public-sector and private-sector stakeholders in energy sector areas</td>
<td>48</td>
<td>$400,000</td>
<td>$100,000</td>
<td>$100,000</td>
<td>$100,000</td>
<td>$100,000</td>
</tr>
<tr>
<td>Identify best practices for counties and municipalities on topics related to weight limits; road damage enforcement; pavement materials, standards, and construction methods; truck routing enforcement; and staffing and funding</td>
<td>36</td>
<td>$1,800,000</td>
<td>$600,000</td>
<td>$600,000</td>
<td>$600,000</td>
<td></td>
</tr>
<tr>
<td>Develop and maintain a centralized database and information infrastructure to facilitate data exchange among stakeholders</td>
<td>48</td>
<td>$500,000</td>
<td>$200,000</td>
<td>$200,000</td>
<td>$50,000</td>
<td>$50,000</td>
</tr>
<tr>
<td>Develop guidelines to improve traffic data collection practices in energy development areas, including traffic volumes, origins and destinations, supply chains, and vehicle axle weights</td>
<td>36</td>
<td>$500,000</td>
<td>$200,000</td>
<td>$150,000</td>
<td>$150,000</td>
<td></td>
</tr>
<tr>
<td>Analyze OS/OW permit data to extract information about truck traffic trends in energy development regions</td>
<td>12</td>
<td>$150,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develop data-driven tools to forecast and quantify the location, magnitude, and impact of energy developments at different levels of spatial and temporal aggregation</td>
<td>24</td>
<td>$400,000</td>
<td>$200,000</td>
<td>$200,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaluate the use and effectiveness of different revenue and funding sources to address transportation infrastructure issues in energy development areas</td>
<td>24</td>
<td>$400,000</td>
<td></td>
<td>$200,000</td>
<td>$200,000</td>
<td></td>
</tr>
<tr>
<td>Develop guidelines to improve transportation planning processes to account for oil and gas energy development locations and trends</td>
<td>24</td>
<td>$400,000</td>
<td></td>
<td>$200,000</td>
<td>$200,000</td>
<td></td>
</tr>
<tr>
<td>Develop highway/railroad integration strategies to optimize the transportation system in energy development areas</td>
<td>24</td>
<td>$300,000</td>
<td></td>
<td></td>
<td>$150,000</td>
<td>$150,000</td>
</tr>
<tr>
<td>Document correlations between energy developments, crashes, and transportation infrastructure conditions</td>
<td>24</td>
<td>$400,000</td>
<td></td>
<td>$200,000</td>
<td>$200,000</td>
<td></td>
</tr>
<tr>
<td>Develop guidelines to improve driver safety in energy development areas</td>
<td>24</td>
<td>$300,000</td>
<td></td>
<td>$150,000</td>
<td>$150,000</td>
<td></td>
</tr>
<tr>
<td>Develop technologies and guidance to improve work zone safety in areas of active energy sector developments</td>
<td>24</td>
<td>$400,000</td>
<td></td>
<td>$200,000</td>
<td>$200,000</td>
<td></td>
</tr>
<tr>
<td>Provide guidelines for traffic control signage along truck routes in energy development areas</td>
<td>24</td>
<td>$300,000</td>
<td></td>
<td>$150,000</td>
<td>$150,000</td>
<td></td>
</tr>
<tr>
<td>Develop strategies to reduce the use of water and promote public awareness about best water conservation strategies in energy development areas</td>
<td>24</td>
<td>$500,000</td>
<td></td>
<td>$250,000</td>
<td>$250,000</td>
<td></td>
</tr>
<tr>
<td>Develop a data-driven methodology to identify, prioritize, and select maintenance projects</td>
<td>24</td>
<td>$400,000</td>
<td>$200,000</td>
<td>$200,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develop a simplified process to select strategies for pavement repairs and minimum depth</td>
<td>18</td>
<td>$250,000</td>
<td></td>
<td>$150,000</td>
<td>$100,000</td>
<td></td>
</tr>
<tr>
<td>Develop guidelines to mitigate impacts to bridges and other structures in energy development areas</td>
<td>24</td>
<td>$300,000</td>
<td></td>
<td></td>
<td>$150,000</td>
<td>$150,000</td>
</tr>
<tr>
<td>Develop guidelines for more effective use of local resources and recycling for roadway maintenance and energy developments</td>
<td>36</td>
<td>$900,000</td>
<td>$300,000</td>
<td>$300,000</td>
<td>$300,000</td>
<td></td>
</tr>
<tr>
<td>Develop methodologies to partially open roads under rehabilitation or reconstruction to heavy traffic</td>
<td>24</td>
<td>$400,000</td>
<td>$200,000</td>
<td>$200,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$9,000,000</strong></td>
<td><strong>$2,000,000</strong></td>
<td><strong>$2,850,000</strong></td>
<td><strong>$3,100,000</strong></td>
<td><strong>$1,050,000</strong></td>
<td></td>
</tr>
</tbody>
</table>
REFERENCES


APPENDIX – RESEARCH NEED STATEMENTS

This appendix includes research need statements for the 19 research ideas that were identified at the workshops. Each research need statement includes the following elements:

