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16. Abstract

Many innovative freight delivery strategies and technologies have been proposed to address the future freight needs of Texas's growing population. Changes in both buying habits and a shift toward direct home package delivery threaten to dramatically change distribution patterns and increase the number of intercity and local delivery trucks on Texas Department of Transportation (TxDOT) roadways. Emerging freight delivery technologies such as automated freight vehicles and innovative operational freight strategies such as nighttime off-peak-hour deliveries to businesses are potential ways to better use existing infrastructure. Unfortunately, TxDOT and local transportation planners currently lack an established process to evaluate operational changes or technology applications needed to ensure continued, timely flow of commercial freight through the Texas transportation system. The primary objective of Phase I of this project was to establish a process to evaluate freight operational changes or technology applications to ensure continued, timely flow of commercial freight through the Texas transportation system. This phase identified over 50 currently proposed freight strategies and technologies and evaluated them to determine which should be further evaluated for implementation in future project phases.

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ASSESSMENT OF INNOVATIVE AND AUTOMATED FREIGHT STRATEGIES AND TECHNOLOGIES—PHASE I FINAL REPORT

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DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of FHWA or TxDOT. This report does not constitute a standard, specification, or regulation.

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CHAPTER 1. BACKGROUND AND PROJECT OVERVIEW

INTRODUCTION

Many innovative freight delivery strategies and/or technologies have been proposed to address the future freight needs of Texas's growing population. Planners in the Texas Department of Transportation (TxDOT) and local/regional transportation planners in the state lack necessary tools to evaluate proposed operational changes or technology applications to ensure continued, timely flow of commercial freight through the Texas transportation system. The project phase described in this report sought to both identify and assess worldwide innovative/automated freight strategies and technologies and develop a tool for assessing future freight strategies and technologies.

New and/or emerging freight delivery technologies (such as automated freight vehicles or airborne small package delivery) and innovative operational freight strategies (such as nighttime off-peak-hour deliveries or conversion of high-occupancy vehicle or managed lanes to truck-only use during high port traffic periods) are examples of potential ways to better use existing infrastructure. Demographic shifts and changes in the buying habits of consumer goods toward direct home package delivery could also dramatically shift distribution patterns and increase the number of intercity and local delivery trucks on TxDOT roadways. Identification of new strategies and technologies to address future freight challenges is vital for TxDOT to promote business/economic development in the state and improve quality of life for its citizens.

RESEARCH OVERVIEW

TxDOT Project 0-6837 is one of the initial projects authorized under TxDOT's Innovative Project Program, which was solicited under TxDOT Request for Proposal (RFP) #14-82 in 2014. This project was developed under Research Area 2 of the referenced RFP, which stated the following as the intent for this project research area:

> TxDOT seeks innovative proposals under this area to identify, develop, and prove infrastructure and in-vehicle technologies and requirements for statewide freight corridors that leverage real-time data availability and utilize assisted driving, autonomous vehicle, or drone technologies. Proposals may include all aspects of freight movement and should not be limited to highway applications.
>
> Proposals under this area should:
>
> 1. Result in improved freight connectivity and more efficient intermodal facilities.
> 2. Increase freight efficiency (target is 50 percent improvement over current levels).

3. Improve traveler safety.
4. Reduce congestion (both freight and traveler).
5. Support the activities of the TxDOT Freight Advisory Committee in the near- to mid-term, and inform the long-term vision of the Committee.

Each project under RFP #14-82 was required to be envisioned as a three-phased project, with Phase I being exploratory and preparatory in nature, Phase II being tied to actual testing/evaluation of the methods under study, and Phase III being an implementation phase where results from the previous phases could be transferred and implemented into practice within TxDOT. Figure 1 shows how these three phases were taken into account in drafting the original proposal, which became Project 0-6837, which covered only Phase I and initial planning for Phase II of the larger, envisioned overall project.

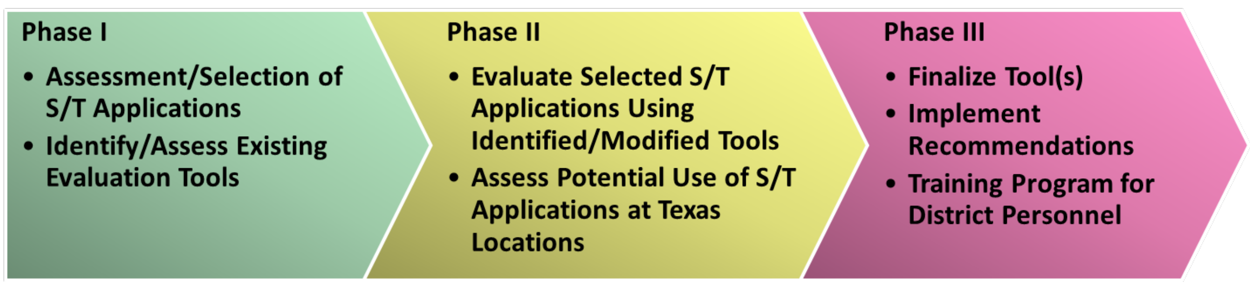


Figure 1. Overview of the Three Phases of the Overall Project.

Research Objectives

The primary objectives of Phase I of this project were to identify from worldwide freight practices the most innovative or automated strategies and technologies related to freight movement and to establish a process to evaluate freight operational changes or technology applications to ensure continued timely flow of commercial freight through the Texas transportation system. As explained in the previous section, future phases of the project will develop and adapt the evaluation metrics as necessary for longer-term use by TxDOT. The first phase of the project also assessed the identified freight strategies and technologies through a series of steps applying screening criteria as well as subject matter expert panel analysis and ranking, and utilized the assistance of the TxDOT project team panel to determine which of these should be further evaluated for implementation on the Texas transportation system during Phase II. The remainder of this report and its associated appendices describe the work conducted.

Research Approach

In order to accomplish the objectives of this project, the research team utilized the following approach for Phase I:

- Identified and defined innovative and automated freight strategies and technologies for in-depth analysis within three major freight movement categories—intercity or long-distance freight corridors, urban freight delivery, and major freight generators.
- Established through a thorough literature review initial freight concept evaluation tools for use, further development, or medication.
- Compared candidate strategies and evaluation methods with TxDOT freight infrastructure needs and draft Texas Freight Mobility Plan (TFMP) recommendations.
- Addressed the findings of the research with the TxDOT research panel to select appropriate strategies and technologies for recommendation for further evaluation in Phase II with a view toward implementation of TFMP goals.

REPORT ORGANIZATION

This report documents the findings of Phase I of TxDOT Research Project 0-6837. Chapter 1 provides an overview of the project. Chapter 2 reviews some of the major freight issues facing the state and metropolitan areas. Chapter 3 reviews multimodal freight project prioritization methods identified during the literature review. Chapter 4 discusses the initial list of innovative freight strategies and technologies identified during the research. Chapter 5 explains the reasoning behind consolidating the original strategies and technologies into broader focus areas. Chapter 6 describes the proposed consolidated strategies and technologies that were presented to the TxDOT research advisory panel for consideration for Phase II investigation and the description of the final nine selected by the panel. The report closes in Chapter 7 with conclusions and an overview of planned Phase II activities.

CHAPTER 2. MAJOR FREIGHT TRANSPORTATION CONCERNS

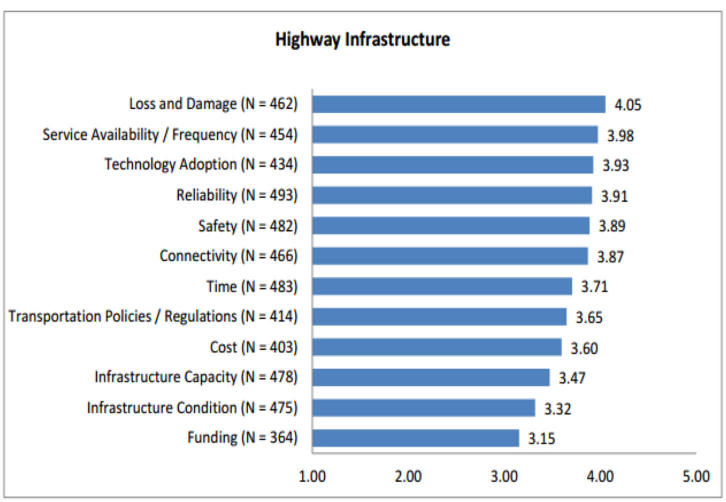
INTRODUCTION

This chapter provides background information related to the general freight concerns of the business community in Texas, the state's metropolitan planning organizations (MPOs), and as stated in the TFMP. (It should be noted that the TFMP was in draft status during the conduct of the majority of the 0-6837 Phase I research prior to final adoption by the Transportation Commission in January 2016. References throughout this report to the TFMP are generally to the draft TFMP versions of late 2015 which do not vary appreciably in content from the final, adopted TFMP which will be used during future phases of the project.)

FREIGHT PLANNING BACKGROUND

Major Freight Transportation Concerns of the Business Community in Texas

In mid-2015, TTI's Transportation Policy Research Center performed the Texas Freight Pilot Survey to measure the level of service of Texas's transportation system with more than 500 Texas freight establishments. The survey considered the respondents' rankings related to highways, rail, ports, and border crossings. The results, which are reported in *Texas Freight Survey: Final Report* (*1*), suggest that the satisfaction levels for highway infrastructure were lowest related to the funding levels, infrastructure conditions, and infrastructure capacity. As Figure 2 shows, survey respondents were most satisfied with the categories of loss and damages, service availability/frequency, and technology adoption levels while other infrastructure-related scores were relatively low.



Source: Texas Freight Survey: Final Report (1)

Figure 2. Average Ranking of Transportation Factors for Highway Infrastructure.

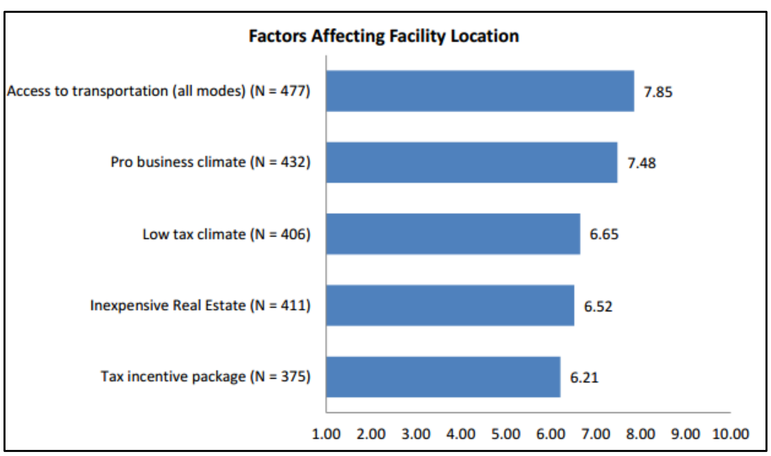
Figure 2 also shows that the overall scores related to highway infrastructure ranged generally only from neutral to somewhat satisfied, which was also true for rail and port infrastructure; however, the satisfaction levels for the border infrastructure were evaluated at a lower level. Table 1 shows the three lowest (or worst) ranked factors for each freight modal infrastructure segment as well as highway according to survey respondents. In other words, these are the areas that had the lowest satisfaction rating among the given choices for each modal infrastructure type. Infrastructure capacity appears for the highway, port, and border segments (i.e., in all but the rail area).

Table 1. Three Lowest-Ranked Factors for Each Freight Infrastructure Segment.

Highway	• Funding • Infrastructure Condition • Infrastructure Capacity
Rail	• Service Availability/Frequency • Funding • Time
Port	• Time • Infrastructure Capacity • Connectivity
Border	• Infrastructure Capacity • Time • Reliability

Source: *Texas Freight Survey: Final Report* (*1*)

Participants were also asked to rate the importance of five factors in determining freight establishment location within Texas. Figure 3 provides the rankings and demonstrates that businesses consider access to transportation (all modes) as the most important factor.



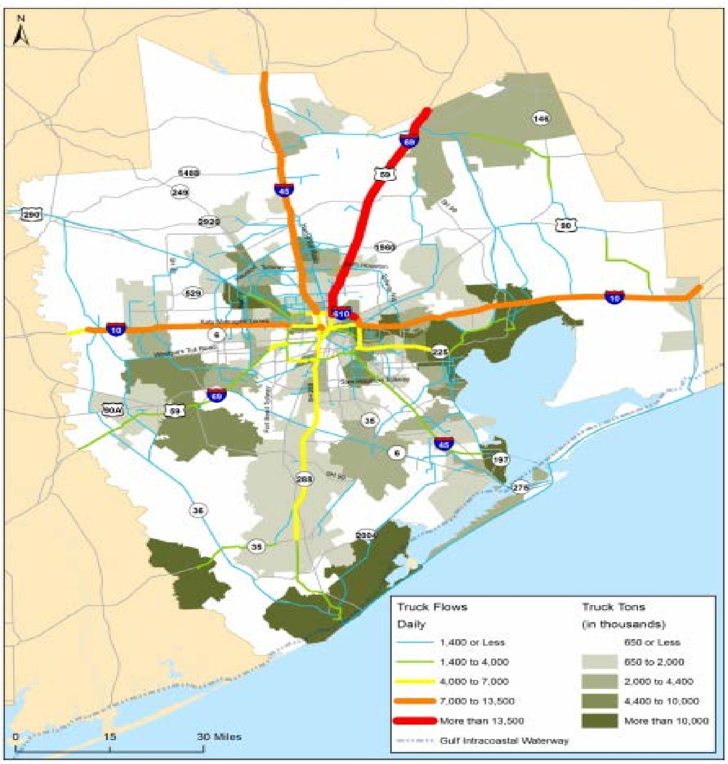
Source: *Texas Freight Survey: Final Report* (*1*)

Figure 3. Importance Scores for Factors That Impact Facility Location Decisions.

Major Freight Transportation Concerns of MPOs

The Texas freight pilot project conducted in 2011 found that the main infrastructure weaknesses in Texas are related to the condition of the infrastructure, the congestion and bottlenecks along major freight corridors, and the ability to fund necessary improvements. The related final report, by Prozzi et al., identifies lack of port-rail connections, last-mile delivery connectivity, and border congestion as additional weaknesses (*2*).

Several MPOs in Texas have identified a number of similar issues with transportation network capacity that will hamper the performance of regional freight systems. The Houston-Galveston Area Council's (H-GAC's) *Regional Goods Movement* report mentions the following main issues and challenges: chokepoints and bottlenecks, and traffic congestion that produces more than 153 million hours of delay with around $3.2 billion in losses (*3*). In particular, the north, west, and southwest areas of the Houston-Galveston region are growing most quickly, which will produce more transportation demand and constrain distribution of freight shipments in these sectors unless additional infrastructure capacity can be provided, as Figure 4 illustrates.



Source: Cambridge Systematics Inc. (3)

Figure 4. Growth in Average Annual Daily Truck Traffic with All Commodities in Houston-Galveston Area, 2007–2035.

Capacity is also a major freight issue in Hidalgo County. The county is served by two major interstate highways, I-69 and I-2, and has the major freeway interchange between the two highways, known as the Pharr Interchange. This interchange is expected to be a congestion chokepoint for a many years to come. The volume-to-capacity (V/C) ratio of the Pharr Interchange is high, and it is expected to deteriorate further as the county's population and employment grows. Table 2 lists the V/C ratios based on the county's population and employment projections. In addition to capacity issues, deteriorating infrastructure, funding shortage for infrastructure improvement/projects, and a truck driver shortage are other major issues impacting the Hidalgo County region (*4*).

Table 2. Forecasted Congestion Index Using Volume-to-Capacity Ratios at the Pharr Interchange.

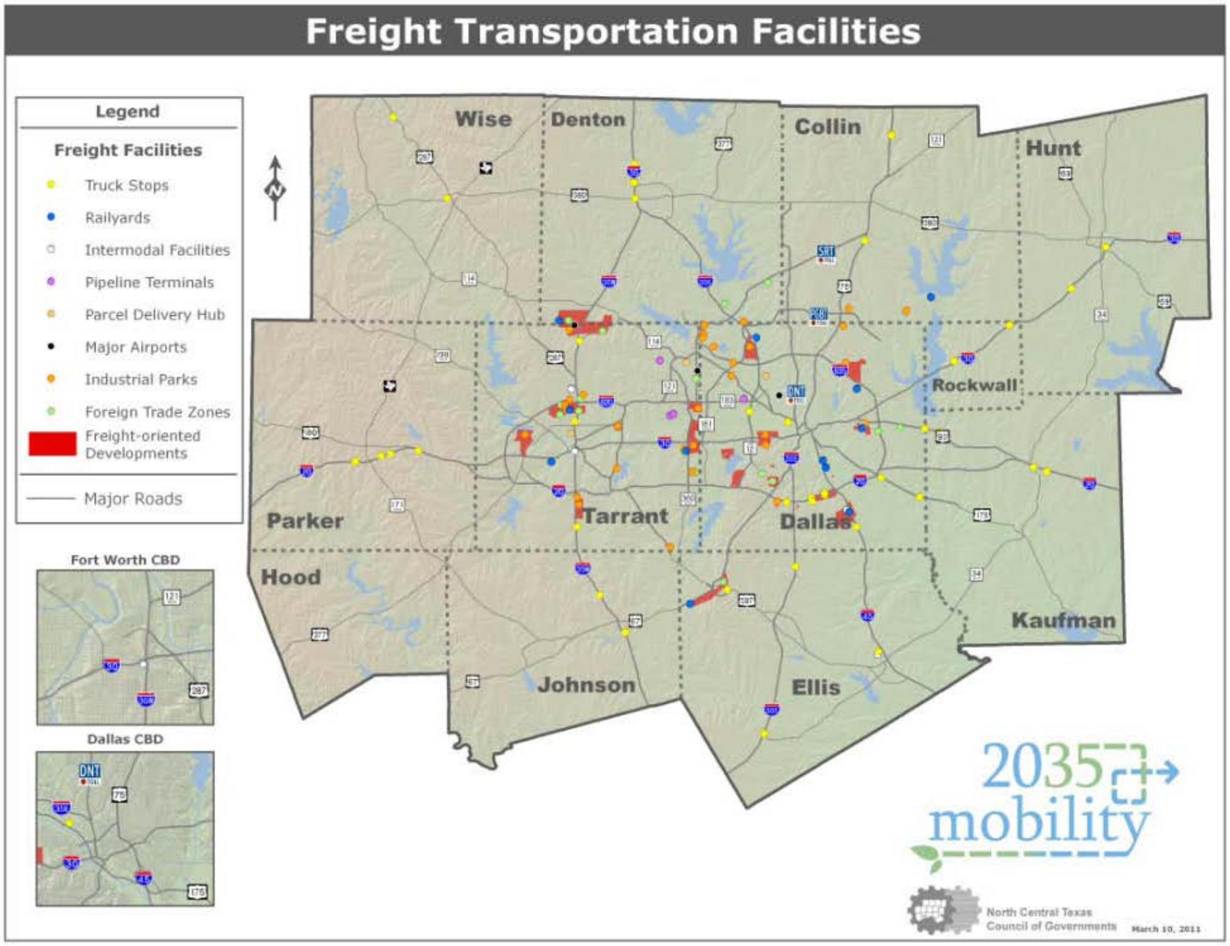
	1990	2000	2010	2020	2030	2040	2050
People	383,545	569,463	774,769	953,069	1,156,580	1,366,923	1,589,783
Jobs	113,197	166,285	219,373	272,461	325,549	378,637	431,725
V/C	(1.0 < V/C < 1.3) Uncongested to Congested		(V/C > 1.3) Severely Congested				

Source: Hidalgo County Metropolitan Planning Organization's *2015–2040 Metropolitan Transportation Plan* (*4*)

The Port of Beaumont's close proximity to the Gulf of Mexico and to the Intracoastal Waterway as well as its connection to all three major rail carriers—BNSF, UP, and KCS—propelled the port to be the fourth busiest port in the United States according to the U.S. port ranking by cargo tonnage in 2013 (*5*). The Port of Beaumont's biggest concern is rail congestion. Plans from the Jefferson-Orange-Hardin Regional Transportation Study Area identify four major issues of ports in the region as follows: (a) dredging and dredged material management, (b) port security funding, (c) antiquated cargo-handling facilities, and (d) intermodal transportation connections (*6*).

Since the H-GAC area includes port infrastructure, H-GAC is also concerned about intermodal connectors, as is also reflected in the regional analysis in the *Texas Freight Survey: Final Report* (*1*). The key issues are deficiencies in geometric design, insufficient truck capacity and access control, poor pavement level and drainage, and limited signs for drivers to navigate truck routes and find main facilities. Dealing with the current capacity and the new capacity is difficult because of the regulatory bottlenecks, insufficient funding, and policy and investment decisions that are not made at the system level (*3*).

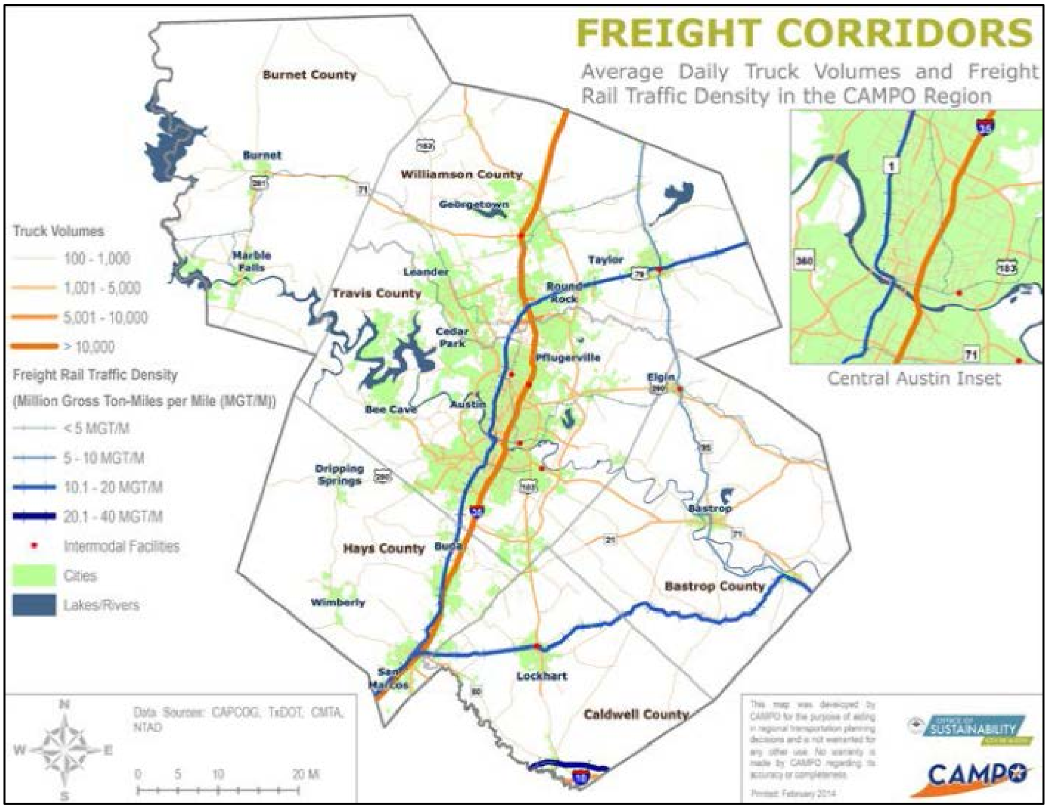
Similar issues can be found in the Mobility 2035—2014 Amendment to the Metropolitan Transportation Plan by the North Central Texas Council of Governments (NCTCOG). Freight represents a significant amount of the Dallas–Fort Worth regional economy, as evidenced by the percentage of Texas gross domestic product in this region of 32 percent. The amendment notes that the region's goals in freight planning include monitoring freight traffic and identifying potential bottlenecks, improving freight movement, and promoting safety, mobility, and accessibility (*7*). Figure 5 shows the large number of concentrated freight facilities in the NCTCOG area.



Source: NCTCOG (7)

Figure 5. Freight Transportation Facilities in North Central Texas Area.

Despite the large amounts of freight moving in and out of the Austin area, the Capital Area Metropolitan Planning Organization (CAMPO) is not a main generator of freight traffic. Most freight travels through the region, which is the freight movement that “has the largest effect on the region’s transportation system” (*8*). Two major networks pass through the CAMPO region—the National Primary Freight Network and the Texas Highway Priority Freight Network—as seen in Figure 6. The networks need to be improved regarding efficiency in freight movement and congestion.



Source: CAMPO (8)

Figure 6. Freight Corridors in the CAMPO Area.

The Laredo MPO region contains five border crossing bridges between the United States and Mexico. Among them, only three bridges—the Colombia-Solidarity Bridge, the World Trade Bridge, and the Laredo International Railway Bridge—are allowed for commercial usage. One of the issues this border region faces is congestion, especially during peak hours. The highway and rail congestion is mainly due to the border crossing wait times (*9*). According to the Laredo MPO's Metropolitan Transportation Plan, this delay can be relieved by changing trans-border security measures. In particular, if the use of barcodes is widely adopted, the traffic will move more quickly, which will assist in relieving congestion issues at border crossings (*10*). This issue can also be found in the El Paso area. Based on the criterion of peak crossing wait times, several areas connecting to El Paso ports of entry (POEs) already exceed operational capacity, as illustrated in Figure 7 (*10*).

Source: El Paso MPO (10)

Figure 7. El Paso Truck Route Level of Service, 2040.

As the United States enters into more trade agreements with Asian and South American countries, it will handle larger volumes of truck and rail traffic, particularly through coastal ports and landside POEs. The Laredo MPO is considering constructing a new international commercial bridge in order to addresses border congestion issues (*9*).

Because the importance of the air quality has become more significant to the U.S. government, MPOs are also concerned about the air quality related to the freight system. According to the H-GAC report, trucks are the main generator of air pollutants, emitting 72 percent of the region's transportation-related nitrogen oxides, 68 percent of the transportation-related particulate matter, 53 percent of the transportation-related carbon dioxide, and 37 percent of the volatile organic compounds (*3*). The H-GAC area is already labeled as "non-attainment" for a number of pollutants, which will restrict the area's ability to invest in freight system infrastructure. NCTCOG also indicates that one of its goals is to reduce air quality impacts of freight movements (*7*).

In general, Texas MPOs are concerned about growing freight traffic, the effects of that growing traffic on existing freight infrastructure and facilities, and how more freight traffic will exacerbate current chokepoints and strain intermodal connections at Gulf Coast ports and POEs along the Texas-Mexico border.

Major Concerns Identified within the Texas Freight Mobility Plan

The TFMP (*11*), which was adopted as final by the Texas Transportation Commission in January 2016, identifies and documents challenges faced by the freight transportation system of the state, ranging from issues such highway and rail capacity, intermodal connectivity, and border crossings to public awareness and funding. Highway and rail congestion and the lack of statewide freight network connectivity directly affect efficiency in moving goods, fuel usage, and safety. Bottlenecks, which are major issues of highway or railroad capacity, lead to more congestion and delays that eventually result in higher costs for both cargo shippers and consumers. Most highway freight bottlenecks are concentrated in urban areas such as Austin, Dallas, Fort Worth, and Houston. Lack of statewide systems for traffic management centers, traffic incident management programs, and alternative routes to interstate highways were also identified as deterrents to smooth freight movement throughout the state. Improvements in rural-urban connectivity, intermodal connections, and first- and last-mile connectors were acknowledged as additional measures that could enhance accessibility, increase modal options, and eventually improve freight movement efficiency.

The TFMP indicates that increasing congestion at border crossings results in a critical impact on international commerce. Therefore, Texas must adjust inadequate staffing at ports of entry and deploy cross-border technology applications in order to improve freight movement efficiency across the border and enhance security. Also, Texas needs to investigate Mexico's freight transportation policies and planned infrastructure improvements to gather background information in planning for expected trade growth with Mexico in the coming years (*11*).

TxDOT also notes in the TFMP that improving awareness and understanding of freight needs, issues, and roles by the general public has a vital impact on public support of projects and policies regarding freight. Moreover, improvements to funding levels and inflexible funding programs are needed in order for the transportation system to keep up with current freight transportation needs (*11*).

CHAPTER 3. MULTIMODAL FREIGHT PROJECT PRIORITIZATION METHODS LITERATURE REVIEW

INTRODUCTION

Many state departments of transportation (DOTs) and other entities have begun to develop evaluation tools to appraise projects proposed for the transportation system and to the impacts that can be expected from individual projects. The number of states and other planning agencies that have applied these types of evaluation processes to freight-specific projects is much smaller. The content of this chapter describes the process undertaken in Project 0-6837 to conduct a literature review to determine the state of the practice in this type of analysis. The chapter reviews various multimodal freight project prioritization methods including descriptions of their basic concepts, discussion of the methodological process employed, and potential applicability to future, planned phases of Project 0-6837.

PRIORITIZATION METHODS

The following sections describe each of the existing and/or exemplary freight project prioritization methods identified during the 0-6837 Phase I project. Each section below concludes with the assessment of how it might influence future project phases and analysis. Components of each will be considered in development of the final tool for future TxDOT use in freight project appraisal and selection.

Oregon DOT: Multimodal Freight Project Prioritization Methods, 2014

Overview

As discussed above, many DOTs have begun to develop evaluation tools to appraise the value of transportation system projects and their impacts. The study found that there are two primary reasons why state DOTs are becoming more eager to develop project prioritization methodologies: one is the increase in available data that can be applied in this area of analysis, and the other is the recent passage of several national transportation funding bills that have begun to support increasing objective evaluation of projects prior to funding approval. According to a review of state DOT websites performed by the researchers performing this analysis, only a few states are using official prioritization methodologies for freight projects, and the methodologies can be classified under two large groups: a scorecard methodology and a benefit-cost analysis. After the literature examination, the research team found that many of the project prioritization methodologies are mainly focused on the project's benefit rather than cost, which means that it is difficult to develop a single prioritization method applicable to both cost and benefits. Additionally, USDOT has emphasized the importance of developing an evaluation tool to help decision-makers make mode neutral investment prioritization decisions, which makes finding a single tool—taking into account the varying characteristics of different modes—even more difficult.

Methodology Description

Oregon DOT funded a study (*12*) that reviewed selected DOTs currently using investment prioritization processes and recently published academic articles to evaluate and eventually suggest a multimodal freight project prioritization methodology. As a part of that study, five scorecard methodologies and four benefit-to-cost methodologies were reviewed and documented in the corresponding report. The five scorecard methodologies were from Maryland DOT (MDOT), Ohio DOT (ODOT), Puget Sound Regional Council, Florida DOT (FDOT), and Missouri DOT. The latest versions of prioritization methodologies from MDOT, ODOT, and FDOT are discussed in detail later in chapter.

All the criteria from each DOT's evaluation methodology were categorized by the Oregon DOT study into 10 parts:

- General mobility.
- Safety and security.
- Environmental stewardship.
- Economic impact.
- Land use and development plans.
- Connectivity for freight mobility.
- System preservation.
- Reduction in transportation costs.
- Freight-specific mobility.
- New or retained jobs.

Findings showed that more than half of the DOTs' tools used the first six criteria as the most important factors in their evaluation process.

When measuring the above factors, the availability and consistency of the data are crucial. For example, the mobility and safety factors rely on proper data of volumes and crashes; therefore, the consistency of modes and the functionality of multimodal comparisons are important in supporting evaluation criteria. When measuring environmental stewardship, there are various factors that must be considered—mostly emissions and the impact of investments on wetlands, potential for sinkholes or other adverse geologic occurrences, and long-term environmental sustainability.

Application to Project 0-6837

The referenced report provides a comparison and review of other states' project reports and recent academic articles, and it is hard to directly conclude that specific evaluation tools can be adequate for the needs of Texas as called for in Project 0-6837. However, the commonly used criteria from other DOTs' evaluation methodologies can provide in-depth perspectives for this research team for proposing suitable evaluation factors to decision-makers (*12*).

TxDOT/CTR: Developing Emerging Transportation Technologies in Texas, 2013

Overview

The Texas Department of Transportation strives to examine and evaluate new transportation technologies to save costs, reduce traffic congestion, secure driver and pedestrian safety, and enhance economic growth. In a related project and report, researchers at the Center for Transportation Research (CTR) categorized emerging transportation technologies, evaluated them, identified key issues and concerns, and proposed a way to implement strategic transportation and economic development goals in Texas (*13*).

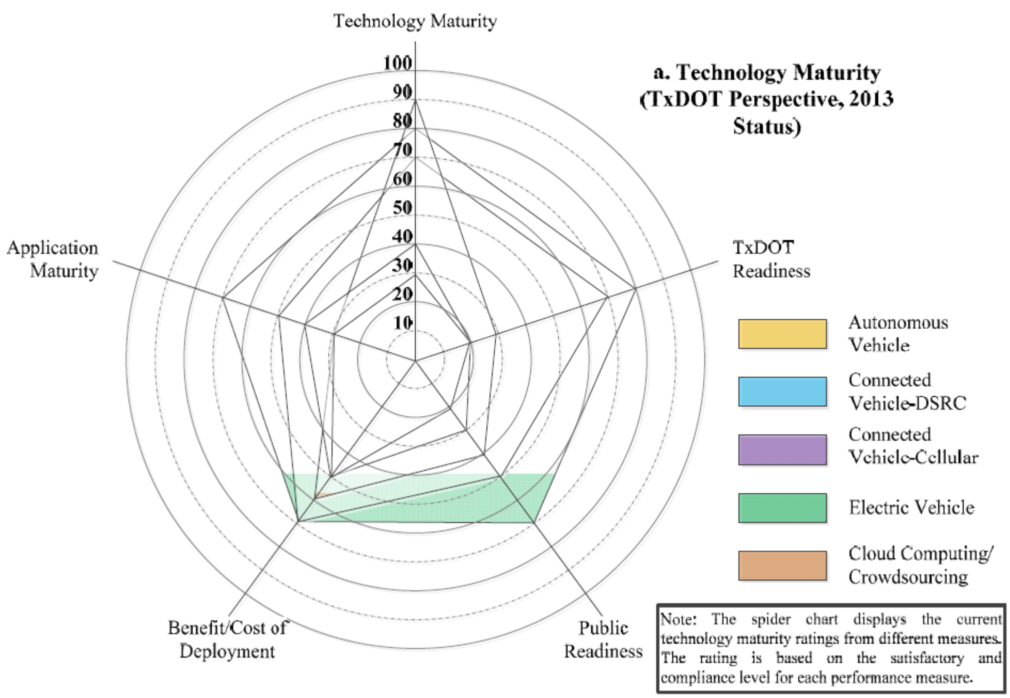
Methodology Description

To begin the project, the research team classified technologies into four categories: connected vehicles, autonomous vehicles, electric systems, and cloud computing or crowdsourcing technologies. Connected vehicle technologies enable wireless communications between vehicles, infrastructure, and personal communication devices. An autonomous vehicle is a self-driving vehicle that can sense its environment through radar, Lidar, global position system (GPS), image recognition, and more. Electric systems include DC fast charging stations and wireless electricity transfer technologies. Cloud computing enables people to use information technology (IT) infrastructure, platforms, and software through the Internet, and crowdsourcing quickly collects information from the system users.

After the classification, the research team developed evaluation tools in pursuit of indicating technology's development stages, current and near-term future maturity, synergies with other technology, and the possibility to achieve transportation goals. Largely, a technology development process can be divided into two sectors or phases—the research and development phase and the deployment phase. The research and development phase includes general ideas, prototype testing on closed systems, and large-scale field testing on public roads. On the other hand, the deployment phase indicates strategies of implementing technologies to the real world. This phase contains initial deployment, interim transition system from legacy technologies to innovative technologies, and market domination with technologies' functionalities and effects.

The research team assessed each technology's maturity test on both TxDOT perspectives and consumer/driver perspectives to provide detailed information about the current and expected status of each technology.

In terms of TxDOT perspective, which is focused upon the technologies' deployment and feasibility to the market, five measurement criteria have been identified: technology maturity, application maturity, TxDOT readiness, public readiness, and deployment benefit/cost. Challenges that can occur during the deployment stage and the development status of the technology's supporting hardware and software can be determined from the technology's maturity factor. The application maturity factor measures the sophistication and applications of technology to a certain part of transportation. The TxDOT readiness factor indicates whether TxDOT is ready to adopt a technology by confirming prepared or acquired policies, legislation, or funding. Also, the public acceptance level can be evaluated by assigning a public readiness factor. The deployment benefit/cost factor measures benefits from implementing technology in terms of social and financial aspects over its deployment cost. Figure 8 portrays an example of technology maturity in the TxDOT perspective using a spider chart for analysis, as was done in the CTR study.