- Title.
- Background and research need.
- Objective.
- Estimated time and funding requirements.
- Potential funding and partnership opportunities.
Title
Identify Best Practices and Strategies to Improve Communication, Coordination, and Cooperation among Public-Sector and Private-Sector Stakeholders in Energy Sector Areas

Background and Research Need
The lack of effective communication, coordination, and cooperation among public-sector and private-sector stakeholders in energy development areas is pervasive. In the public sector, it is common for agencies not to have a formal mechanism in place to facilitate a meaningful exchange of information among stakeholders. As a result, agencies are not aware of each other’s needs, goals, and objectives. In the private sector, lack of communication and coordination with public-sector agencies is often the result of companies wanting to protect information they see as confidential; not understanding their role in preserving the transportation system; and mistrust and the perception that public-sector agencies are only looking for information to increase the level of regulation over the industry. It takes considerable time and effort to develop working relationships with the oil and gas industry. Some public-sector agencies, particularly at the local level, have had some success interacting with the private sector. Cities typically have formal or informal meetings with single operators. Industry stakeholders have also indicated that confrontational relationships have become less frequent nowadays, resulting in improved and more effective communications and cooperation that are more effective. At the same time, the industry recognizes that conflicts are not region-specific, but span multiple states.

Objective
The research objective is to identify and compile examples of best practices to improve communication, coordination, and cooperation among public-sector and private-sector stakeholders. The research should canvas the state to document and quantify case studies where the lack of communication and coordination has resulted in inefficiencies to all the parties involved. The research should develop and test strategies to address those issues, as well as document case studies where communication, coordination, and cooperation have been effective. The research should also prepare briefings, brochures, and presentations to educate stakeholders on issues, underlying causes, and strategies to address those issues.

Estimated Time and Funding Requirements
Duration: 48 months
Funding: $400,000

Potential Funding and Partnership Opportunities
For the research to be effective, it will be critical to enlist the participation of a sample of agencies, stakeholders, and trade organizations representing a wide range of interests. These agencies and stakeholders are likely to be sources of funding and/or partnership opportunities. Examples of agencies include, but are not limited to, TxDOT, MPOs, the County Judges and Commissioners Association, and energy trade organizations.
Title
Identify Best Practices for Counties and Municipalities on Topics Related to Weight Limits; Road Damage Enforcement; Pavement Materials, Standards, and Construction Methods; Truck Routing Enforcement; and Staffing and Funding

Background and Research Need
Counties and local agencies face numerous challenges and limitations in managing the impact of oil and gas developments on the transportation system within their jurisdictions. For example, counties need urgent help in a number of areas, such as, but not limited to, the following:

- Road damage enforcement. Counties would like to be able to say, “If you break it, you fix it.” A practical challenge is how to know who broke it or what to do about it.
- Pavement materials, standards, and construction methods. Counties need assistance in many areas related to pavement design, construction, and maintenance. Counties frequently receive offers from the private sector to help with repairing or paving roads using byproducts or surplus materials, and need guidance to decide which of these materials (if any) may be acceptable for road construction.
- Truck routing enforcement.
- Staffing and funding. Only a few counties in Texas have county engineers, so many depend on outside resources. Consultants can help, but a concern is that after they deliver their product, they leave and are no longer available on an ongoing basis.
- Limited time windows to spend available funds
- Cash flow issues (i.e., how to manage the lag between impact and revenue).
- Coordination with other agencies.

Many of these issues also affect municipalities of various sizes in energy development areas.

Objective
The research objective is to develop a sustainable infrastructure and program to provide long-term assistance to counties and municipalities in a wide range of issues related to the impact of energy developments to their transportation infrastructure. In the short term, the research should develop a catalog of best practices based on lessons learned from various regions in Texas and other states. Part of this effort should involve scheduling and conducting workshops and training sessions to disseminate the result of the compilation of best practices. To ensure the program sustainability, the research should also develop a catalog of research and research implementation ideas that focus on the transportation needs of counties and municipalities.

Estimated Time and Funding Requirements
Duration: 36 months (initial phase)
Funding: $1,800,000 (first 36 months)

Potential Funding and Partnership Opportunities
Texas Legislature, County Judges and Commissioners Association, Texas Municipal League, TxDOT.
Title
Develop and Maintain a Centralized Database and Information Infrastructure to Facilitate Data Exchange Among Stakeholders

Background and Research Need
Agencies often have to search through many data sources and perform cross-referencing, data cleaning, and other activities prior to conducting analyses to document issues related to the interaction between energy developments and transportation systems. Federal, state, and local government agencies have data in a variety of formats, making it necessary to convert disparate data to compatible formats. This can be time-consuming, contributing to inefficiencies. One of the reasons is that agencies have to spend a significant amount of time and effort becoming familiar with different data dictionaries, processing raw data, and updating datasets on a regular basis. Another problem is the lack of appropriate hardware and software to facilitate the data cleaning and data mining process, as well as the lack or unavailability of trained staff.

Agencies would like to have access to data from the private sector to improve transportation planning, design, construction, operations, and maintenance. At the same time, the energy sector has expressed interest in accessing transportation infrastructure data (e.g., roadway performance and bridge height and width) to improve their own operations (e.g., by incorporating these data into navigation tools and maps to assist truck drivers in avoiding certain roadway segments).