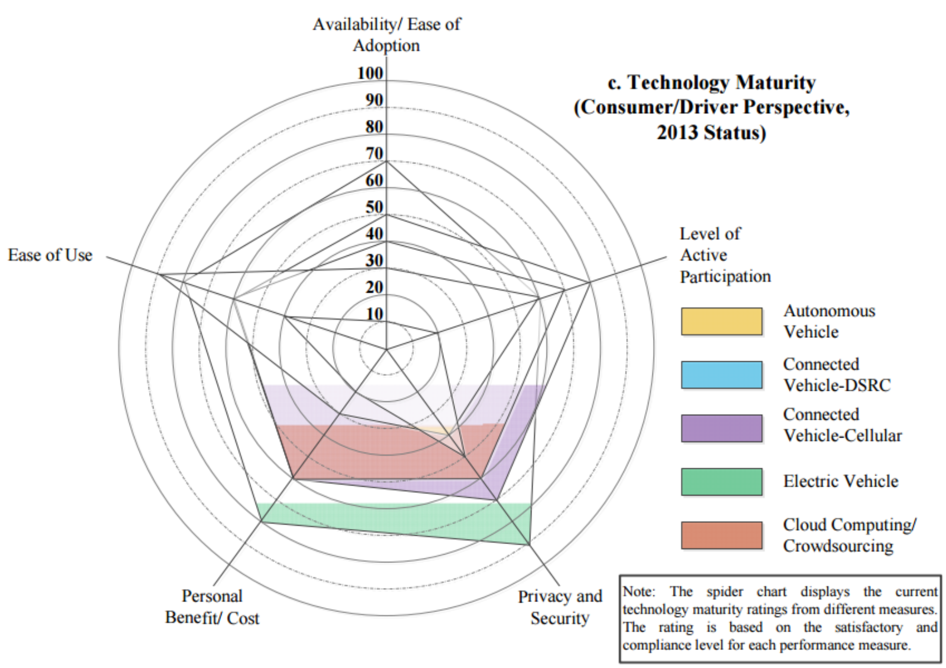


Source: CTR (13)

Figure 8. Examples of Technology Maturity in TxDOT Perspective.

In terms of the consumer or driver perspective, which focuses on the provided services, there are also five indices to be measured: availability/ease of adoption, ease of use, level of active participation, privacy and security, and personal benefit/cost. The availability or ease of adoption index is highly related to the technology and application maturity of the TxDOT perspective. However, this index is more focused on consumers' opinions and whether the technology is easy and available for them to use. The ease-of-use factor measures the level of user friendliness of technologies. The degree of driver involvement in using technologies will be shown in the level of active participation index. This index, especially, seems to be an important measurement for the connected or automated vehicle technologies. A privacy and security factor indicates the level of privacy protected and the reliability of security solutions, which can be very important for consumers who have concerns about privacy and cyberspace security due to the data transferred through a wireless network. A personal benefit/cost factor calculates expected consumer personal gain over the technology purchasing costs. Figure 9 provides an example of technology maturity in the consumer/driver perspective.

After the technology maturity assessments, the research team measured the impact of collaborated technology to prove its potential and benefits. Finally, the last step of each technology evaluation methodology was appraisal of each technology's goals, issues, and concerns. Goals are to be measured against State of Texas, TxDOT, and USDOT goals, while concerns are separated into public agency, societal, and consumers divisions.



Source: CTR (13)

Figure 9. Example of Technology Maturity in Consumer/Driver Perspective.

Application to Project 0-6837

Assessing the technology maturity from different perspectives (i.e., the TxDOT perspective and consumer/driver perspective), the research team seeks to provide a comprehensive understanding of challenges and issues for evaluating and implementing new technologies. The CTR report categorizes emerging technologies as connected vehicles, autonomous vehicles, electric systems, and cloud computing/crowdsourcing (*13*). These categories are highly related to the innovative and automated technologies for freight movement in Texas that the researchers are evaluating in Project 0-6837, and the research team will examine them for use in future freight needs.

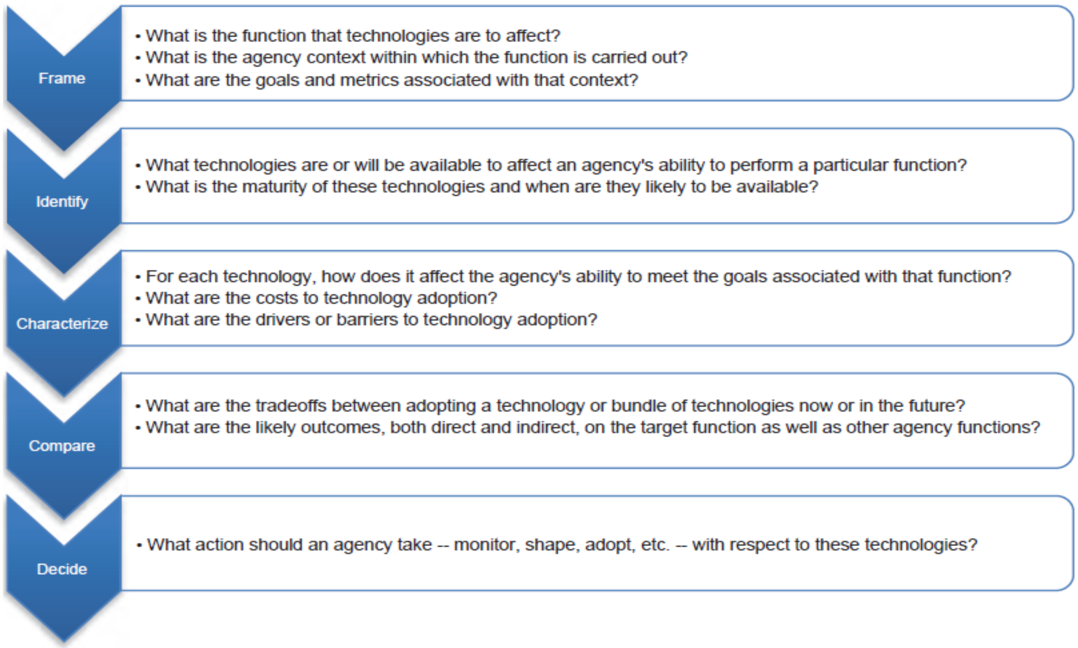
Transportation Research Board: NCHRP Report 750 Strategic Issues Facing Transportation—Volume 3: Expediting Future Technologies for Enhancing Transportation System Performance, 2013

Overview

As documented in National Cooperative Highway Research Program (NCHRP) Report 750—Vol. 3 (*14*), the project research team at RAND Corporation's Transportation, Space, and Technology Program developed the Systematic Technology Reconnaissance, Evaluation, and Adoption Methodology (STREAM). This process was developed to help transportation agencies and decision-makers in assessing current and potential technologies according to highly related characteristics such as the goals of the transportation agency and the present/forecast policy environment. STREAM incorporates more effectively the existing agency functions and the assessment, and it is expected to improve the quality of evaluation and outcomes, especially when agencies and decision-makers are applying technologies to the transportation area. The methodology not only clearly explains inherent uncertainties (some of which are in distribution, adoption, and implementation) but also indicates prospective future technologies' impacts. The research team summarizes the procedure of STREAM evaluation as a five-step process: frame, identify, characterize, compare, and decide.

Methodology Description

The STREAM process, shown in Figure 10, starts with defining the problem and goals. The main objective of this *Frame* step is to clearly explain the alternative technologies that need to be considered, the objectives, and the metrics. This step is easily ignored; however, the absence of this step may cause researchers many difficulties while performing the next procedure. Most importantly, the result of this step is going to be development of a set of criteria to judge alternative technologies.



Source: NCHRP (14)

Figure 10. The Major Steps in the STREAM Process.

Second, the *Identify* step is about identifying suitable technology applications by reviewing detailed information regarding the technology, expected improvements, and literature background. Overall, this step is a comprehensive screening process to determine whether technologies are within or beyond the range of decision.

The *Characterize* step is based upon the results of the *Frame* and *Identify* steps. It provides quantitative and qualitative evaluations on each technology and its impact on the agency's functions and goals. Arguable information and opinions from different points of view are maintained in the analysis procedure and can provide detailed comparisons among alternative technologies in the next step. Also, the characterization phase includes weighing and evaluating technologies to measure the possibilities of something going wrong. To perform this task, the NCHRP research team developed a probability of successful implementation (POSI) score and investigated three major impediments: technology, agency process or institutions, and external to agency (*14*). Table 3 demonstrates the specific barriers affecting POSI by category of impediment.

In addition, costs need to be characterized in this step. The NCHRP study states that this task should be considered separately from the previous task because of the different functionalities between them, and that the costs need to be measured on a net basis (*14*). In summary, the main goal of this step is to characterize alternative technology applications with the effects on agency missions, costs, and barriers to evaluate the ability for the project to be implemented successfully by using a POSI score for each of these aspects.

The *Compare* step is for comparing main characteristics of each technology by using visualizations and presentation techniques. This last step involves a decision about the kind of response that the agency should make regarding the proposed technologies.

Table 3. Categorized Impediments That Reduce POSI (*14*).

Category of Impediments	Specific Barriers Affecting POSI
Technology	Unfamiliarity with core or applied technology
	Uncertainty concerning actual performance
	Additional implementation requirements (training, standards, etc.)
Agency Process or Institutions	Need for new or conflict with existing regulations or standards
	Non-fungibility of funding for required expenditures
	Extended or problematic approval processes
External to Agency	Inertia of existing processes and methods
	Insufficient political or public acceptance
	Lacking presence of necessary vendor or support base

Application to Project 0-6837

STREAM is developed for transportation agencies and decision-makers to provide guidelines and a defined process in appraising technologies as part of an overall decision-making process. Moreover, the methodology provides a common process and lexicon to reduce the gap between transportation agencies and stakeholders when they are sharing information, appropriate guidelines to enhance the quality of evaluation, and a formal checklist to differentiate steps or tasks that have an issue to examine. The research team generally considers NCHRP Report 750—Volume 3 and the STREAM process to be the most suitable evaluation tools in measuring innovative freight strategies and technologies moving forward with Project 0-6837. In fact, the case study of the STREAM process applied to driver information systems (Appendix C of the NCHRP report) provides a guideline/example for adapting the process into this project (*14*).

Ohio General Assembly: Transportation Review Advisory Council: Policy and Procedures, 2013

Overview

In 1997, the Ohio General Assembly established the Transportation Review Advisory Council (TRAC) to help in the decision-making process involving major statewide and regional transportation investments. The related TRAC report defines policy and procedures for selecting new major projects in the state and provides detailed information about scoring criteria and how those criteria can be used in evaluating projects (*15*).

Methodology Description

Table 4 shows the criteria and scoring methodology used by TRAC. The methodology considers all transportation modes—highway, transit, intermodal, and freight. TRAC's goal was to seek an efficient management method to improve freight movement in Ohio while relieving roadway congestion, reducing road and bridge maintenance costs, and enhancing air quality (*15*). The scorecard starts to evaluate a given freight project location by first measuring freight congestion based upon V/C ratio. The council wants to invest in the project that can mitigate the existing intermodal freight capacity constraints, including road, water, and rail facilities. Figure 10 contains factors for measuring the V/C ratio for different modes.

Second, the scorecard methodology measures proposed freight capacity factors based upon the number of twenty-foot equivalent units per day that a facility can be expected to accommodate. Finally, the daily reduction of truck miles traveled (TMT) based upon the project is translated into points from 0 to 5 to measure the third factor—reduction in TMT. Benefits of a freight project are calculated by the cost-to-TMT reduction. This calculation generates a quantified unit cost by removing one TMT from the highway by shifting it to a rail, water, or air freight movement.

ODOT is also highly concerned about the environment and air quality. All projects from ODOT are required to meet the regulations of the National Environmental Policy Act and the National Ambient Air Quality Standards. Therefore, TRAC evaluates the project's air quality by two factors—reduction in fuel consumption and reduction in ozone precursors (i.e., NO_x and hydrocarbons). Air quality factors of the freight project are calculated by using the reduction in TMT and then applying standard emission rates of the vehicle types involved.

To evaluate the intermodal connectivity factor, TRAC tries to market Ohio as a destination for freight and seeks development of the logistics industry, rather than the state becoming just a passage of freight. In evaluating and selecting transportation-related projects, one of the main objectives is to develop the state's economy with factors such as employment, job creation, business retention, and property development. From among these, job creation and retention accounts for more than half of the total points available.

Table 5 shows the equivalent factors for measuring V/C ratio across the varying freight modes. Inputs are separated by volume inputs and capacity inputs for each mode for road, port railroad, and intermodal terminal.

Table 4. TRAC Criteria and Scoring Methodology (*15*).

Transportation Factors				
Evaluation Factors	**Road**	**Transit**	**Freight**	**Points**
Traffic	V/C Ratio	Existing Peak Hour Ridership/Capacity	Existing Freight Volume/Capacity	10
	Safety	Proposed Peak Hour Capacity Increase	Proposed Freight Capacity Increase	10
	ADTT	VMT Reduction	Truck Reduction	5
Benefit and Cost	Benefit/Cost	Cost/VMT Reduction	Cost/Truck Reduction	10
Air Quality	Emission Reduction			5
Functional Class				10
Intermodal Connectivity				5
			Total Transportation Points Available:	**55**

Economic Performance Factors	
Existing Jobs Within the Project Area	5
Estimated Jobs Created	3
Estimated Gross State Product Generated	2
Considering Factors of Economic Distress	2.5
Economic Distress in relation the Estimated Economic Performance	2.5
Total Transportation Points Available:	**15**

Local Investments	
Percentage of Acres Served by Local Streets	15
Percentage of Acres Served by Local Water and Sewer	
Percentage of Acres Served by Local Electricity	
Thousand Square Feet of Light Industrial Buildings Within the Project Area	
Thousand Square Feet of Heavy Industrial Buildings Within the Project Area	
Thousand Square Feet of Warehouse Buildings Within the Project Area	
Thousand Square Feet of Commercial Buildings Within the Project Area	
Thousand Square Feet of Institutional Buildings Within the Project Area	
Percentage of Road Routes Served by Fixed Transit Routes	
Percentage of Square footage of existing buildings are currently vacant	
Estimated Dollar value of Committed or Recent Public Investment (within 5 years) in New, Non-project Infrastructure & Services	
Estimated Value of Private Investments in Existing Private Facilities (within 5 years)	
Total Local Investment Points Available:	**15**

Project Funding Plan	
Local Funding Investments for the Phase(s) Being Requested	8
Local Funding Investments for Future Phase(s)	4
Number of Non-ODOT Funding Sources	3
Total Project Funding Plan Points Available:	**15**

Table 5. Factors for Measuring Volume/Capacity Ratio for Different Mode Types (*15*).

Equivalent Factors for Evaluating Volume-to-Capacity Ratio for Different Modes of Freight Transportation				
	Road	**Port**	**Railroad**	**Intermodal Terminal**
Volume Inputs	Traffic volume: ▪ Autos ▪ Trucks ▪ Peak hour factor	Port volume: ▪ Break bulk tons ▪ Containers (TEUs) ▪ Dry bulk tons ▪ Liquid bulk gallons	Train traffic, expressed as: ▪ No. of railcars ▪ No. of trains ▪ Train length	Terminal throughput: ▪ Containers (TEUs) ▪ Other transfer measure (e.g., rail/barge, rail/truck)
Capacity Inputs	▪ Type of road ▪ Number of lanes ▪ Speed limit ▪ Terrain ▪ % truck traffic ▪ Etc.	Per hour or per diem capacity expressed in tons, TEUs, etc.	Per hour or per day capacity (expressed in railcars, trains, etc.), as controlled by: ▪ No. of tracks ▪ Signalization ▪ At grade crossings	Per hour or per day transfer capacity, for example, containers (TEUs) per day.

The first factor among the economic performance factors—existing jobs within the project area—can be measured by the number of existing jobs, which can range from one to more than 16,000 within a mile of the project area. To measure the estimated jobs created factor, the estimated total number of jobs created is divided by the total project cost to calculate the ratio of estimated jobs created per million dollars of project cost.

Application to Project 0-6837

As Table 4 shows, this scorecard methodology compares various freight modes. However, according to the report from the Oregon DOT (*12*) mentioned previously, the comparison with the calculated and forecast or assumed data has a problem in that "a TMT reduction on roads will occur when projects for other freight modes are undertaken." In other words, freight diversion is not necessarily a one-for-one trade. Also, this scoring methodology provides various types of evaluation factors; however, the methodology seems to need to include more detailed data and additional factors that reflect the characteristics of Texas's population and freight traffic levels (*15*).

TxDOT/TTI: Identification of Priority Rail Projects for Texas—Initial Methodology/User Manual and Guidebook, 2012

Overview

The population and the resultant freight movement needs have rapidly grown in Texas. As a result, TxDOT planners and their partners at MPOs, regional mobility authorities, and councils of governments see the need for rail system improvements as a crucial issue. However, TxDOT's rail funding sources and options, in terms of both funding levels and allowable uses, have been highly limited. In order to prioritize worthy projects and prevent budget deficits from impacting individual projects, and in order to develop a transparent and straightforward process for selection of rail projects, TxDOT determined that a project prioritization system was needed. The process was later adopted by the Texas Transportation Commission (TTC) and documented as part of the Texas Rail Plan.

Methodology Description

In a related TTI report (*16*), researchers reviewed existing rail project evaluation methodologies from around the world and at the state level. Many of them are specifically related to performing the current project. After the literature review, the research team selected common criteria from the methodologies studied and originally proposed 11 criteria in three categories that could be used to evaluate rail projects. These criteria are shown in Table 6. After review by TxDOT and TTC, researchers adjusted and re-aligned the criteria from the original version, as shown in Table 7, which reflects how they are listed in the 2010 Texas Rail Plan.

Table 6. Project Evaluation Criteria by Categories (*16*).

Sustainability	Transportation	Implementation
1. Cost Effectiveness	6. Connectivity	9. Project Readiness
2. Economic Impact	7. Mobility	10. Partnerships
3. Environmental/Social Justice	8. System Capacity	11. Innovation
4. Safety and Security		
5. Asset Preservation		

Table 7. Final Project Evaluation Criteria by Categories Selected by the Texas Transportation Commission (*16*).

Sustainability	Transportation	Implementation
Economic Impact	Safety and Security	Cost Effectiveness
Environmental/Social Impact	Connectivity	Project Development
Asset Preservation	Congestion Relief	Partnerships
	System Capacity	Innovation

The first category, sustainability, includes economic impact, environmental/social impact, and asset preservation. The report indicates that short-term job creation, shipper savings, tax revenue, and long-term forecast economic growth (which can be interpreted as a long-term job creation factor) could all be evaluated as indicators of economic impact. There are also five sub-criteria taken into account for the environmental/social impact. These include air quality, energy usage, natural resources, noise and vibration, and disadvantaged population impacts (*16*). Since the objective of Project 0-6837 includes development of evaluation tools for the innovative and automated freight systems, issues regarding air quality and energy usage outlined in this project report are highly relevant. Also, noise and vibration problems are crucial in evaluating urban freight delivery strategies and technologies. The asset preservation factor includes preservation of rail infrastructure and highway infrastructure.

Second, the transportation category includes four major factors: safety and security, connectivity, congestion relief, and system capacity. Safety and security can be evaluated by the level of crashes, fatalities, injuries, property damage, security, resiliency in natural disasters, and conformity of hazardous materials movement. Cyberspace should be secured, and liability issues related to safety impacts also need to be well settled. In this evaluation methodology, congestion relief is measured by the travel time, recurring congestion (bottlenecks), and nonrecurring congestion that can be attributed to a proposed project.

The implementation category includes four criteria, which are cost effectiveness, project development, partnerships, and innovation. Cost effectiveness is evaluated through the project's net present value, benefit-cost ratio, and projected operation and maintenance costs.

The weighting of each criterion is totally based upon a user-defined scale that uses a scale from 0 to 10, where 10 reflects the most positive outcome. Both quantitative measures and non-quantifiable or qualitative measures can be considered together. In this sense, the process used is similar to multi-criteria decision analysis methods. The determination process of rating on the non-quantifiable or qualitative criteria is based upon the professional experience and expertise of TxDOT staff and/or an advisory panel consisting of industry experts and members of the public. The evaluation and weighting of each factor were also designed to be adjustable depending on funding sources that might become available or changes in departmental goals. Changes of this type to the rating methods could be carried out by the TTC as required.

Application to Project 0-6837

Since the TTI report's focus is on the prioritization process for proposed rail projects, it is mostly concentrated on each project's expected performance and the criteria and elements to consider in performing the prioritization process among many projects (*16*). As mentioned above, this methodology can become a solution for the rail system, or be applied to overall transportation. The proposed criteria in this report can largely be useful in developing evaluation tools for the 0-6837 project. The multi-criteria nature of the framework is adaptable to the comparison of strategies and technologies.

Transportation Research Board: NCFRP Report 12: Framework and Tools for Estimating Benefits of Specific Freight Network Investments, 2011

Overview

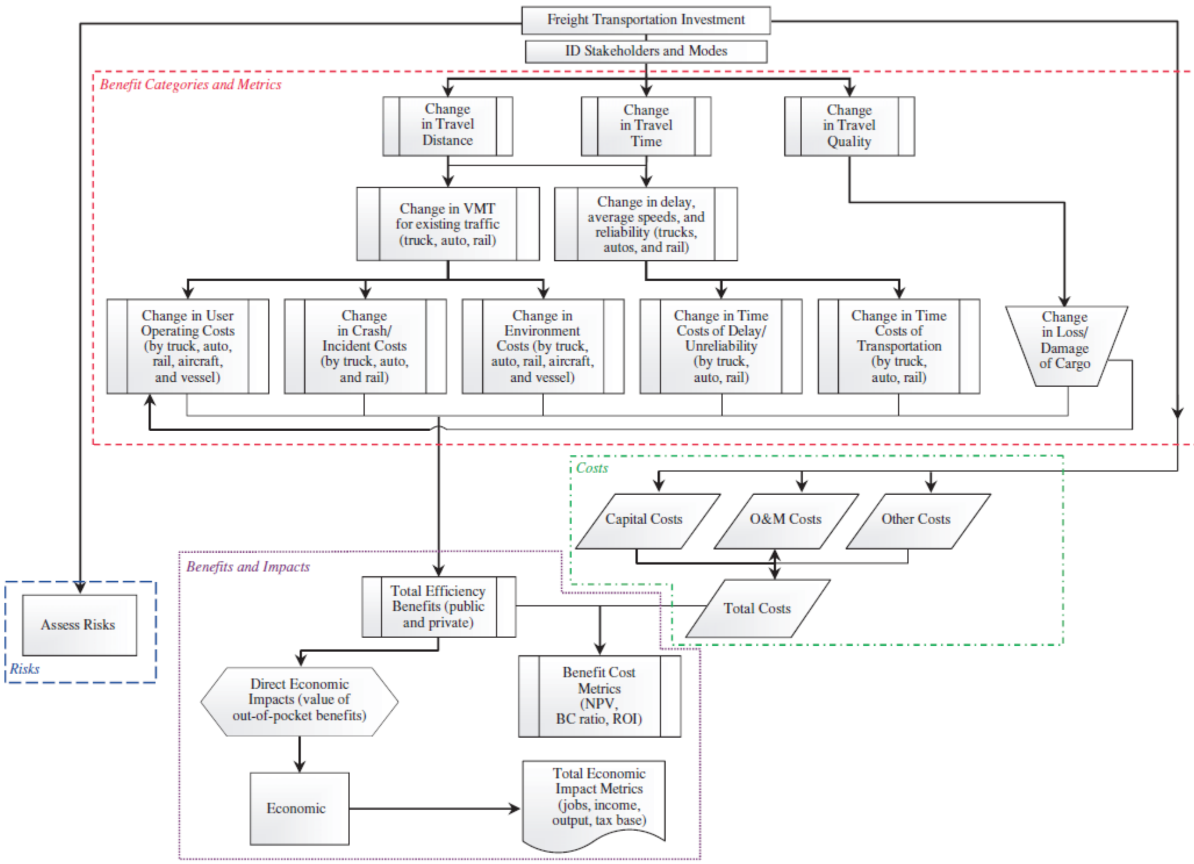
Many state DOTs and MPOs have moved forward from the planning stage and have begun to show more interest in managing freight needs and initializing freight improvement projects. A National Cooperative Freight Research Program (NCFRP) report describes the main issues and challenges in evaluating freight projects and provides a developed evaluation framework, which is called the Freight Evaluation Framework (FEF) (*17*). The framework enables decision-makers to make freight-related decisions more effectively by providing broad perspectives and developing each party's interests in freight investment within a decision-making process. Unlike most publicly managed projects, freight projects often need a consultation and agreement between public infrastructure owners and private freight service providers. Therefore, the FEF supplements benefit-to-cost analysis by allotting different impact measurements to each stakeholder. Moreover, this framework can enhance mutual cooperation between public agencies and private participants if both parties agree to be transparent and understand each other's concerns.

Methodology Description

Figure 11 shows a diagram showing the FEF process. The FEF procedure can be divided into four sections: benefit categories and metrics, costs, benefits and impacts, and risks. First, the framework identifies benefit categories and metrics. This step is crucial because stakeholders can decide whether to invest in the proposed project. This phase of the project will include a more detailed description of the types of freight stakeholders, as well as their concerns and pursuits. According to the NCFRP research report, freight stakeholders can be divided into four types: asset provider, service provider, end user, and other impacted party. Asset providers include state DOTs, financiers, and commercial real estate developers. Private stakeholders such as trucking companies, logistics providers, and railroads can be included under the service provider category, and customers and freight shippers are indicated under the end user category. Also, financial interests or the perspective of each stakeholder type is divided into four areas: direct financial, indirect financial, major nonfinancial, and tangential. Unlike previous research studies, this framework classifies projects into four types—physical infrastructure projects, productivity projects, reliability and density projects, and integration and consolidation projects—to increase the performance of the evaluation process (*17*).

Next, project costs are calculated, including both the facility capital costs and the subsequent operating and maintenance costs. Facility capital costs are concerned with the location and design of the project and the partners from the planning step. Safe operation is included under the facility maintenance costs, with operating costs including labor costs, fuel costs, equipment costs, and the time lost due to congestion.

The third step is calculating benefits and impacts over the project's life cycle. In this phase, benefit-to-cost analysis is performed and the overall economic growth is estimated by the economic impact analysis. Last, the FEF procedure is completed by assessing risks associated with the project.



Source: NCFRP (17)

Figure 11. Freight Evaluation Framework.

The NCFRP report indicates the importance of analysis measurements according to the types of stakeholder, as shown in Figure 12. This allows differing ratings of each project based upon stakeholder type.

	Tool Types						
Stakeholder Types	Strategic Planning	Carrier Cost and Performance	Shipper Cost and Performance	Transportation System Efficiency	Economic Development Impact	Financial Impact	Risk Assessment
Asset Provider	●	●	○	●	●	●	●
Service Provider	●	●	◐	●	○	◐	●
End User	◐	◐	●	◐	○	◐	◐
Other Impacted Party	○	○	○	◐	◐	○	○

Key: Less Important ○ → ◐ → ● More Important

Source: NCFRP (17)

Figure 12. Importance of Analysis Measurements.

Application to Project 0-6837

The FEF was developed to enhance the public planning and decision-making process regarding freight projects, to support benefit-to-cost analysis with distributional impact measures, and to develop close cooperation between the public and private sectors. Since the FEF can be applied to the various aspects of projects, elements of the FEF process could be expected to perform well in evaluating innovative strategies and technologies in Texas (*17*).

Florida DOT: The Florida Rail System Plan: Investment Element, 2010, and Strategic Investment Tool, 2008

Overview

In 2003, Florida's legislature and governor established Florida's Strategic Intermodal System (SIS) to provide a safer and more secure transportation system for passengers, drivers, and freight. Using the SIS, FDOT wants to preserve and manage Florida's transportation infrastructure effectively, enhance mobility of passengers and freight, maximize economic strength on transportation, and increase residents' quality of life while maintaining consistent environmental stewardship. By following these objectives, FDOT developed the SIS Strategic Investment Tool (SIT) as support for determining priorities of proposed investments given the limited available funding (*18*).

Methodology Description

In its rail system plan, FDOT used five criteria and 24 prioritization factors to evaluate highway and connector projects, as shown in Table 8 (*19*).

Table 8. SIT Highway and Connector Measures (*19*).

Goal Measured	Measure	Maximum Score
Safety and Security	Crash Ratio	10
	Fatal Crash	4
	Bridge Appraisal Rating	3
	Link to Military Base	3
	Possible Subtotal	***20 points***
System Preservation	Volume /Capacity (v/c) Ratio	10
	Truck Volume (AADTT)	6
	Vehicular Volume (AADT)	2
	Bridge Condition Rating	2
	Possible Subtotal	***20 points***
Mobility	Connector Location	1
	Volume /Capacity (v/c) Ratio	4
	Truck Volume (% Trucks)	2
	Vehicular Volume (AADT)	2
	System Gap	2
	Change in v/c -LOS (for Mainline segments only) Interchange Operations (for Interchanges only)	3
	Bottleneck/Grade Separation	2
	Delay	4
	Possible Subtotal	***20 points***
Economics	Demographic Preparedness	5
	Private Sector Robustness	5
	Tourism Intensity	5
	Supporting Facilities	5
	Possible Subtotal	***20 points***
Quality of Life	Land and Social Criteria	4
	Geology Criteria	4
	Habitat Criteria	4
	Water Criteria	8
	Possible Subtotal	***20 points***
	Total Maximum Score	**100 points**

Crash ratio is used for the safety and security section evaluation factor. This ratio is calculated as crashes per mile, and segments with higher ratios receive a higher score. Fatal crashes related to the project area are measured in the same manner as crash ratio. Bridge appraisal rating is determined by the bridge inspection results. The most inadequate bridge will receive the highest score. If the project is within 10 miles of a military base, then full points can be assigned for the link to military base factor.

In the system preservation section of the process, the bridge condition rating is performed more specifically than the previous section. Each bridge's individual components of deck, superstructure, substructure, and culvert are appraised and combined with the overall bridge condition scoring.

In the third section, full points are awarded to the connector location factor if the project is on a connection between two or more SIS corridors or between an SIS hub and an SIS corridor. A system gap factor is measured based on a "missing" section of a roadway that is less than 30 miles from another corridor and largely different in type from the remaining roadway corridor. A bottleneck is defined by the mobility chokepoint, and projects addressing roadways with longer daily hours of delay earn more points.

Under the economics criterion, there are four factors, which are equally weighted. Demographic preparedness can be evaluated by the combination of population density, work force size, educational attainment level, population growth rate, and per capita income. Economic impact is measured in the private-sector robustness section by four industrial sectors: freight intensity, property tax, seaports, and presence of military bases. Tourism intensity points are awarded based upon the per capita sales tax and the number of visitors. Evaluation in the support facilities section includes the presence of institutions of higher education, medical centers, and technical centers in relation to urban interstates, rural interstates, urban arterial/collectors, and rural arterial/collectors.

Finally, for the last criterion—quality of life—land and social conditions are measured based upon numbers of farms, land use types, and social benchmarks. The geology criterion considers proximity to sinkhole, archeological and historical sites, and hazardous waste sites. The habitat criterion measures the presence of potential hazards to the ecology, and the water criterion considers flood history and ways to protect the quality and availability of drinking water.

According to the 2010 Florida Rail System Plan: Investment Element, the five criteria for rail projects (as shown in Table 9) are safety and security, quality of life and environmental stewardship, maintenance and preservation, mobility and economic competitiveness, and sustainable investments, which are also highly related to the overall objectives of the SIS (*19*).

Application to Project 0-6837

The Florida Rail System plan process described here found that rail projects are affected more by the need for facilitating project cooperation because rail projects are funded primarily by the private sector. Also, FDOT provides more detailed guidelines to the highway prioritization methodology than other modes in this process. However, unlike rail project descriptions, the methodology for highway projects does not include additional specific environmental stewardship process descriptions or measures of a project’s sustainability, which can be considered a crucial factor in prioritization procedures.

Table 9. FDOT Rail Performance Measures by Goal (*19*).

Goal	Performance Measures
Safety and Security	• Crash reduction from auto/truck diversion • Reduced exposure to grade crossings • Use of Intelligent Transportation Management technologies
Quality of Life and Environmental Stewardship	• Change in auto/truck fuel consumption and CO_2 emissions • Noise reduction • Status of environmental screening process • Project included in land use plans, State Transportation Plan, LRTP, or County/Municipal Improvement Plan
Maintenance and Preservation	• Train capacity increase • Consistent with asset management approach • Support modernized rail system management and operation technologies
Mobility and Economic Competitiveness	• Auto/Truck VMT reduction • Reduced travel time and vehicle operating costs • Increase in passenger rail ridership • Increase in freight ton-miles • GDP growth • Jobs created as a result of the project
Sustainable Investments	• Project underwent public review • Support from stakeholders • Status of application for funding • Eligible for state or Federal funding • Non-Federal state/Federal funding available and programmed for project • Supports underserved areas • Project of Statewide significance

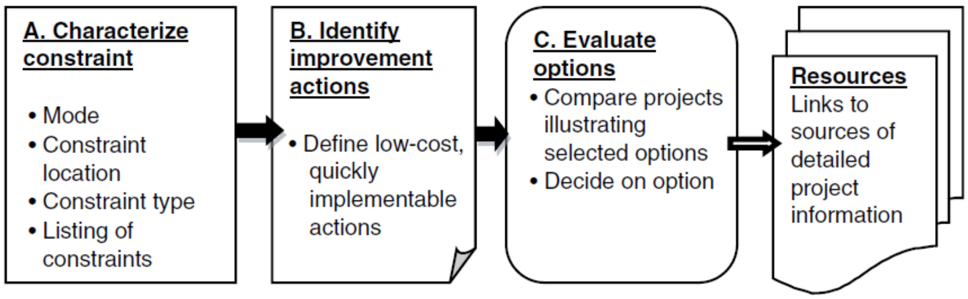
NCFRP Report 7: Identifying and Using Low-Cost and Quickly Implementable Ways to Address Freight-System Mobility Constraints, 2010

Overview

In Chapter 6 of NCFRP Report 7, a framework methodology for identifying and evaluating improvements to the freight system is introduced. The main objective of the report is to develop a computer-based methodology for public- and private-sector decision-makers to assist in identifying, categorizing, and evaluating low-cost capital, operational, regulatory, or public policy actions to enhance freight mobility. Basically, this methodology is a simple application tool that helps decision-makers in choosing suitable projects and defining constraints with feedback about possible actions (*20*).

Methodology Description

Figure 13 indicates the overall framework of the methodology, which consists of three categories: characterize constraint, identify improvement actions, and evaluate options.

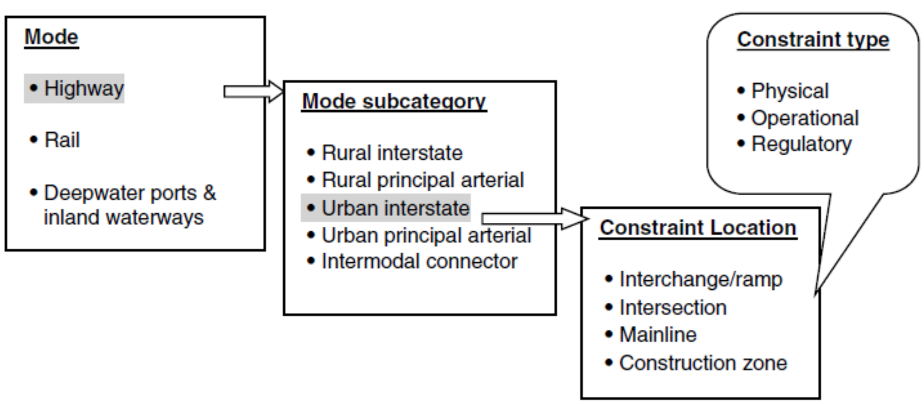


Source: NCFRP (20)

Figure 13. Framework of Methodology.

First, the process starts with selecting the freight transportation mode of interest, such as highway, rail, or port. For the selected mode, a subcategory of the mode will be provided. After that, constraint location can be decided. For example, Class I, regional, and shortline railroads can be indicated as a subcategory of the rail mode, and mainline, siding, terminal/yard, or IT/process improvement can be indicated as options for the constraint location.