Objective
The research objective is to develop and maintain a data and information warehouse that provides adequate access and support to stakeholders. The data warehouse would include a centralized database and information infrastructure to facilitate data exchange. The research would involve preparing a business case documenting the framework and general characteristics of the data and information infrastructure, building database and application servers, developing and documenting data models, preparing information products (e.g., maps, tables, reports), and conducting workshops and giving presentations to promote the use of the data and information warehouse. Preparing the business case would involve reaching out to public-sector and private-sector stakeholders to identify in which kinds of data and information products the community would be interested. It would also include identifying potential revenue stream opportunities to ensure the future sustainability of the program.

Estimated Time and Funding Requirements
Duration: 48 months (initial phase)
Funding: $500,000

Potential Funding and Partnership Opportunities
TxDOT, Texas Railroad Commission, TxDPS, TxDMV, industry trade associations, data aggregators.
Title

Background and Research Need
Energy developments have altered traffic circulation patterns throughout the state. Such changes have happened extremely fast, frequently taking state, county, and local agencies by surprise. A challenge with the current network of traffic count stations, including WIM stations, is that most stations are located along major highways, not secondary roads or local streets. As a result, a frequent complaint is that official traffic counts are not indicative of actual traffic conditions in energy development areas. In addition to counts, agencies are interested in documenting O-D trends, supply chains, and typical routes to understand traffic patterns in connection with oil and gas well developments. MPOs and other agencies conduct O-D surveys for large regional studies, but most of these studies focus on metropolitan transportation planning applications.

Objective
The research objective is to test data collection techniques and protocols to characterize traffic flows in energy development areas more effectively. The research should examine the usability and limitations of existing methodologies and prepare a catalog of technologies and procedures for testing and implementation. Potentially, this could become a long-term research program. In the short term, the research should examine options such as, but not limited to, the following:

- Portable WIM stations. Research is needed to increase the reliability and accuracy of the data as well as the capability of the devices to withstand the harsh environment in which they would need to operate, particularly on secondary roads characterized by uneven pavement surfaces and a lack of adequate lane control.
- Permanent WIM stations. Research is needed to analyze and develop information products from the wealth of data already collected through the network of permanent WIM stations.
- Bluetooth and cell phone signals.
- Connected vehicle technologies.
- Aggregated GPS data acquired through agreements with commercial data aggregators.
- Driveway permitting process.
- Agreements with energy developers and service companies.

Estimated Time and Funding Requirements
Duration: 36 months
Funding: $500,000

Potential Funding and Partnership Opportunities
TxDOT, trade associations, commercial data aggregators, counties.
Title
Analyze OS/OW Permit Data to Extract Information about Truck Traffic Trends in Energy Development Regions

Background and Research Need
The Texas Department of Motor Vehicles issues thousands of OS/OW permits every year, which allow commercial vehicle operators to drive vehicles that exceed maximum legal limits with respect to height, width, length, and weight (both axle weight and gross vehicle weight). A significant number of OS/OW permits are in connection with loads needed for energy developments. Previous and current research efforts have documented trends such as typical routes, percentages of OS/OW trucks that travel on Texas roads, and general impacts of OS/OW vehicles. While these initiatives are providing useful information to planners, engineers, and decision makers, a number of issues that happen in the real world highlight the need for a more systematic approach to the analysis and use of OS/OW data. Examples of issues include the following:

- Oversized trucks hitting bridges and other structures. Single-trip permits take into account road restrictions. However, it is not clear whether restriction data are always up-to-date. In addition, some drivers operate their vehicles on route segments that were not permitted or drive vehicles that exceed the dimensions or weight that were stated during the permitting process.
- Annual permits not having routes assigned to them. The potential number of trips associated with annual permits (for which route information is unknown) is much higher than the number of trips associated with single-trip permits.
- Pavement and bridge infrastructure exhibiting significant deterioration, although it is unknown to what degree oversized or overweight trucks are responsible for that deterioration, or to what degree permit fees are adequate to compensate for the damage.

Objective
The research objective is to develop and test methodologies to improve OS/OW permit data analysis capabilities to extract information about truck traffic trends in energy development regions. The research should review and extend current research efforts and develop a framework to facilitate future longitudinal analyses. The research should examine both single-trip permit data and annual permit data.

Estimated Time and Funding Requirements
Duration: 12 months
Funding: $150,000

Potential Funding and Partnership Opportunities
TxDOT, TxDMV.
Title
Develop Data-Driven Tools to Forecast and Quantify the Location, Magnitude, and Impact of Energy Developments at Different Levels of Spatial and Temporal Aggregation

Background and Research Need
A fundamental challenge that state, county, and local agencies face is how to allocate scarce funds to address transportation infrastructure investment and maintenance needs. Allocation of limited funds has always been a challenge, but this challenge has become worse in recent years due to the accelerated deterioration of the transportation infrastructure in energy development regions. One of the reasons is the limitations of current analytical and forecasting tools, which were developed primarily for urbanized areas assuming relatively small annual growth rates, predictable land development patterns, and vehicle fleets with small truck percentages. Another reason is the lack of adequate knowledge about truck traffic volumes, origins and destinations, typical routes, and individual energy development phases. A related issue is the lack of adequate communication and coordination between energy developers and transportation agencies related to critical information needed for analysis and forecasting (e.g., when companies decide that they will develop a site or field, what technologies they will use to develop a site, and how much truck versus pipeline transportation they will use).