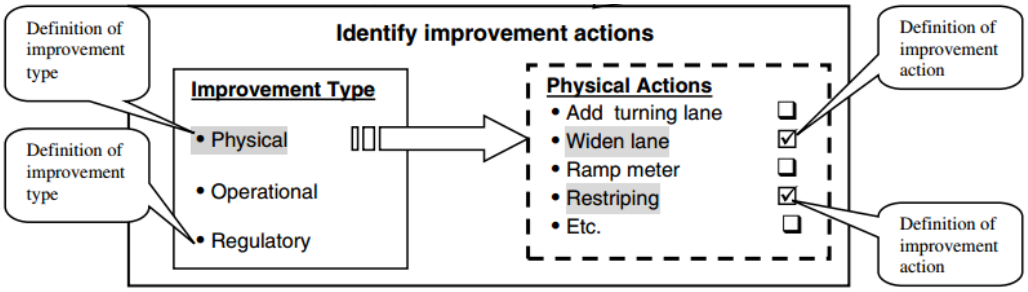
The next task is to categorize the constraint into one of three types: physical, operational, or regulatory. Figure 14 describes the process of characterizing constraint with the example of highway. For the selected type of constraint, a list of potential constraints that might happen at the location will be indicated. With the list, decision-makers can then decide the constraint that best works with the given project.



Source: NCFRP (20)

Figure 14. The Process of Characterization of Constraint.

The second step (B) of the framework is to identify potential low-cost improvement options to support the constraint indicated in the first step. The first task of this step is to make a selection from the list of possible options to address the selected constraint. The improvement options of the selected mode are made based upon the literature review, interviews, and survey data collected from the various types of stakeholders. With the selected improvement type, the best actions to take are determined. Figure 15 shows the entire procedure of step B.



Source: NCFRP (20)

Figure 15. Identify Improvement Actions.

Once potential low-cost improvement options are identified, those options can then be evaluated to provide details and compare selected implementation options for users. A reference list of each project is made at this point with the chosen options. The characteristics that will be on the list are as follows: project name, mode, location of constraint, constraint, improvement, description of project, location of project, date of implementation, performance measure, pre-improvement value, post-improvement value, cost, benefits, selection criteria, implementation duration, and lessons learned.

To help users in making appropriate choices, this methodology is all linked to a software application tool, which is based on the Microsoft.Net Framework 2.0 programming platform.

Application to Project 0-6837

The freight system evaluation methodology provided in NCFRP Report 7 suggests a highly detailed assessment process in evaluating projects, including all types of the freight transportation modes. However, since this methodology focuses more on measuring systems or projects, the process will not necessarily be suitable for evaluating strategies or technologies. Therefore, some modifications would be needed in order to adapt this methodology for use in Project 0-6837.

Maryland DOT: Maryland Statewide Freight Plan, 2010

Overview

While developing its Statewide Freight Plan, Maryland's freight project prioritization process identified many projects that may benefit not only those primarily involved with freight but also a variety of key stakeholder sectors. Figure 16 shows the definition of freight project that the stakeholder committees and study team developed for the Maryland transportation system as a guide to the selection of freight projects (*21*).

Freight Project Definition

*A **freight project** is a planned improvement to the Maryland transportation system that sustains goods movement and supports the state's economic competitiveness. The project may provide improved operations, expansion, or new capacity. It is distinguished from other transportation projects because it provides improved service or capacity to one of the freight modes (highway, rail, water, air) on a transportation facility that significantly supports the local, regional, state, or national economy.*

Source: MDOT (21)

Figure 16. Freight Project Definition by Maryland Department of Transportation.

As an extension of the definition, MDOT developed prioritization methodologies that mostly focused on the projects' freight aspect, but they also considered the impacts of background traffic factors, such as the quality of service and safety and security criteria.

Methodology Description

In the MDOT Statewide Freight Plan, projects were evaluated and classified by the order of priority based on the five project evaluation criteria proposed by MDOT and its research team. The criteria were developed based on the objectives of the Maryland Transportation Plan and the Maryland Development Plan. Weightings of the criteria were decided by reflecting feedback from an Interagency Advisory Committee, the Freight Stakeholder Advisory Committee, and other freight stakeholders throughout the project.

The Statewide Freight Plan report focused mainly on highway and rail modes. The evaluation criteria were commonly applied to the overall projects, but the details of each criterion clearly reflected distinctive mode characteristics. Table 10 shows the evaluation criteria for each freight project as ultimately used in the final project recommendations.

Table 10. Evaluation Criteria for Freight Projects (*21*).

Criteria	Weighting	Description
Quality of Service	30 %	Potential for the project to reduce delay and increase reliability
Safety and Security	25 %	Potential for the project to provide a safer operating environment and reduce opportunities to compromise the supply chain
Environmental Stewardship/Development Plan Goals	10 %	Potential for the project to reinforce the development of freight-related land uses within existing freight activity centers or direct new development to PFAs and sites with adequate infrastructure
Connectivity for Freight Mobility	25 %	Potential for the project to enhance connectivity between freight modes and/or improve access to clusters of freight-intensive industries
Coordination	10 %	Potential for the project to fulfill the plans, programs or goals of multiple agencies

Highway Mode

In the MDOT plan, the quality of service is evaluated with the combination of average annual daily truck traffic, truck percentage, current volume/capacity ratio, and forecasted V/C ratio. The safety and security criterion can be divided into safety and security by a factor of nine to one with safety being predominant. The average yearly truck crash rate per mile is the basis of safety ratings, and the level of development of truck inspection/weigh stations is used as a standard of measuring security. The third criterion, environmental stewardship/development plan goals, relates to whether the project is totally included in a state priority funding area (PFA) or connects two PFAs in the state's development plan. The connectivity for freight mobility is evaluated based upon the distance between the project and a freight cluster either within Maryland or 20 miles from the Maryland border. The coordination rating is decided by the extent to which the project can be identified in various agency plans, such as local plans, Mid-Atlantic truck operations, and annual priority letters from each county in the state outlining their priority projects. Table 11 provides an example highway project evaluation.

Table 11. Highway Projects Evaluation Example (*21*).

High	Medium	Low
●	◑	○

Map ID	Name of Project	Jurisdiction	Overall Score	Quality of Service (30 %)	Safety and Security (25 %)	Environmental Stewardship/ Development Plan Goals (10%)	Connectivity for Freight Mobility (25%)	Coordination (10%)
3	Interstate 81 Reconstruct and widen- WV Line to PA Line	Washington County	●	●	◑	●	●	◑
5	Interstate 70 Reconstruct and widen – I -81 to Frederick County Line	Washington County	●	●	◑	◑	●	◑
6	Interstate 70 Reconstruct and widen – Washington County Line to west of Mt. Phillip Road	Frederick County	●	●	◑	○	●	◑
8	Reconstruct and widen U.S. 40-U.S. 15 to I-270	Frederick County	●	◑	◑	●	●	◑
9	Reconstruct and widen MD 85 – English Muffin Way to N. of Grove Road	Frederick County	●	●	◑	●	●	◑

Rail Mode

The quality of service rating in rail mode is based upon the combination of current and future rail level of service defined from A to F. Unlike truck transportation, rail transportation has inherent systems that ensure high safety and security levels. Therefore, the high rating for this criterion is given to almost all of the rail projects. Since rail transportation is more fuel efficient and environmentally friendly, it can also generally earn the higher rating in environmental stewardship/development plan goals factors when compared to truck transportation. Similarly, connectivity for freight mobility and coordination factors also tends to receive higher ratings in rail transportation. Both Norfolk Southern's Crescent Corridor and CSX Transportation's National Gateway rail corridor efforts include routes in Maryland and are considered vital railway connections that remove freight traffic from the state's roadways.

Application to Project 0-6837

The Oregon DOT report (*12*) commented on the Maryland Statewide Freight Plan report (*21*), stating that metrics cannot be maintained consistently across modes, although the report used the same criteria for all freight modes such as highway, rail, and marine. Overall, this methodology has well-defined evaluation criteria and weighting methods. However, it would need revision to be adopted in evaluating innovative technologies and projects for the same reason that Oregon DOT described in its evaluation of the report.

Private Sector- Transport Macharis: The Importance of Stakeholder Analysis in Freight Transport, 2005

Overview

As the complexity of transportation-related problems has increased, the frequency of use of multi-criteria analysis to evaluate projects against one another has also increased. Moreover, in the early 2000s, the importance of including stakeholders such as policymakers, private enterprises, or households in the evaluation process was recognized through many research studies and recommended at the federal level. As a result, a research paper by Macharis introduced the concept of a multi-stakeholder, multi-criteria analysis evaluation framework to evaluate potential projects (*22*).

Methodology Description

Initially in his report, Macharis introduces five commonly used evaluation methods—private investment analysis (PIA), cost-effectiveness analysis (CEA), economic-effects analysis (EEA), social cost-benefit analysis (SCBA), and multi-criteria decision analysis (MCDA). The first three methods do not involve stakeholder input. The PIA performs its analysis from the confined private or public investor's point of view, and the CEA has a uni-criterion, uni-actor perspective, which can be effective for achieving one specific goal. The EEA method specifically focuses on the government perspective and considers only limited (three) criteria related to the stakeholder's perspective. SCBA, on the other hand, provides a broad societal perspective including the external costs of transport. However, the costs of one stakeholder can be compensated by the benefits of another at the end of the process because this method is eventually based upon the compensation criterion. Although this problem can be avoided, it still has a problem with excluding some subjective or qualitative costs or benefits from the analysis. Unlike other methods, MCDA constructs a framework to evaluate different options using different criteria and can be designed to include the input of stakeholders in initial project evaluation. However, in using traditional MCDA, stakeholder input can be limited in later stages of development. After compensating for defects in previous research on MCDA, where the concept of stakeholders was not clearly defined, this paper proposed the methodology of a multi-stakeholder MCDA, which has subsequently been successfully applied in several projects (*22*).

The multi-stakeholder MCDA evaluation framework consists of seven steps, as diagrammed in Figure 17. The process starts with defining the problem and identifying alternatives. In this step, a minimum of two alternatives are needed for comparison; otherwise, SCBA can be a better method. The second step is identifying related stakeholders and key objectives. To assess different alternatives properly, developing a profound understanding about each stakeholder group's objective is crucial. The next step is categorizing objectives into criteria and assigning weights (i.e., relative importance measures) to each criterion. For the fourth stage, indicators for each criterion are developed and are then used in measuring each alternative's contribution to a criterion. The first four steps consider the objectives of all stakeholder groups, which can be regarded as a separate analytical process and precedes the overall analysis.

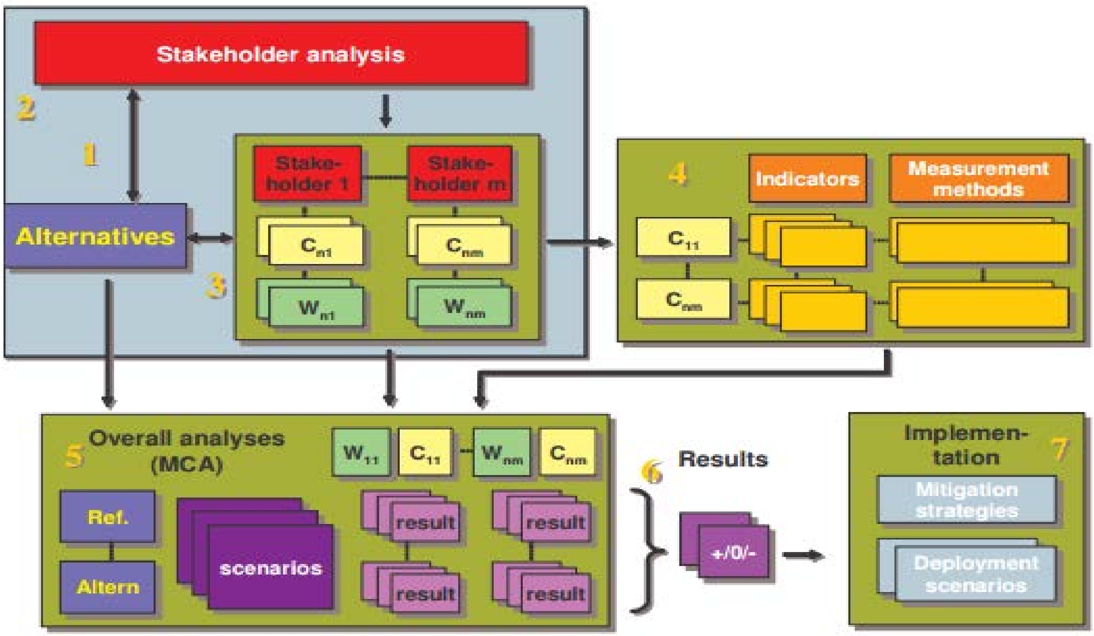


Figure 17. Methodology for a Multi-Stakeholder, Multi-Criteria Decision Analysis (*22*).

In the next step, the overall analysis and ranking process is performed with a constructed evaluation matrix. The analytical hierarchical process, which enables pair-wise comparisons and the overall consistency of the whole procedure, is used to appraise each different strategic alternative. After the overall analysis, alternatives can be ranked and aligned by order, and strong and weak points of each can be indicated. For the last step, once a decision is made, the chosen alternative can be implemented.

Application to Project 0-6837

The proposed multi-stakeholder, multi-criteria analysis method outlined by Macharis incorporates various types of stakeholders and several criteria into the analysis process (*22*). Including detailed stakeholder input in the analysis causes some delays in the beginning of the analysis. However, the proposed alternative of using this methodology is expected to have a high possibility of public acceptance of the final decision.

European Union/European Commission: RAILPAG: Railway Project Appraisal Guidelines, 2004

Overview

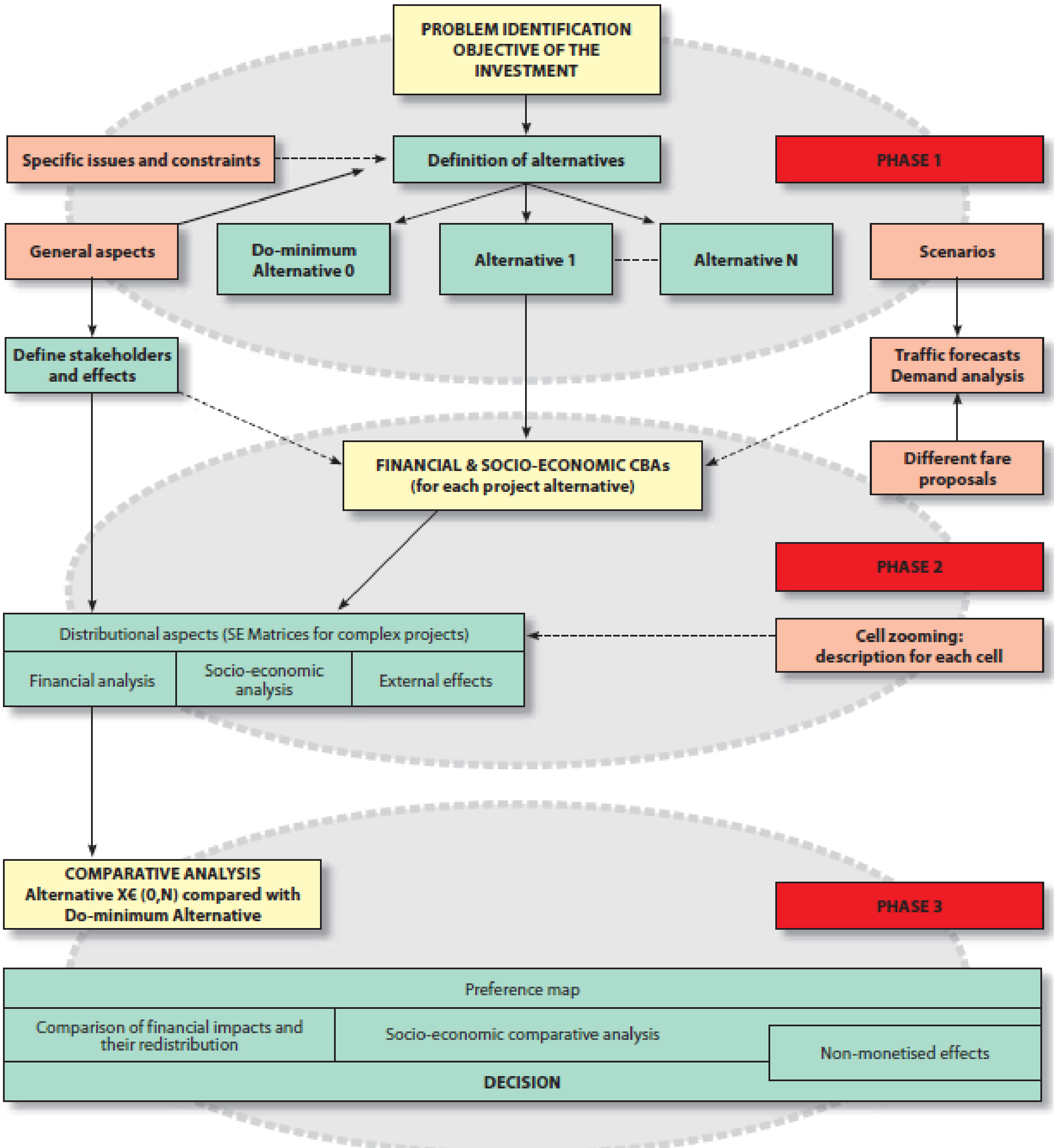
There are several guidelines and manuals that propose a method of performing cost-to-benefit analysis (CBA) for rail projects. However, many of them do not provide consistent methodologies or meet the requirements of the European Union (EU) or international financial institutions (IFIs). In need of a new project appraisal tool for rail projects, the European Commission created standard guidelines that include a methodology that sought to provide a balanced comparison between different transport modes while fulfilling the European Commission's goal of being able to compare rail project investments. The Railway Project Appraisal Guidelines (RAILPAG) were created to provide a comprehensive set of guidelines for socioeconomic and financial evaluations of railway projects and the following investments across the EU (*23*). The report should only be regarded as a first step or foundation of more detailed and developed methodological documents and evaluation tools. The report provides consistent information about adopting CBA on rail projects while maintaining flexibility in the fast-changing sector. Started from a general CBA basis, RAILPAG suggests use of a more specialized CBA by adopting the EU Transport Infrastructure Needs Assessment (TINA) to provide guidelines from the general sectors to the economic analysis.

Methodology Description

The procedure of RAILPAG consists of three phases, as shown in Figure 18. The first phase is identifying the problem and objective of the investment (i.e., purpose and need), which clarifies general issues and alternatives to establish the proper objectives of the project. The second phase is conducting financial and socioeconomic CBAs. Specifically, this phase is about implementing financial and socioeconomic CBAs for project alternatives, including analyzing investment costs, determining transition methods for maintenance and operating costs of the infrastructure, and assessing vehicle operating costs while taking into account journey times, safety, and other externalities and their associated costs. The final phase is conducting a comparative analysis, which analyzes and compares each project alternative and the relative values of each of the alternatives, which can then be considered by decision makers at the EU and in the individual countries.

The process of RAILPAG begins with defining the project's main goals and the potential multimodal alternatives. The critical points of this step are the technical quality and the creativity of the design team and its ability to visualize appropriate solutions from outside of the rail mode, which is often difficult for external evaluators to verify at the end of the process.

The second phase builds upon the initial CBA with additional indications from TINA. Basically, this part of the RAILPAG process was developed based on the TINA guidelines, which indicate essential factors to consider when evaluating transport infrastructure and selecting equipment. Since TINA guidelines are too general to address some particular aspects of rail mode, the research team developed some measures from principles in TINA and provided the well-identified rail appraisal process that is documented in RAILPAG. Because it complies with TINA, RAILPAG methods are also acceptable to the IFIs for seeking funding for the transportation infrastructure projects, once final selections are made. This step does include a stakeholder/effect (SE) matrix, shown in Figure 19, which provides a refined distributional analysis.



Source: European Commission (23)

Figure 18. RAILPAG Appraisal Process.

SE MATRIX		STAKEHOLDERS						
		USERS	TRANSPORT SERVICE OPERATORS	INSURANCE COMPANIES	CONTRACTORS & SUPPLIERS	INFRASTRUCTURE MANAGERS	NON USERS	GOVERNMENT
EFFETCS	USER SERVICE							
	OPERATION							
	ASSETS							
	EXTERNAL EFFECTS							

Source: European Commission (23)

Figure 19. The Basic SE Matrix.

The SE matrix presents information regarding the effects (in the rows) and stakeholders (in columns) by summarizing the important economic and financial implications of the project and indicating connections between stakeholders and the distribution of costs and benefits. The first task of the CBA in the second phase is establishing the main stakeholders and effects to consider. This task is included because if the SE matrix needs to be included in the process, the CBA should calculate and fill out the SE matrix for each of the other alternatives that were considered in the previous phase. All the information indicated in the SE matrix provides input to the overall outcome of the project, including the information on non-monetized socioeconomic and financial aspects, which makes it easy to evaluate the qualities of the project.

Finally, the process analyzes the alternatives, which then leads to development of the overall socioeconomic and financial implications, and the expected redistribution impacts of a given project. As a result, in this phase, the common or global indicators of stakeholder impacts from the proposed project are crucial. Also, any financial difficulties in implementation or unbalanced results for certain stakeholders from the socio-economically best option can be identified and used to appropriately affect the ranking of alternatives. Therefore, the relationship between socioeconomic and financial analysis, and performance indicators and risk, must be developed to complete the RAILPAG process. Figure 20 demonstrates the SE matrix proposed by RAILPAG for the appraisal of a rail project.

CELL CLASSIFICATION																										
			STAKEHOLDERS																							
SE MATRIX			USERS				TRANSPORT SERVICE OPERATORS				INSURANCE COMPANIES	CONTRACTORS & SUPPLIERS				INFRASTRUCTURE MANAGERS				NON USERS (external)		GOVERNMENT			
			RAIL LINES		ALTERNA-TIVE MODES		RAIL									RAIL									
EFFECTS			Pax	Freight	Pax	Freight	Rail Operator 1	Rail Operator 2	...	Other modes		Infrastructure	Superstructure	Rolling stock	Electrification & signaling	Rail manager 1	Rail manager 2	...	Other modes	LOCAL	REGIONAL	LOCAL	REGIONAL	NATIONAL	EU
USER SERVICE	Fares		●	●	●	●	●	●		●	●											●	●	●	
	Travel time		●	●	●	●																			
	Reliability of service		●	●	●	●																			
	Comfort		●		●																				
	Convenience		●	●																					
	Safety / accidents (economic / financial)		●	●	●	●					●					●	●			●	●	●	●	●	
	Consumer surplus (new traffic)		●	●	●	●																			
OPERATION	DIRECT	Fees					●	●								●	●							●	
		Vehicle operating costs					●	●		●															
		Operating personnel					●	●		●															
		Facilities operations					●	●																	
	INDIRECT	Overhead management -HQ					●	●																	
		Subsidies					●	●								●	●					●	●	●	
		Taxes					●	●		●														●	
ASSETS	INVESTMENT	Land value														●	●			●		●		●	
		Infrastructure					●	●				●				●	●					●	●	●	●
		Superstructure					●	●					●		●	●	●					●	●	●	●
		Stations & terminals					●	●					●		●	●	●					●	●	●	●
		Garage & repair facilities					●	●						●		●	●					●			
		Rolling stock (vehicles)					●	●						●								●	●	●	●
		Residual value					●	●								●	●								
		Taxes					●	●				●	●	●	●	●	●					●	●	●	
	MAINTAIN-ANCE (ROUTINE)	Infrastructure & Superstructure										●	●			●	●							●	
		Rolling stock					●	●						●										●	
EXTERNAL EFFECTS	NETWORK EFFECTS (not included above)		●	●			●	●								●								●	●
	ENVIROMENTAL	Noise & vibrations																		●					
		Air pollution																		●	●				
		Climate change																			●			●	
		Use of space																		●					
	TERRITORIAL DEVELOPMENT																			●	●				

Source: European Commission (23)

Figure 20. SE Matrix for the Appraisal of Rail.

Application to Project 0-6837

The RAILPAG policy was aimed at making a "comprehensive harmonized methodology" for evaluating rail investments in the EU and neighboring European countries. However, there are several challenges in applying RAILPAG directly to Project 0-6837. According to the factors from the effects side on the SE matrix, there is currently no way to weigh the importance of each factor. In adopting new technologies, environmental factors or passenger/driver safety issues would likely be considered more important than the other factors. Also, this methodology is highly focused on the rail mode and would need to be adjusted to take into account features and benefits of other modes before it could be applied to the strategies and technologies in Project 0-6837. Another drawback with RAILPAG was pushback from certain EU members who did not agree that projects in more developed areas would directly compare with those in less-developed countries (*23*).

CHAPTER 4. FREIGHT STRATEGY AND TECHNOLOGY CLASSIFICATION

INTRODUCTION

This chapter discusses the initial list of innovative freight strategies and technologies (STs) identified during the research and the potential geographic locations where proposed STs could be applied. The research team assessed over 50 currently proposed freight STs from which specific recommendations would later be made regarding which ones should undergo in-depth evaluation regarding potential implementation on the Texas transportation system in future project phases.

STRATEGY AND TECHNOLOGY CLASSIFICATION

This section describes the efforts to identify innovative freight STs for consideration for Phase II of this project.

Freight Movement Categories

In order to better classify the potential role that each strategy or technology could play in the improvement of freight operations in the state, three distinct categories or application areas were developed describing the type of freight movement problems being addressed. These three major categories were:

- Intercity or Long-Distance Freight Corridors.
- Urban Freight Delivery.
- Major Freight Generators/Intermodal Exchange Areas.

Each category breakdown describes the major type of freight movement that the strategy/technology addresses. While each strategy and technology application is associated with a primary freight movement category, there are many instances where the application (strategy or technology) could be associated with more than one category. The following section briefly describes each of these freight categories as defined for this project.

Intercity or Long-Distance Freight Corridors

Intercity or long-distance freight corridors are defined as freight applications that address intercity or long-distance freight transport corridors rather than specific sites. Options addressing freight needs along or parallel to existing/planned interstate, U.S., or major state highway corridors would be a special focus of these strategies/technologies, as would identified U.S. and international trade routes.

Urban Freight Delivery

Urban freight delivery is defined as freight applications that address first- and last-mile pickups/deliveries within an urban area. This type of freight transport impacts TxDOT planning and operations by generating freight traffic in and around manufacturing and distribution center areas. This group of strategies/technologies includes analysis of land use/infrastructure planning methods, time-of-day shifts, and other urban freight delivery approaches to reduce congestion.

Major Freight Traffic Generators/Intermodal Exchange Areas

Major freight traffic generators/intermodal exchange areas are freight applications that address special needs around major freight traffic generator sites, such as seaports and constrained railyards within an urban area. Due to the intermodal nature of many of these facilities, the potential strategies/technologies to address freight traffic near these nodes require specialized treatment or operational planning approaches.

LIST OF INITIALLY IDENTIFIED STRATEGIES AND TECHNOLOGIES

Following identification of the three freight ST categories, the research team identified specific freight STs that could be used to transform and/or improve freight operations in Texas. These STs were identified through extensive reviews of research material and through the ongoing research efforts and professional experience of project team researchers who are experts within various freight transportation disciplines. The review of freight strategies and technologies resulted in 57 specific STs. Table 12 contains the initial list, with headings indicating the major categories.

Table 12. Initially Identified Freight Strategies and Technologies.

Intercity, Long-Distance Corridors

1. Airships/Aerial Transport
2. Automated and Low-Emissions Intercity Freight System
3. Consolidated Grade-Crossing Corridor Safety/Grade Separation Programs
4. Freight Rail Public-Private Partnerships
5. Natural-Gas-Fueled Heavy-Duty Highway Freight Transportation
6. Natural-Gas-Fueled Locomotive
7. Passenger Rail Cargo Delivery
8. Railroad Infrastructure Relocation
9. Truck Platooning

Urban Freight Delivery

10. Adaptive and Advanced Signal Control Systems (AASCSs)
11. Automated and Driverless Trucks
12. Commercial Motor Vehicle (CMV) Only Lanes
13. Compressed Natural Gas and Liquefied Natural Gas
14. Electric Delivery Trucks and Dual-Mode, Hybrid Diesel/Electric Trucks
15. Electric Truck Designs
16. Ethanol Fuel Delivery Vehicles
17. Fully Automated Vehicles (FAVs): European Experience
18. Geographically Focused Incentives for Off-Hours Delivery
19. Hazardous Material Vehicle Location Status/Shipment Tracking
20. Hydrogen Fuel Cell
21. Innovative Urban Delivery Modes: Reception Boxes
22. Innovative Urban Delivery Modes: Collection and Delivery Points
23. Ramp Metering
24. Short-Haul Rail Movements within Urban Areas
25. Truck-Only Roadway
26. Truck-Only-Toll (TOT) Lanes
27. Unmanned Aircraft Systems and Their Use in the Freight/Logistics Industry
28. Urban Delivery Sharing System (Uber-Type Dispatching for Freight Trucks)
29. Urban Truck Parking

Major Generators/Intermodal Areas

30. At-Grade Separation Programs
31. Backscatter X-Ray Imaging
32. Container Movement Software—Connecting Drayage Trucks with Terminals and Shippers
33. Container Sharing in the Seaport Hinterland
34. Creation of a Freight Village (FV) Facility
35. Customs-Trade Partnership Against Terrorism (C-TPAT)
36. Dedicated Truck Lanes during Peak Port Freight Flows
37. FAST (Free and Secure Trade for Commercial Vehicles) Trusted Traveler Program
38. Hi-Tech Yard Management Systems
39. Innovative Horizontal Transshipment Technique
40. Intelligent Truck Control System
41. International Border Crossing Electronic Screening of Trucks
42. ITS for Seaports
43. License Plate Readers (LPRs)
44. Natural-Gas-Fueled Towboat
45. Off-Peak Incentive Program for Container Terminals/Extended Gate Hours
46. On-Dock Rail
47. Photonuclear Gamma Ray Imaging
48. Port-to-Rail Intermodal Improvements
49. Precision Docking System
50. Radiation Portal Monitors (RPMs)
51. Semi-Automated Intermodal Facility
52. Traffic Signal Priority System
53. Truck Appointments at Freight Terminals
54. Underground Freight Transportation
55. United States/Mexico Integrated Data Tracking System (IDTS)
56. United States/Mexico Pre-Clearance Pact
57. Zero-Emissions Container Mover System (ZECMS)

In order to describe each item uniformly, researchers developed a common profile template that allowed them to produce relatively similar descriptions for each ST so that features could be more readily compared. Each freight strategy/technology profile draft includes the following features:

- Name of Strategy/Technology.
- Potential Texas Application of Strategy/Technology (100 words).
- Freight Movement Category/Categories Addressed (defined further below).
- Strategy/Technology Profile (100–150 words).
- Keys to Successful Implementation (150 words).
- Challenges to Implementation (100 words).
- Success Story/Stories (100 words).
- Measures of Effectiveness (100 words).
- Time to Implement (Likert scale from 1 to 5).
- Cost to Implement (Likert scale from 1 to 5).
- Supplemental Information and/or References (100 words).

Appendix A contains the developed uniform sheets for each of the 57 freight STs.

POTENTIAL GEOGRAPHIC LOCATIONS AND BARRIERS TO IMPLEMENTATION OF CANDIDATE STRATEGIES AND TECHNOLOGIES

Building on the core information documented in the templates, the research project further evaluated the 57 STs in order to establish the characteristics necessary to select a set of strategies and technologies for Phase II of the project. The additional information includes sites where the freight STs have been implemented, locations in Texas where the action could be applied, and possible barriers to implementation. To accomplish this, researchers developed a tabular summary of characteristics collected in the templates, along with the new information, to display the information. The resultant table includes columns related to:

- Extent of Use (U.S. or international).
- Location(s) of Use (deployed, pilot, or planned).
- Characteristics of Use (conditions).
- Texas Locations (types of freight locations where it could be deployed).
- Barriers to Implementation (engineering/technical, financial, or policy barriers).
- Time (assessment of overall time to strategy/technology development; 5-point Likert scale).
- Dollars (assessment of overall cost; 5-point Likert scale).

Appendix B contains the tabular summary of the potential geographic locations and barriers to implementation of each candidate ST.

CHAPTER 5. FREIGHT STRATEGY AND TECHNOLOGY CONSOLIDATION

INTRODUCTION

The focus of Phase I of the project was to identify a wide collection of innovative strategies and technologies and then to narrow the list to a small number for more in-depth analysis within Phase II of the project. Selecting a small number of strategies and technologies from the full set of 57 proved to be problematic. In addition, researchers determined that characteristics of several of the original items could be consolidated. This chapter documents a framework utilized to consolidate the original 57 freight strategies and technologies into 28 consolidated concepts. This consolidated framework is then compared to the policies, programs, strategies, and projects in the Texas Freight Mobility Plan.

FREIGHT STRATEGY AND TECHNOLOGY CONSOLIDATION FRAMEWORK

Chapter 4 documents the identified 57 freight strategies and technologies that are associated with three general categories:

- Intercity and Long-Distance Corridors.
- Urban Areas.
- Special Generators.

Given that these three freight project type categories are characterized by scope and geography, a number of the 57 overall STs suggested as solutions were similar or somewhat related to one another across these three categories. In order to more easily compare and contrast among the different approaches, the project team consolidated similar STs into 28 separate groups, referred to in the remainder of this document as consolidated strategies and technologies (CSTs).

Adopting this framework the further combine the STs employed a variety of methods for grouping the 57 write-ups:

- *Near equivalence:* some STs were very closely related (examples: ST46 On-Dock Rail and ST48 Port-to-Rail Intermodal Improvements, and ST21 Innovative Urban Delivery Modes: Reception Boxes and ST22 Innovative Urban Delivery Modes: Collection and Delivery Points).
- *Related strategies or technologies:* some STs covered strategies and technologies that involved similar technological issues but affected different modes, such as STs 5 (Natural-Gas-Fueled Heavy-Duty Highway Freight Transportation), 6 (Natural-Gas-Fueled Locomotive), 13 (Compressed Natural Gas and Liquefied Natural Gas for Urban Delivery), and 44 (Natural-Gas-Fueled Towboat) or strategies with similar

elements, such as several that involved border congestion strategies, including STs 35 (C-TPAT), 37 (FAST), 55 (United States/Mexico Integrated Data Tracking System), and 56 (United States/Mexico Pre-Clearance Pact). In some of these cases, TxDOT's supportive role may be indirect.

- *Common impacts:* some STs were technologically different but had similar impacts on a freight issue, such as items related to border inspection technology.

Table 13 shows the general categories and individual CSTs on the left side of the table, with CSTs numbered within each category. On the right side of the table are the original STs presented in Chapter 4. Table 14 lists the CSTs in final summarized form.

Table 13. Framework for Strategy and Technology Consolidation.