Objective
The research objective is to develop data-driven modeling tools that allow planners and engineers to forecast and analyze the location, magnitude, and effect of energy developments at different geographic levels (i.e., individual energy development, corridor, county, region) and different temporal levels (i.e., individual energy development, month, season, year). At the finest levels of disaggregation, the effect should be estimated at the individual roadway segment at least in terms of anticipated truck volumes and truck axle loads. Additional measures could include travel times, speeds, and system delays. The research should develop a catalog of data elements needed to support the analysis at each level of spatial and temporal aggregation, examine different business processes (e.g., drilling, hydraulic fracking, completion, production, water disposal), select and/or develop a modeling environment, and calibrate and validate the modeling environment. The research should also use the modeling environment to execute what-if scenarios to provide stakeholders with a range of possible answers to questions such as: “What is the likelihood that wells will be developed in this part of the county over the next two years?” to “How many single-axle and tandem-axle loads should I expect along this corridor for the next five to 10 years?”

Estimated Time and Funding Requirements
Duration: 24 months
Funding: $400,000

Potential Funding and Partnership Opportunities
TxDOT, TRB, FHWA.
Title
Evaluate the Use and Effectiveness of Different Revenue and Funding Sources to Address Transportation Infrastructure Issues in Energy Development Areas

Background and Research Need
Agencies spend considerable time and resources planning and developing projects, some of which are not further developed for a long time due to funding limitations. Allocation of limited funds has always been a challenge, but this challenge has become worse in recent years due to the accelerated deterioration of the transportation infrastructure in energy development regions. Prior research at TTI indicates that the impact to the state highway network (only including secondary roads, but not main highways or bridges) resulting from these activities is about $1 billion/year, with a similar estimate representing the impact to county and local roads. The actual cost is probably higher than this estimate. The reason is that the estimate accounts mainly for the cost to repair roads back to their original condition (in many cases narrow roads with limited or no shoulders), not the additional cost to rebuild roadways to a higher standard capable of withstanding large amounts of heavy truck traffic safely for an extended period of time. In recent years, the Texas Legislature has allocated additional funds to help address this issue, but the total amount that has been allocated is much lower than the actual cost of the impact. This discrepancy highlights the urgent need to find alternative, innovative revenue and funding sources to account for the difference.

Objective
The research objective is to evaluate the use and effectiveness of a variety of revenue and funding alternatives to address transportation infrastructure issues in energy development areas. The research should examine the evolution and effectiveness of current funding strategies, including programs authorized by the Texas Legislature in recent years (e.g., SB 1747, 83rd Legislature). The research should establish correlations between oil and gas energy developments; truck traffic volumes; allocated funds at the state, county, and local levels; projects that have been completed; and the corresponding results in the field. The research should examine potential revenue and funding alternatives, such as, but not limited to, permit fee structures, performance bonds, public-private partnerships, ETJ boundary adjustments, property and sales taxes, and donation agreements. The research should examine the degree to which these strategies would help to alleviate the impact resulting from the lag between the time that energy developments take place (which place all kinds of demands on existing infrastructure) and the time that state, county, and local jurisdictions begin to receive economic benefits.

Estimated Time and Funding Requirements
Duration: 24 months
Funding: $400,000

Potential Funding and Partnership Opportunities
Texas Legislature, TxDOT, County Judges and Commissioners Association, MPOs, COGs.
Title

Develop Guidelines to Improve Transportation Planning Processes to Account for Oil and Gas Energy Development Locations and Trends

Background and Research Need

Including energy sector trends and needs in the transportation planning process results in additional challenges because of the dynamic nature (in both space and time) of the oil and gas industry. Obtaining information directly from the energy industry would be one of the most cost-effective ways to gather data needed to improve travel demand forecasting practices. However, achieving this goal is notoriously difficult. Sometimes, planners are able to obtain some data indirectly, but this is not always feasible.

One of the limitations in traditional transportation planning is the requirements for projects to be financially constrained. The usual transportation planning process involves identifying projects based on where the need is most acute, but anticipating where pavements will suffer the most is very difficult in energy development areas without information about where energy developments will happen or how extensively. In other cases, project prioritization is based on traffic safety or mobility considerations. Unfortunately, agencies are often operating in a reactive mode, trying to respond to problems that are critical instead of planning proactively in order to anticipate where problems might occur.

Objective

The research objective is to develop guidelines to improve transportation planning processes in areas affected by energy developments. The research should examine current planning practices at the metropolitan and rural levels, identify issues and limitations of those practices, and recommend strategies for implementation at planning agencies such as MPOs and RPOs. The strategies should also outline recommendations for TxDOT and other agencies that provide support to the regional and local transportation planning process. The research should examine issues such as coordination with the oil and gas industry; additional requirements for data collection in rural and urbanized areas; differences in land ownership patterns in different parts of the state, which could have transportation planning impacts; and designation of specific corridors at the state, county, and local levels to support oil and gas well developments. The research should also examine the identification of roadway funding categories and their applicability, as well as processes to select transportation projects.