Category	No.	CST Name	No.	Original ST
Aviation	A1	Airships/Aerial Transport	1	Airships/Aerial Transport
	A2	Unmanned Aircraft Systems (UASs)	27	Unmanned Aircraft Systems (UASs)
			38	Hi-Tech Yard Management Systems
Non-Highway Systems	NH1	Automated, Zero-Emissions Freight Systems	2	Automated and Low-Emissions Intercity Freight System
			57	Zero-Emissions Container Mover System (ZECMS)
	NH2	Passenger Rail Cargo Delivery	7	Passenger Rail Cargo Delivery
Freight Rail	FR1	Grade Crossings and Separations	3	Consolidated Grade-Crossing Corridor Safety/Grade Separation Programs
			30	At-Grade Separation Programs
	FR2	Freight Rail Public-Private Partnerships (P3s)	4	Freight Rail Public-Private Partnerships (P3s)
	FR3	Railroad Infrastructure Relocation	8	Railroad Infrastructure Relocation
Alternate Fuels	AF1	Natural Gas Freight Vehicles	5	Natural-Gas-Fueled Heavy-Duty Highway Freight Transportation
			6	Natural-Gas-Fueled Locomotive
			13	Compressed Natural Gas and Liquefied Natural Gas for Urban Delivery
			44	Natural-Gas-Fueled Towboat
	AF2	Electric/Hybrid Freight Vehicles	14	Electric Delivery Trucks and Dual-Mode, Hybrid Diesel/Electric Trucks
			15	Electric Truck Designs
	AF3	Other Fueled Freight Vehicles	16	Ethanol Fuel Delivery Vehicles
			20	Hydrogen Fuel Cell
AV/CV Truck	AV1	Truck Platooning	9	Truck Platooning
	AV2	Automated Trucks	11	Automated and Driverless Trucks
			17	Fully Automated Vehicles: European Experience
ITS and Operations	IT1	Traffic Signal Coordination Systems	10	Adaptive and Advanced Signal Control Systems (AASCSs)
			23	Ramp Metering
			52	Traffic Signal Priority System
	IT2	Truck-Shipper Matching Systems	28	Urban Delivery Sharing System (Uber-Type Dispatching for Freight Trucks)

Category	No.	CST Name	No.	Original ST
			32	Container Movement Software Connecting Drayage Trucks with Terminals and Shippers
			33	Container Sharing in the Seaport Hinterland
	IT3	Port ITS Systems	40	Intelligent Truck Control System
			42	ITS for Seaports
	IT4	Hazardous Material Vehicle Location Status/Shipment Tracking	19	Hazardous Material Vehicle Location Status/Shipment Tracking
	IT5	Intermodal Terminal Efficiency	39	Innovative Horizontal Transshipment Technique
			49	Precision Docking System
			51	Semi-Automated Intermodal Facility
Truck Infrastructure	TI1	Dedicated Truck Roadways	12	Commercial Motor Vehicle (CMV) Only Lanes
			25	Truck-Only Roadway
			26	Truck-Only Toll (TOT) Lanes
	TI2	Truck Lanes in Surge Freight Flows	36	Dedicated Truck Lanes during Peak Port Freight Flows
Urban Freight	UF1	Short-Haul Rail Movements within Urban Areas	24	Short-Haul Rail Movements within Urban Areas
	UF2	Underground Freight Transportation	54	Underground Freight Transportation
	UF3	Truck Delivery Timing Programs	18	Geographically Focused Incentives for Off-Hours Delivery
			29	Urban Truck Parking
	UF4	Package Consolidation Boxes/Lockers	21	Innovative Urban Delivery Modes: Reception Boxes
			22	Innovative Urban Delivery Modes: Collection and Delivery Points (CDPs)
	UF5	Freight Village Facility Development	34	Creation of a Freight Village (FV) Facility
Border	B1	Border Inspection Technology	31	Backscatter X-Ray Imaging
			41	International Border Crossing Electronic Screening of Trucks
			43	License Plate Readers (LPRs)
			47	Photonuclear Gamma Ray Imaging
			50	Radiation Portal Monitors (RPMs)
	B2	Institutional Arrangements	35	Customs-Trade Partnership Against Terrorism (C-TPAT)
			37	FAST (Free and Secure Trade for Commercial Vehicles) Trusted Traveler Program
			55	United States/Mexico Integrated Data Tracking System (IDTS)
			56	United States/Mexico Pre-Clearance Pact
Seaports	S1	Truck-Terminal Coordination	53	Truck Appointments at Freight Terminals
			45	Off-Peak Incentive Program for Container Terminals/Extended Gate Hours
	S2	Port-Related Rail Improvements	46	On-Dock Rail
			48	Port-to-Rail Intermodal Improvements

Table 14. Consolidated Strategies and Technologies.

Category	CST Number	CST Name
Aviation	A1	Airships/Aerial Transport
	A2	Unmanned Aircraft Systems (UASs)
Non-Highway Systems	NH1	Automated, Zero-Emissions Freight Systems
	NH2	Passenger Rail Cargo Delivery
Freight Rail	FR1	Grade Crossings and Separations
	FR2	Freight Rail Public-Private Partnerships (P3s)
	FR3	Railroad Infrastructure Relocation
Alternate Fuels	AF1	Natural Gas Freight Vehicles
	AF2	Electric/Hybrid Freight Vehicles
	AF3	Other Fueled Freight Vehicles
AV/CV Truck	AV1	Truck Platooning
	AV2	Automated Trucks
ITS and Operations	IT1	Traffic Signal Coordination Systems
	IT2	Truck-Shipper Matching Systems
	IT3	Port ITS Systems
	IT4	Hazardous Material Vehicle Location Status/Shipment Tracking
	IT5	Intermodal Terminal Efficiency
Truck Infrastructure	TI1	Dedicated Truck Roadways
	TI2	Truck Lanes in Surge Freight Flows
Urban Freight	UF1	Short-Haul Rail Movements within Urban Areas
	UF2	Underground Freight Transportation
	UF3	Truck Delivery Timing Programs
	UF4	Package Consolidation Boxes/Lockers
	UF5	Freight Village Facility Development
Border	B1	Border Inspection Technology
	B2	Institutional Arrangements
Seaports	S1	Truck-Terminal Coordination
	S2	Port-Related Rail Improvements

MATCHING CSTS TO TEXAS FREIGHT MOBILITY PLAN ELEMENTS

The draft TFMP (October 2015) includes a range of recommendations, including overall policies, programs, and projects. Chapter 11 of the draft TFMP lists the policy and program recommendations. The 21 policy recommendations offer an overall framework for freight transportation investment decision making. The TFMP states that the policies provide the basis for aligning this investment with the state's economic goals to enhance economic competitiveness. The 21 policy recommendation headings are listed below:

1. TxDOT Freight Planning Capacity and Activities.
2. Freight Network Designation and Investment.
3. Texas Highway Freight Network Design Guidelines and Implementation.
4. System-Based Approach.
5. Multimodal Connectivity.
6. Rural Connectivity.
7. Economic Development and Economic Competitiveness.
8. Texas as a North American Trade and Logistics Hub and Gateway.
9. Safety, Security and Resiliency of the Freight Transportation System.
10. Freight Transportation Asset Management.
11. Freight-Based Technology Solutions and Innovation.
12. Stewardship and Project Delivery.
13. International Border/Ports-of-Entry.
14. Energy Sector Development Transportation.
15. Rail Freight Transportation.
16. Port and Waterway Freight Transportation.
17. Air Cargo Transportation.
18. Pipeline Infrastructure.
19. Funding and Financing.
20. Institutional Coordination and Collaboration.
21. Public Education and Awareness.

The TFMP indicates that the eight program recommendations support the policies and also address the freight transportation challenges identified in the plan. The eight program recommendation headings are listed below:

1. TxDOT Multimodal Freight Planning.
2. Freight Movement Education and Public Awareness.
3. Freight-Based Technology and Operations.
4. Texas Border/Ports-of-Entry Transportation and Trade.
5. Highway Safety, Design, Construction, Bridge, Interchange Improvement.
6. Rail Development and Improvement.
7. Port and Waterway Development and Improvement.
8. Aviation-Air Cargo Development and Improvement.

Also included in the TFMP are recommendations related to strategic/future transportation needs. The six areas listed below reflect the most critical components of the statewide freight transportation system, according to the plan. They are:

1. Highway Projects.
2. Strategic/Future Operational and Technology Improvements.

3. Strategic/Future Rail Improvements.
4. Strategic/Future Port and Waterway Improvements.
5. Strategic/Future Air Cargo Improvements.
6. Strategic/Future Border and Port-of-Entry Improvements.

This project examined the CSTs and correlated them to the TFMP policy and programming recommendations, along with the strategic improvements. The tables containing this assessment are located in Appendix C.

Additionally, the draft TFMP summarizes a number of freight projects and needs recommended on the highway, rail, port, air cargo, and border networks in Texas. The TFMP makes a distinction between highway projects that are currently programmed (but not necessarily fully funded) and highway segments that are identified as future freight needs (but are not currently programmed for project development and study tasks).

To summarize the overall connection between the CSTs and elements of the TFMP, Table 15 indicates which CSTs are related to policies, programs, strategies, and projects in the plan.

Table 15. Summary of CSTs and Draft Texas Freight Mobility Plan Elements.

No.	CST Name	Texas Freight Mobility Plan Elements			
		Policies	Programs	Strategies	Projects
A1	Airships/Aerial Transport	Y	Y	-	-
A2	Unmanned Aircraft Systems (UASs)	-	-	-	-
NH1	Automated, Zero-Emissions Freight Systems	-	-	-	-
NH2	Passenger Rail Cargo Delivery	Y	Y	Y	-
FR1	Grade Crossings and Separations	Y	Y	Y	Y
FR2	Freight Rail Public-Private Partnerships (P3s)	Y	Y	Y	Y
FR3	Railroad Infrastructure Relocation	Y	Y	Y	Y
AF1	Natural Gas Freight Vehicles	-	-	-	-
AF2	Electric/Hybrid Freight Vehicles	-	-	-	-
AF3	Other Fueled Freight Vehicles	-	-	-	-
AV1	Truck Platooning	-	Y	-	-
AV2	Automated Trucks	-	-	-	-
IT1	Traffic Signal Coordination Systems	-	Y	Y	Y
IT2	Truck-Shipper Matching Systems	Y	Y	Y	-
IT3	Port ITS Systems	Y	Y	Y	Y
IT4	Hazardous Material Vehicle Location Status/Shipment Tracking	Y	Y	-	-
IT5	Intermodal Terminal Efficiency	Y	Y	-	-
TI1	Dedicated Truck Roadways	Y	Y	Y	-
TI2	Truck Lanes in Surge Freight Flows	Y	Y	Y	-
UF1	Short-Haul Rail Movements within Urban Areas	Y	Y	Y	-
UF2	Underground Freight Transportation	Y	Y	Y	-
UF3	Truck Delivery Timing Programs	-	-	-	-
UF4	Package Consolidation Boxes/Lockers	-	-	-	-
UF5	Freight Village Facility Development	Y	Y	-	-
B1	Border Inspection Technology	Y	Y	Y	-
B2	Institutional Arrangements	Y	Y	Y	-
S1	Truck-Terminal Coordination	Y	Y	Y	-
S2	Port-Related Rail Improvements	Y	Y	Y	Y

CHAPTER 6. SELECTION OF FINAL STRATEGIES AND TECHNOLOGIES

INTRODUCTION

During the course of the Phase I project, 57 individual strategies and technologies were identified for potential consideration for further investigation in Phase II of this project. As discussed in the previous chapter, those 57 were later combined as part of the research into 28 consolidated freight strategies and technologies. This chapter discusses the process undertaken to select a reduced set of recommended strategies and technologies to present to the TxDOT research panel and the final items selected and approved by the panel. The final selected consolidated strategies and technologies will undergo more in-depth analysis and evaluation during Phase II of the project.

It is important to understand that strategies and technologies selected for presentation to the panel and those final items selected by the panel are items believed as best for this project to move forward and not the only ones of interest to TxDOT. Several interesting strategies and technologies (e.g., truck platooning, underground freight transport) are the subject of other individual innovative research projects currently being undertaken by TxDOT but were excluded from the selection process described in the remainder of this chapter. Those items not selected to advance into Phase II analysis remain valuable and important strategies and technologies to consider in freight planning.

PROPOSED NINE CONSOLIDATED STRATEGIES AND TECHNOLOGIES

This section describes the general process undertaken to select a recommended subset of the identified STs to present to the TxDOT project team panel for advancement to Phase II analysis.

Process of Selection

The Phase I project agreement indicated that approximately six strategies and technologies would be presented to the panel for further investigation in Phase II. The process to attempt to identify which items should be selected began following Tasks 1 and 2. Members of the research team were asked to select their top 20 strategies and technologies, and to rank those 20 items. In addition, a panel consisting of senior TTI transportation experts was asked to perform the same evaluation. The outcome of these exercises did not present a clear set of strategies and technologies to advance. In total, 56 of the 57 strategies and technologies were selected by one research team or senior panel member. Feedback received as part of this exercise led to the consolidation of strategies and technologies, as discussed in the previous chapter.

General Criteria Utilized

The previous chapter reported the 28 consolidated strategies and technologies that are part of 10 major categories. After the development of these CSTs, the research team utilized several general criteria for selecting the CSTs to present to the TxDOT 0-6837 Project Team panel members during the third project update meeting. The following list includes the criteria that the project team used to make recommendations:

- Do not select CSTs that are already being thoroughly investigated within other TxDOT innovative or traditional research projects.
- Select one CST per each of the 10 major categories.
- Select CSTs that are generally longer term in nature.

Recommended Nine CSTs

Ultimately, the research team selected nine CSTs to present to the panel, as demonstrated in Table 16. The AV/CV Truck category is currently being investigated as part of another TxDOT innovative research project (Project 0-6836), as is CST UF2 Underground Freight Transportation (Project 0-6870). This removed the AV/CV truck and underground freight movement categories from consideration. Eight of the remaining nine categories have CSTs selected. While the Seaports category does not contain a specific selection, the Port ITS Systems (IT3) selection within the ITS and Operations category focuses specifically on seaport ITS applications. Table 16 shows the CSTs recommended by the research team to advance, as noted by bold type and an asterisk.

Table 16. Proposed Consolidated Strategies and Technologies.

Category	CST Number	CST Name
Aviation	A1	Airships/Aerial Transport
	***A2**	**Unmanned Aircraft Systems (UASs)**
Non-Highway Systems	***NH1**	**Automated, Zero Emissions Freight Systems**
	NH2	Passenger Rail Cargo Delivery
Freight Rail	FR1	Grade Crossings and Separations
	***FR2**	**Freight Rail Public-Private Partnerships (P3s)**
	FR3	Railroad Infrastructure Relocation
Alternate Fuels	***AF1**	**Natural Gas Freight Vehicles**
	AF2	Electric/Hybrid Freight Vehicles
	AF3	Other Fueled Freight Vehicles
AV/CV Truck	AV1	Truck Platooning
	AV2	Automated Trucks
ITS and Operations	***IT1**	**Traffic Signal Coordination Systems**
	IT2	Truck-Shipper Matching Systems
	***IT3**	**Port ITS Systems**
	IT4	Hazardous Material Vehicle Location Status/Shipment Tracking
	IT5	Intermodal Terminal Efficiency
Truck Infrastructure	***TI1**	**Dedicated Truck Roadways**
	TI2	Truck Lanes in Surge Freight Flows
Urban Freight	UF1	Short-Haul Rail Movements within Urban Areas
	UF2	Underground Freight Transportation
	UF3	Truck Delivery Timing Programs
	UF4	Package Consolidation Boxes/Lockers
	***UF5**	**Freight Village Facility Development**
Border	***B1**	**Border Inspection Technology**
	B2	Institutional Arrangements
Seaports	S1	Truck-Terminal Coordination
	S2	Port-Related Rail Improvements

Note: Selected items noted with asterisk and bold font.

SELECTION OF FINAL CONSOLIDATED STRATEGIES AND TECHNOLOGIES

The nine proposed consolidated strategies and technologies were presented to the TxDOT research panel on February 12, 2016. Discussions with the panel resulted in selection of up to nine consolidated strategies and technologies to move forward in Phase II of the project. These included the creation of a new strategy/technology topic; removal of two of the proposed items; addition of two items; and expansion of several CSTs to include additional concepts. Table 17 provides the final nine items selected by the TxDOT research panel.

Table 17. TxDOT Research Panel Selected Final Consolidated Strategies and Technologies.

Category	Updated Selection	CST Number	CST Name
Aviation		A1	Airships/Aerial Transport
	Removed by panel	A2	Unmanned Aircraft Systems (UASs)
Non-Highway Systems	**1**	**NH1**	**Automated, Zero-Emissions Freight Systems**
		NH2	Passenger Rail Cargo Delivery
Freight Rail		FR1	Grade Crossings and Separations
	2	**FR2**	**Freight Rail Public-Private Partnerships (P3s)**
		FR3	Railroad Infrastructure Relocation
Alternate Fuels	**3**	**AF1**	**Natural Gas Freight Vehicles**
		AF2	**Electric/Hybrid Freight Vehicles**
		AF3	**Other Fueled Freight Vehicles**
AV/CV Truck		AV1	Truck Platooning
		AV2	Automated Trucks
ITS and Operations	Removed by panel	IT1	Traffic Signal Coordination Systems
	4	**IT2**	**Truck-Shipper Matching Systems (Freight Traveler Information)**
	5	**IT3**	**Port ITS Systems**
		IT4	Hazardous Material Vehicle Location Status/Shipment Tracking
		IT5	Intermodal Terminal Efficiency
Truck Infrastructure	**6**	**TI1**	**Dedicated Truck Roadways (All Infrastructure to Separation of Trucks from Cars)**
		TI2	Truck Lanes in Surge Freight Flows
Urban Freight		UF1	Short-Haul Rail Movements within Urban Areas
		UF2	Underground Freight Transportation
	7	**UF3**	**Truck Delivery Timing Programs (Truck Parking Information Systems)**
		UF4	Package Consolidation Boxes/Lockers
	8	**UF5**	**Freight Village Facility Development**
Border	Removed by panel	B1	Border Inspection Technology
		B2	Institutional Arrangements
	9	**New**	**Border Advanced Freight Traveler Information**
Seaports		S1	Truck-Terminal Coordination
		S2	Port-Related Rail Improvements

Description of the Final Nine Consolidated Strategies and Technologies

The following section offers an overview description of the nine strategies and technologies selected and approved to advance for potential Phase II analysis by the panel. Actual performance of Phase II analysis and a work plan and budget for Phase II will be approved separately by TxDOT, which could change the final number or scope of planned analysis.

Automated, Zero-Emission Freight Systems (Non-Highway Systems)

Texas highways near major urban areas are experiencing congestion, traffic safety issues, pollution, and infrastructure deterioration due to truck movements. Usually, heavy-duty diesel trucks carry intercity and port-to-inland freight along these major freight corridors. The burden from the intercity and port-to-inland heavy-duty truck traffic could be alleviated by using highly automated and zero- or low-emissions intercity freight transportation transport systems in areas where significant volumes of containers are moved, such as between port terminals and nearby warehouses or intermodal facilities. Moving to zero- or low-emissions systems could potentially improve air quality within urban areas, reduce energy usage, and reduce congestion growth on existing infrastructure.

Freight Rail Public-Private Partnerships (P3s) (Freight Rail)

Freight and passenger rail operations in major urban areas—or at chokepoints like bridges or at-grade intersections—are so interrelated and complex that often no single public entity or private operator can afford to tackle the problem. This is particularly the case if more than one railroad would benefit from doing so. In such cases, the public sector can leverage funding and project planning to bring about major infrastructure improvements by combining projects, describing benefits, and assigning relative cost sharing—perhaps even in constructing and operating the new facilities.