Estimated Time and Funding Requirements

Duration: 24 months
Funding: $400,000

Potential Funding and Partnership Opportunities

TxDOT, MPOs.
Develop Highway/Railroad Integration Strategies to Optimize the Transportation System in Energy Development Areas

Background and Research Need
The Texas Legislature authorized La Entrada al Pacífico Rural Rail District to improve rail freight transportation along a corridor that stretches from the Mexican coast of the Gulf of California to the West Texas plains, via Presidio and Midland-Odessa. The rail district proposed to connect the TxDOT-owned South Orient Railroad with a rail facility in Seagraves. The rail district anticipates a demand for 40,000 carloads, including fracking sand, drilling pipes, and cement (delivered to the region) and crude oil (shipped to refineries). Anticipated benefits include a reduction in truck traffic and truck-related crashes and fatalities. The rail district has the power of eminent domain and the authority to issue bonds. However, a question is whether this power and authority are enough or if additional strategies are necessary to make the district (and other rural rail districts around the state) more effective.

Current research at TTI is examining how potential investments at the state level in rail infrastructure (e.g., in the form of new or improved rail infrastructure, rail capacity improvements, or reactivation of former rail lines) could be used as an alternative approach to address freight transportation needs in shale energy regions. However, a number of questions remain, including what the state role should be in formulating rail policy, what kind of regional planning impacts must be addressed, and how to engage the energy and railroad industries to promote communication and coordination for transportation-planning applications.

Objective
The research objective is to develop a set of strategies that could result in a more effective integration of highways and railroads in energy development areas. The research should review rural rail districts in Texas and examine the degree to which these districts can provide for a more effective transportation of materials and products related to the development and operation of energy sites. In the larger picture, the research should examine what the state role should be in formulating rail policy, what kind of regional planning impacts must be addressed, and how to engage the energy and railroad industries in transportation planning. There is also a need to address operational and safety issues that can affect multiple agencies and jurisdictions, ranging from railroad crossing operations to the safe movement of crude oil by rail.

Estimated Time and Funding Requirements
Duration: 24 months
Funding: $300,000

Potential Funding and Partnership Opportunities
TxDOT, FRA, RRF, Department of Energy
**Title**

Document Correlations between Energy Developments, Crashes, and Transportation Infrastructure Conditions

---

**Background and Research Need**

The number of crashes in energy development regions has increased. Recent research completed at TTI indicates that the number of crashes and resulting injuries has increased along with oil- and gas-well-development activities, but the changes are not uniform either by crash location and type of vehicles involved or by injury severity. The increases in the number of crashes and injuries are more prominent in rural areas where energy developments take place (i.e., Eagle Ford Shale and Permian Basin regions). The highest increase is in the case of rural crashes that involve commercial vehicles (CMVs). There are also significant differences geographically within each region. Overall, there is a strong correlation between rural CMV crashes and the number of new wells. The percentage of crashes on state highways has increased. As the severity of the injuries increases, the percentage of crashes on state highways has also increased.

While a significant number of crashes can be attributed to driver causes for which enhanced enforcement is part of the solution, a driver-contributing factor has not been identified in close to 40 percent of crashes. Many crashes are likely related to inadequate transportation infrastructure conditions. In some cases, engineers know their “hot spot” areas. In practice, district offices follow a complicated, time-consuming process to identify safety improvement projects. However, the process is often impeded by limitations such as staff availability, lack of training, or inadequate access to or knowledge of appropriate software or techniques. The result is often inefficient allocation of staff time and resources, reduced project effectiveness, and projects that are selected in areas that do not have a significant safety problem.

---

**Objective**

The research objective is to develop a systematic approach to determine and quantify possible causes of crashes in energy development areas so that appropriate engineering-based safety improvement strategies can be implemented. Based on the results of the research that was recently completed, the research should review innovative methods that have or are being developed throughout the country, examine a sample of crashes in energy development areas, conduct field assessments and measurements, and develop and test an engineering-based framework and methodology to analyze crashes and select safety improvement projects.

---

**Estimated Time and Funding Requirements**

Duration: 24 months  
Funding: $400,000

---

**Potential Funding and Partnership Opportunities**

TxDOT, TRB, FHWA.
Title
Develop Guidelines to Improve Driver Safety in Energy Development Areas

Background and Research Need
Recent research completed at TTI indicates that the number of crashes and resulting injuries has increased along with oil- and gas-well-development activities. The increases in the number of crashes and injuries are more prominent in rural areas where energy developments take place. The highest increase is in the case of rural crashes that involve commercial vehicles. There are also significant differences geographically within each region. Overall, there is a strong correlation between rural CMV crashes and the number of new wells. The percentage of crashes on state highways has increased. As the severity of the injuries increases, the percentage of crashes on state highways has also increased. A significant number of crashes can be attributed to driver causes. Examples of leading causes include unsafe speed, failure to control speed, driver inattention, faulty evasive action, fatigued or asleep, and failure to drive in a single lane. Although enhanced enforcement should be considered part of the solution, research is needed to develop and test an array of strategies to improve driver safety in energy development areas.

Objective
The research objective is to develop and test a catalog of practices and techniques to improve driver safety in energy development areas. The research should examine current safety improvement practices and evaluate their effectiveness, limitations, and challenges in a wide range of areas such as enforcement; safety campaigns; funding at the state, county, and local levels; and existing laws and regulations. The evaluation of practices should include both government agencies and the energy sector (e.g., reviewing safety campaigns by individual companies and those promoted by trade organizations). The research should review a wide range of related issues and topics, including, but not limited to, the following:

- Impact of the availability of funding on law enforcement capabilities and effectiveness
- Impact on local populations
- Differences in safety training policies across the industry
- Effectiveness of interagency working groups to raise safety awareness
- Impact of truck driver pay structure on operations and safety
- Habitual traffic law violators
- Thresholds for vehicle inspection authority at municipalities

Estimated Time and Funding Requirements
Duration: 24 months
Funding: $300,000

Potential Funding and Partnership Opportunities
TxDOT, DPS, FMCSA, NHTSA.
Title
Develop Technologies and Guidance to Improve Work Zone Safety in Areas of Active Energy Sector Developments

Background and Research Need
Agencies provide information about active work zones to the public using a variety of mechanisms. TxDOT provides information about highway construction projects and closures through web-based mapping applications such as http://drivetexas.org and social media outlets such as Twitter. A wide range of public-sector and private-sector stakeholders use this information. For example, TxDPS uses it to make decisions on patrolling schedules. The private sector uses it to evaluate the impact of active work zones on their own operations. While this information is useful, it has a number of shortcomings in rural areas where there are limited alternative corridor options and, at the same time, substantial amounts of traffic that can change dramatically from one day to the next.

A common problem in oil and gas shale energy regions is energy sector trucks entering the road in the middle of a work zone. In many cases, traffic is limited to one-lane operations with a one-lane, two-way control zone. The problem arises when trucks enter the road from driveways located between the two control zone ends but the drivers do not know which of the two directions is active at that time. This issue is particularly critical at night. There are general guidelines for one-lane, two-way control zones, but there is a need to update current methodologies to properly account for situations such as those that occur in energy development areas.

Objective
The research objective is to investigate and test methods and technologies to improve traffic safety in work zones in areas of active energy developments. The research should examine both road-based techniques (intended to assist truck drivers) and web-based techniques (intended to assist fleet managers, construction zone managers, truck drivers, and law enforcement agencies). An example of a road-based technique is the use of technologies such as arrow boards or flashing signs to alert drivers about which direction is active at any point in time. An example of a web-based technique is a web-based map that displays which direction is active in real time, shows the location of trucks that are approaching the state highway under construction from an access road, and triggers an alarm if the truck driver enters the highway in the wrong direction.

Estimated Time and Funding Requirements
Duration: 24 months
Funding: $400,000

Potential Funding and Partnership Opportunities
TxDOT, TxDPS, trade associations.
Title
Develop Guidelines for Traffic Control Signage Along Truck Routes in Energy Development Areas

Background and Research Need
Recent research completed at TTI indicates that the number of crashes and resulting injuries has increased along with oil- and gas-well-development activities. The increases in the number of crashes and injuries are more prominent in rural areas where energy developments take place. Overall, there is a strong correlation between rural CMV crashes and the number of new wells. The percentage of crashes on state highways in energy development regions has increased. As the severity of the injuries increases, the percentage of crashes on state highways has also increased.

A significant number of crashes can be attributed to driver causes such as unsafe speed, failure to control speed, driver inattention, faulty evasive action, fatigued or asleep, and failure to drive in a single lane. Although enhanced enforcement and safety campaigns should be considered part of the solution, there is a need to develop or improve strategies and technologies to warn drivers about dangerous situations through proper traffic control signage.

Objective
The research objective is to develop or test innovative techniques to improve traffic control signage along truck routes in energy development areas. The research should include an objective review of practices that several districts are experimenting with, including, but not limited to, improved signage on narrow bridges, using flashing traffic signs that are actuated when speeding occurs on curves, or chevron arrow lights that flash when trucks enter the roadway. The research should examine the feasibility of using or adapting systems that have been successful in other applications (e.g., the wrong-way detection system that the TxDOT San Antonio District developed). The research should also examine the feasibility of innovative implementation strategies (e.g., engaging energy developers to help pay for these devices using donation agreements).

Estimated Time and Funding Requirements
Duration: 24 months
Funding: $300,000

Potential Funding and Partnership Opportunities
TxDOT, trade associations.
Title
Develop Strategies to Reduce The Use of Water and Promote Public Awareness about Best Water Conservation Strategies in Energy Development Areas

Background and Research Need
Developing a new horizontal well in Texas requires 1000–1500 heavy truck trips. Although accurate numbers are generally not available, several estimates point to hydraulic fracturing operations being responsible for more than 50 percent of all five-axle truck traffic needed to develop a new horizontal well. In addition to water needed at the well site for fracking operations, the industry must deal with flowback and produced water. Unless a pipeline network exists or treatment is feasible at the site, this water needs to be transported by truck, often to a remote location. Many of the roads used to develop oil and gas well sites were never designed to carry high numbers of heavy trucks or loads. The result has been accelerated pavement degradation and damage to roadside infrastructure. The cost to repair the damage or rebuild this transportation infrastructure is significant. However, the industry does not include this cost in the cost to transport equipment, materials, or water to a well site.

Transporting water costs money. Some energy developers introduce efficiencies (e.g., by recycling water and by moving some of the water by pipeline instead of truck). Current research at TTI is examining practices for permitting, locating, and maintaining temporary lines within the right-of-way. Additional research is examining the feasibility of bringing desalinated water from the Gulf of Mexico to Eagle Ford Shale region operations. These initiatives point to an urgent need to identify and evaluate strategies to lower the economic cost to society. In particular, it is urgent to identify strategies to reduce the use of water and promote public awareness about best water conservation strategies in energy development areas.

Objective
The research objective is to prepare and evaluate a catalog of strategies to reduce the net amount of water needed to develop oil and gas wells and to develop communication strategies to promote public awareness about best water conservation strategies in energy development areas. The research should highlight the connection between energy developments, water management, and transportation system management, using lessons learned from research currently underway. The reason is that the need for water conservation when developing energy sites has been identified elsewhere, but the connection to the cost to repair or rebuild the transportation infrastructure is rarely, if ever, included in the public debate.

Estimated Time and Funding Requirements
Duration: 24 months
Funding: $500,000

Potential Funding and Partnership Opportunities
TxDOT, industry trade associations, TCEQ, counties, cities.
Develop a Data-Driven Methodology to Identify, Prioritize, and Select Maintenance Projects

Background and Research Need
Energy developments have altered traffic circulation patterns throughout the state. Such changes have happened extremely fast, frequently taking state, county, and local agencies by surprise. In some cases, counties have interagency agreements with cities that can be useful to address certain types of road maintenance issues. However, counties frequently face challenges related to scheduling and completing road projects, including limited funding and labor shortages. At the state, county, and local levels, there is frequently a lack of knowledge about the amount of truck traffic generated by energy developments and the resulting impact on pavement structures. Pavement failures are often the result of this lack of knowledge, even on roadways that have been repaired multiple times in the recent past. Part of the problem is that agencies often repair damaged roads using the same guidelines they used decades ago, relying on old pavement structures that cannot carry significant axle loads and therefore fail quickly.

In other situations, maintenance engineers have options ranging from full rehabilitation to overlays and seal coats, but it is not always clear which option to choose or which roadways to prioritize. A major concern by TxDOT is to rehabilitate a pavement with an upgraded pavement structure that can withstand the heavy loads, only to find out that heavy trucks are no longer in the area and are not using the roadway.

Objective
The research objective is to develop and test an asset management, user-friendly, visualization tool (e.g., a web-based platform) that transportation officials can use to review and overlay relevant data (e.g., pavement condition scores, geometric characteristics, work history, traffic data, maintenance expenditures, anticipated oil or gas well site locations, etc.). Such a platform would allow maintenance engineers to identify, prioritize, and select roadway projects quickly, enabling them to allocate funds more efficiently. It would also allow them to respond to funding releases in a timely manner without making rushed and uninformed decisions. The tool or guidance should use updated pavement design parameters that take into account the axle loads that are most likely to happen using current oil and gas development technologies. Based on these input parameters, the tool would provide guidance on maintenance strategies and pavement design characteristics (e.g., type of pavement and thickness of layers and sublayers).

Estimated Time and Funding Requirements
Duration: 24 months
Funding: $400,000

Potential Funding and Partnership Opportunities
TxDOT, counties, cities, FHWA.
Title
Develop a Simplified Process to Select Strategies for Pavement Repairs and Minimum Depth

Background and Research Need
The current process to determine loads to failure and remaining life involves determining what kind of pavement structure is needed, but this requires a detailed understanding of current and expected future use of the roadway, including current and expected traffic use and loads. A problem in practice is not having enough information about the amount of truck traffic generated by energy developments and the resulting impact on pavement structures. A related issue is a lack of adequate communication and coordination between energy developers and transportation agencies related to critical information needed for the analysis (e.g., when companies decide that they will develop a site or field and what kind of trucking activities are anticipated in the future).

In deciding on the appropriate maintenance strategy, questions that transportation agencies often deal with are the required width of the roadway (28, 30, or 32 feet) and whether the pavement depth can be reduced if the roadway width is increased. This prompts the need for a tool or process to determine the necessary type of pavement repairs, including appropriate cross-section width and minimum depth (i.e., shallow repair versus deep repair).

Objective
The research objective is to develop a simplified decision tree or process for the design of pavements in energy development areas. This tool or process would enable maintenance engineers to determine the necessary type of pavement repairs, including appropriate cross-section width and minimum depth (i.e., shallow repair versus deep repair). The tool would help engineers to determine what to do to maintain a roadway in the short term (one to two years) before starting a full rehabilitation. Part of the process would involve selecting the most critical pavement distress factor that pavement design should address.

Estimated Time and Funding Requirements
Duration: 18 months
Funding: $250,000

Potential Funding and Partnership Opportunities
TxDOT.
**Title**
Develop Guidelines to Mitigate Impacts to Bridges and Other Structures in Energy Development Areas

**Background and Research Need**
Developing a new horizontal well in Texas can require anywhere from 1000 to 1500 heavy truck trips. Many of the roads used to develop oil and gas well sites were never designed to carry high numbers of heavy trucks or loads. The result has been faster degradation of pavement structures, bridges, and roadside infrastructure than had been anticipated. Other impacts include increases in the number and severity of crashes and operational inefficiencies. The cost to repair or rebuild the transportation infrastructure is significant.

Bridges are particularly sensitive to the kind of traffic generated by the development of oil and gas well sites. In addition to legal truckloads (i.e., loads that do not exceed the maximum legal limit with respect to dimensions of weight), a significant amount of truck traffic is oversized or overweight. Bridges, particularly narrow bridges, are frequently hit, sometimes sustaining heavy damage. A common perception is that trucks with annual permits and small motor carriers are more frequently involved in this type of incidents. However, there are no reliable statistics confirming this hypothesis. Additional issues affecting bridges in energy development areas are pavement tie-ins and issues on approaches (e.g., longitudinal cracks). There are also issues with current bridge inspection practices. For example, TxDOT inspects all bridges every two years, with a crude ‘maintenance’ inspection every other year. In energy development areas, there is a concern that this protocol might not be sufficient.

**Objective**
The research objective is to develop strategies and recommendations to reduce the number of hits to bridges and other structures, develop recommendations to improve maintenance practices for bridge approaches, and update bridge inspection practices. The research should quantify the impact to bridges in terms of axle loads (including legal and overweight loads), hits due to oversized loads, and structural integrity of the bridge approaches. With this information, the research should offer recommendations for strategies to reduce the impact to bridges, ranging from permitting to enforcement and traffic control strategies. The research should review bridge inspection practices and develop recommendations for changes in areas where energy developments are active.

**Estimated Time and Funding Requirements**
Duration: 24 months  
Funding: $300,000

**Potential Funding and Partnership Opportunities**
TxDOT, counties, cities.
Title
Develop Guidelines for More Effective Use of Local Resources and Recycling for Roadway Maintenance and Energy Developments

Background and Research Need
Using local resources or recycling for roadway maintenance has been studied before. However, agencies are still unsure about how to implement results on a case-by-case basis. Using fewer resources that must be brought in and more of what is available at the site is more cost-effective and safer, but project managers need guidance and solutions. It is especially difficult to mix recycled materials with new materials. For example, the mix may be designed in a laboratory setting but the cement used in the lab is different from the cement delivered to the job site. In other situations, counties receive offers to help with repairing or paving roads using byproducts or surplus materials, but have no guidance to decide which of these materials (if any) may be acceptable for road construction. In the case of oil and gas energy developments, a frequent question is to what degree drill cuttings can be used as a road material, taking into consideration factors such as the engineering properties of the materials (e.g., particle size, strength, and durability), as well as the amount or concentration of contaminants, petroleum-based substances, or radioactive materials. There are also innovations, many of them developed by the private sector (e.g., a product called “mechanical concrete”), which uses recycled tires tied together and filled with aggregate base; polymer-based soil stabilization, which increases the strength of the local soil; and rollout mats (particularly for access roads and pads).

Objective
The research objective is to develop a catalog of innovations that highlight the use of local resources and recycling to assist with roadway maintenance and construction practices related to energy developments. The research should cover the whole spectrum of applications from public roads to access roads and well pad construction and maintenance. The research should examine the usability and limitations of existing methodologies and prepare a catalog of technologies and procedures for testing and implementation. Potentially, this could become a long-term research program. In the short term, the research should include a review of available technologies and selection of a representative sample for testing and prototype implementation. The research should also include workshops to demonstrate the application of promising technologies, and develop a business plan for future testing as new technologies become available.

Estimated Time and Funding Requirements
Duration: 36 months
Funding: $900,000

Potential Funding and Partnership Opportunities
TxDOT, industry trade associations, AASHTO.
Title
Develop Methodologies to Partially Open Roads Under Rehabilitation or Reconstruction to Heavy Traffic

Background and Research Need
Partially opening roads to traffic while the roads are still undergoing rehabilitation or reconstruction is a common practice. However, this is not always suitable, particularly in situations where there are substantial amounts of heavy truck traffic (e.g., when there are active energy developments in the area). In situations like this, there is simply not enough pavement structure to open the road for heavy traffic before the rehabilitation or reconstruction work is finished.

There is a need to test and document methodologies that would allow at least some traffic on the road. Examples include the use of stable platforms that can withstand truck traffic and the use of untreated base material or foamed asphalt that would be removed later. In some situations, it might be possible to close the road for the duration of the project if adjacent roads can absorb the additional truck traffic from the road that is undergoing rehabilitation, or if alternative driveways are provided along those roads so that local traffic can access those roads directly. In any case, close communication and coordination with affected stakeholders would be necessary.

Objective
The research objective is to identify methodologies to partially open roads under rehabilitation or reconstruction to heavy traffic. The research should include a statewide review to document cases where truck traffic is allowed and the general impact this practice has on the road; examine cost, benefits, and limitations of current practices; and prepare a catalog of lessons learned. The research should also identify a sample of promising techniques and conduct a series of field tests to fully document the impact and results.

Estimated Time and Funding Requirements
Duration: 24 months  
Funding: $400,000

Potential Funding and Partnership Opportunities
TxDOT, energy trade associations, counties.