Natural Gas, Electric/Hybrid, and Other Alternate Fueled Freight Vehicles (Alternate Fuels)

Diesel-powered freight vehicles in high-traffic freight corridors greatly contribute to pollution by releasing both greenhouse gas emissions and particulate matter. Particulate matter is harmful to human health and is linked to asthma, heart disease, respiratory diseases, and premature death. Conventional diesel trucks are noisy and subject the driver to vibrations and the smell of diesel. This concern also resides with other modes of freight transportation, such as freight rail locomotives and towboats, as their source of power also comes from onboard diesel engines. Alternative fuels, such as natural gas, compressed natural gas, and hydrogen fuel, or the use of electric- and/or battery-powered freight vehicles has the potential to reduce fuel use and address many of the pollution issues associated with conventional diesel engines in both intercity and congested urban areas.

Truck-Shipper Matching Systems (ITS and Operations)

Developed out of needs identified by both the public and private sectors, third-party software is being deployed to speed movement of cargo among intermodal nodes and between shippers and customers. The systems can consider dispatch scheduling, cargo status and location, driver availability, and traffic levels at both facilities and while en route—all to facilitate trucks moving the specific cargo that shippers need. The anticipated value of these freight information sharing systems is the potential for exchange of information between previously disconnected stakeholders—terminal operators, freight operators (shippers/receivers), and truck operators.

Port ITS Systems (ITS and Operations)

Seaports represent a complex system of highly dynamic interactions between various handling, transportation, and storage units; unfortunately, those who rely on seaports for moving freight often suffer from an incomplete knowledge of what the future holds. As a transport node, a seaport:

- Focuses a number of different means of transport (e.g., maritime, road, rail, inland waterway, and pipelines) in a small area.
- Renders a variety of services (e.g., stevedoring, handling, forwarding, logistics).
- Operates in different dedicated facilities (e.g., bulk, ferry, container terminals, storage areas and warehouses, and land and sea infrastructure connections).

The wider external interconnections between a port and its surroundings need proper coordination, control, and evaluation. Truck traffic around port terminals places a heavy load on the surrounding community. Managing the flow and routing of this traffic could increase the capacity of existing infrastructure, reduce emissions and noise pollution, reduce congestion, and lower the overall costs of freight handling throughout the state of Texas. Improving the flow of movements within a single port facility can also reduce emissions and improve operations in the nearby urban area.

Separation of Trucks from Automobiles (Truck Infrastructure)

The growing number of both automobiles and trucks traveling on U.S. highways has caused more traffic congestion and increased the likelihood of truck-auto related crashes. This growth in crashes is expected to continue in the foreseeable future. Separation of commercial vehicle types from those associated with personal travel is one potential solution to ever-increasing highway congestion and system reliability.

One option is CMV-only bypass or express lanes, which are intended to provide for more efficient movement of goods and improve safety. This approach can be used in areas where freight delivery has a significant impact on public safety and traffic congestion.

A second potential use of truck-only roadways would be to quickly and efficiently connect important logistic centers and/or designated freight villages with high freight-demand nodes. This would increase the direct service levels and decrease waiting times and drivers' fatigue and stress while reducing the likelihood of truck-auto accidents and bottlenecks. Completely separate roadways with highly automated features designed only for truck characteristics are another possibility in this area.

A third form of this strategy/technology would be to implement truck-only toll managed lanes in longer-distance, high freight density corridors alongside general-purpose traffic lanes. TOT lanes are intended exclusively for authorized truck traffic in order to improve safety and provide greater system reliability. The toll revenue collected would provide financing for maintenance and operation of the truck-only lanes. In theory, other types of managed lanes could be temporarily used as TOT lanes during limited time periods of high truck traffic, such as near a port when unloading a container ship or during morning delivery departure times from package delivery hubs. Managed lanes could revert to other purposes outside these designated time windows. (Overhead power/electrification of trucks is another potential truck-only corridor option in high freight density corridors to reduce emission impacts in urban areas.)

Truck Parking Information Systems (Urban Freight)

Inadequate parking for trucks and urban delivery vehicles often results in trucks parking illegally or circling in traffic in an effort to find a parking space. In dense urban areas, this behavior adds to congestion, environmental, and safety concerns. Inadequate truck parking can also hinder truck drivers from adhering to federal requirements limiting total hours of service. Research has demonstrated that if capacity is made available for trucks and delivery vehicles to legally park to deliver and collect items, both freight and passenger vehicles can move through urban areas more efficiently. A number of truck parking strategies exist that could improve the efficiency and lower the operational cost of the urban transportation network.

Freight Village Facility Development (Urban Freight)

A freight village is a defined area—with the best connections to air, sea, road, and rail modes of the transportation network—within which all activities are related to logistics and distribution of goods. These activities—including deconsolidation, warehousing, transshipment, and mid- and long-length transport (both for national and international transit)—are carried out by various operators, ideally with the best equipment for the transshipment between different transport modes. While FVs are intermediate destinations that facilitate the movement of goods to another destination, they also incorporate the functions of other logistics facilities. FVs serve four main purposes: (a) increase intermodal transportation, (b) catalyze regional economic activity, (c) improve local goods distribution, and (d) promote efficient land use.

Border Advanced Freight Traveler Information (Border)

Efficient movement of goods across the border and throughout the region supports improved conditions for both the local areas and also consumers across Texas and the United States. Border regions are plagued by congested border crossings with long wait times and congested roadways. Freight movements are initiated without a full understanding of the border crossing wait times and roadway conditions, which further negatively impacts the conditions. This is largely due to the lack of information disseminated between the border region stakeholders—terminals, industries, truck operators, border crossing entities, and roadway operations managers. A border information sharing system could offer a centralized location to exchange information between previously disconnected stakeholders in order to improve freight operations, roadway conditions, and border wait times.

CHAPTER 7. SUMMARY AND NEXT STEPS

INTRODUCTION

This chapter provides a summary of Phase I of the project and offers an overview of the focus of Phase II.

SUMMARY OF PHASE I ACTIVITIES

Project 0-6837 Phase I conducted an international search of potential innovative and automated freight system strategies and technologies, generating 57 initial candidates for TxDOT consideration. Further Phase I grouping and consolidation identified a cross-section of 28 potential multimodal strategy and technology options, which were then classified into 10 broad, multimodal freight automation and strategy categories related to a number of areas including aviation, non-highway automated systems, freight rail, alternative fuel commercial vehicles, automated/connected commercial vehicles and platooning, ITS-based and operational changes, truck/freight-based infrastructure improvements, urban freight delivery technologies and strategies, border, and seaports.

The research team reduced the number of potential innovative and automated freight strategy and technology concepts through a series of steps applying screening criteria, subject matter expert panel analysis and ranking, and TxDOT project team panel assistance to result in a subset of nine freight strategies/technologies. The TxDOT panel then recommended, on February 12, 2016, moving those nine strategies/technologies forward into more detailed Phase II analysis for evaluation as mid- and long-term TxDOT implementation alternatives to address specific freight system needs identified in the TFMP. It should be noted that the nine strategies/technologies recommended by the panel for Phase II analysis provide wide-ranging coverage of the variety of areas that were of interest to the 0-6837 panel; however, technologies currently being researched by other TxDOT innovative projects or planned research projects (e.g., truck platooning, underground freight transportation, unmanned aerial vehicles) were specifically excluded from recommendation under Project 0-6837 Phase II planning because TxDOT project resources are already being devoted to research in those also-promising areas.

Phase I selection criteria included documentation of the implementation history of each technology in the United States and worldwide; identification of prospective institutional barriers to U.S. and Texas implementation; estimation of cost factors relative to other, more traditional freight system measures; and cross-referencing of each proposed strategy/technology with Texas's freight needs identified in the draft TFMP, the most recent Texas Rail Plan update, other TxDOT modal plans, and major freight planning efforts of individual Texas MPOs.

Phase I efforts also analyzed and documented best practices in assessment and selection of freight projects. Among the multiple assessment processes at state and regional planning agencies or developed by national authorities evaluated by the research team, the NCHRP Report 750: Volume 3 (*14*) STREAM process stood out as the most comprehensive and appropriate for use and adaptation in Phase II of this project. Each of the nine strategies/technologies selected by the TxDOT project team panel will be forwarded for in-depth analysis in Phase II using a modified STREAM process evaluation, which includes five well-defined steps. Specific needs of Texas locations as identified in the now-completed and adopted TxDOT TFMP will also be incorporated into the proposed Phase II work plan, which is now in draft.

PHASE II OVERVIEW

The Phase II work plan, budget, and timeline remain under development at the time of this report. Phase II is planned to examine the nine selected CST areas recommended by the panel and will also include the application and tailoring of evaluation tools for TxDOT to use in considering future freight strategies and technologies. To achieve these goals, the TTI team plans to modify and use the STREAM assessment tool as described in NCHRP 750 (*14*). The report summarizes the procedure of STREAM evaluation as a five-step process: frame, identify, characterize, compare, and decide. This process will allow a deliberate, comprehensive assessment of each of the nine CSTs considering, among other things:

- The applicability of the CST to addressing elements included in the final adopted TFMP.
- The possible applications of each CST in the Texas freight system and the possible barriers to implementation.
- How successful implementation of the CST might affect the overall Texas freight system.
- Possible roles for TxDOT in pursuit of CST implementation—direct engagement, active sponsorship, advocacy and facilitation, or some other approach.

Phase II planning will be completed and evaluated by TxDOT after submission of this Phase I report.

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APPENDIX A. IDENTIFIED INNOVATIVE FREIGHT STRATEGIES AND TECHNOLOGIES

1. Airships/Aerial Transport

Texas Application of Strategy/Technology

While not a new technology, airships—also commonly referred to as blimps or dirigibles—have seen a renewed interest by several organizations in recent years. Private and public entities, including the U.S. military, have examined and continue to explore the possibilities of moving freight by airship. Although recently examined as a way to bypass the frozen Canadian tundra, use of this technology to traverse congested areas and/or provide a more direct route from production to market may be a future option for Texas. In addition, the technology can be used in locations that lack physical facilities like runways or other traditional transportation infrastructure.

Issues Addressed

- Urban Freight Delivery.
- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

Airships have been around since the early 1900s, with the U.S. Navy operating them as early as 1917 for maritime patrol and reconnaissance. In 2011, the Congressional Budget Office reviewed three airship designs that were being examined for military airlift capabilities. These airships had a variety of performance characteristics, with average cruise speeds ranging from 80 to 100 knots, mission ranges from 1,200 to 3,000 miles, and maximum payloads ranging from 20 to 60 tons. Airships also have the potential to operate as unmanned (as well as manned) vehicles (*1*).

Ultimately, Texas could employ this technology to move freight across urban areas, bypassing large, congested cities while moving freight from one transportation hub to another (between intermodal shipping centers). Airships could also be used across longer-distance freight corridors and in rural areas (agricultural production) where requisite transportation infrastructure is not located or needed for this type of technology. Moreover, they can be used for direct delivery of products (e.g., materials/equipment), as well as deliveries to remote locations and in cases of disaster relief. They are also envisioned for use in fire containment and the wind energy industry's delivery of large wind-turbine blades. Using airships to move freight provides an intermediate freight capability that is quicker than moving cargo by ships, but not as fast as traditional air cargo. Depending on the specific needs, airships provide some advantages that may be of interest to Texas.

In addition to the U.S. military, DARPA, and NASA, companies such as Lockheed Martin, Boeing, and Northrop Grumman have looked or are looking at this technology. In addition, smaller companies are also examining the freight moving possibilities of airships.

Keys to Successful Implementation

This technology—while not new but currently under renewed interest—has not been commercially deployed for moving freight. Work continues in the private sector to test and deploy airships, with the U.S. government providing funding toward those purposes in at least one case. Challenges remain in developing hybrid engines and methods/best practices for operating in certain weather conditions. Using the latest in materials, instrumentation, digital control, structural design, and computing capability will be necessary to make airships a viable option.

More work in identifying the best technology (and the best market for it) will be important to the future success of this strategy. Successfully integrating airships into the existing transportation system will be critical to any success. Also, identifying the key characteristics of the airship and its compatibility with the shipping and trucking industries will prove significant. Unlike unmanned aircraft systems (UASs), airships are already operating in the National Airspace System, albeit not moving freight.

Challenges to Implementation

Perhaps the largest challenge to the implementation of airships in moving freight is changing the mindset of traditional operators. A certain unfamiliarity with airships seems to permeate the freight and transportation industries altogether. Previous efforts to develop airships have shown the following reasons for the lack of airship success (these generally pertain to the development process and not the technology itself, although some of those challenges do exist as well, as mentioned above):

- Inadequate funding.
- Poor management.
- Shortage of personnel with airship experience/skills.
- Insufficient customer input/expectations gap.
- Investor/customer impatience.
- Unachievable development schedules.

Today's technologies are believed to be capable of providing solutions to the challenges that have hindered airship development in the past.

Success Story

A lot has been written about airships serving the remote Canadian tundra, which is not only inhospitable but largely inaccessible during parts of the year. The airship's capability to operate in remote areas (e.g., with a minimal need for infrastructure) and deliver mining/drilling equipment may translate well for Texas with its vast geography and remote locations. The state's significant oil activity has significantly impacted its transportation system in those energy producing regions, and airships could potentially relieve some of that stress on the network. NASA believes that airship technology can offer game-changing capabilities for economic and social/environmental reasons, albeit with challenges that can be overcome (*2*).

One company achieving some success is Worldwide Aeros Corp. (Aeros), a California-based company developing airships for a variety of uses, including moving freight. Its Aeroscraft aircraft is an innovative cargo airship that promises to reinvent air cargo both militarily and commercially with vertical takeoff and landing capabilities and capacities larger than the 747-8F and the Antonov 124 aircraft. While the prototype has been successfully tested, it is still currently under development (*3*).

Measures of Effectiveness

While no airship-freight service is currently in use, measures of effectiveness will include, but are not limited to, metrics on the following:

- Costs (operational/capital; less than conventional air cargo).
- Integration into existing operations.
- Fuel efficiency.
- Payload/range/cost trade-offs.
- Weather capabilities (ability to operate in adverse weather conditions).
- Infrastructure requirements/costs.
- Environmental benefits (reductions in noise and emissions).
- Congestion/safety benefits.

Time Required (scale of 1 to 5, where 5 is most time)

5

Dollars Required (scale of 1 to 5, where 5 is most expensive)

3

2. Automated and Low-Emissions Intercity Freight System

Texas Application of Strategy/Technology

Texas highways near major urban areas are experiencing congestion, traffic safety issues, pollution, and infrastructure deterioration due to truck movements. Usually, heavy-duty diesel trucks carry intercity and port-to-inland freight along these major freight corridors. The burden from the intercity and port-to-inland heavy-duty truck traffic can be alleviated by a highly automated and low-emissions intercity freight transportation system.

Issues Addressed

- Intercity or Long-Distance Freight Corridors.

Strategy/Technology Profile

Many individuals have suggested implementing automated and low-emission intercity freight systems as an innovative way to reduce the heavy-duty truck traffic from major freight corridors. To achieve safety enhancement and low emissions, it is suggested that containers be conveyed along dedicated guideway systems using electric power and various high-technology propulsion systems. These systems are mainly divided into three categories:

- Linear induction motor propulsion (LIM).
- Linear synchronous motor propulsion (LSM).
- Electrified rails with DC motors.

Regarding a suspension system, some proposals suggest Maglev technology combined with LIM or LSM to create a frictionless environment. Others are using rubber or steel wheels with the three propulsion systems. The fixed guideways are proposed to be elevated, on existing railroads, or on paved surfaces. The following two figures (Figure A-1and Figure A-2) demonstrate examples of systems with different propulsion systems.

Source:(4)

Figure A-1. Conceptual Drawing of the Freight Shuttle System by Linear Induction Propulsion.

Source: (5)

Figure A-2. Conceptual Drawing of the CargoWay™ Heavy Cargo Transport Train by Electrified Rails.

Keys to Successful Implementation

Automated, fixed-guideway technologies have proven successful on passenger transit systems in many airports. However, the characteristics of the intercity freight system are quite different in terms of weight of the load, loading/unloading mechanism, length of guideway, intermodal facility, and so on. At the present time, there is no actual system in full operation, though a few prototype systems in real environments have been proposed. Various issues would need to be addressed for successful implementation, including the following:

- Creating a scale of economy to be a viable option for existing commercial trucks.
- Identifying the appropriate rights of way for fixed guideways.
- Establishing financing methods to offset the initial large capital cost.
- Creating an advanced terminal design for non-interrupted operation of the transporters.
- Designing a streamlined communications, command, and control (C3) system.

NCFRP Report 34 (*6*) summarizes favorable conditions for automated, fixed-guideway systems for landside transport of ocean containers as follows:

- Single multiuser or clustered terminals.

- High terminal automation.
- Single inland point.
- New or clear ROW context.
- Multiple terminal shifts (24/7).
- Less demand peaking.
- Medium distance (100–500 miles).

Challenges to Implementation

There are several challenges to implementing an automated freight system, such as right of way, community impact, readiness, and completeness of the system as a whole. In the Los Angeles/Long Beach case study described in NCFRP Report 34, the “fixed-guideway options proved to be too costly and provided too little capacity to reduce highway congestion.” In the Baltimore case study profiled in the same report, the “fixed-guideway systems were too costly and could not appreciably reduce the community impact of a new rail intermodal terminal.” Often, proposals of automated freight systems do not achieve the mature level of technical and system readiness to attract public consensus and financing sources (*6*).

Success Story

Since an automated freight system has not been implemented, there are no success stories.

Measures of Effectiveness

Even though there are no real-world implementations to measure the effectiveness of automated freight systems, such systems should provide public benefits by reducing heavy truck volumes from the congested freight corridors. Research report FHWA/TX-11/9-1528-1 describes public benefits of the Freight Shuttle System (FSS) as (*7*):

- **Energy and Air Quality Improvements**. Energy cost per mile for the FSS would be about 12 times less than heavy-duty diesel (HDD) trucks.
- **Infrastructure Cost Savings**. The FSS would save about $0.3174 per mile in pavement damages in the study corridor.
- **Congestion Reduction**. The FSS is expected to attract about 25 percent of the freight truck traffic in the study corridor.
- **Safety and Noise Improvements.** Based on Federal Highway Administration guidelines, the FSS is expected to save a total of $56 million in safety- and noise-related costs for a 10-year analysis period in the study corridor.

Time Required (scale of 1 to 5, where 5 is most time)

4

Dollars Required (scale of 1 to 5, where 5 is most expensive)

5

Supplemental Information

- Automated Freight, Goods Movement and Tube Technologies. Web. https://faculty.washington.edu/jbs/itrans/afreight.htm.
- Hans-Otto Gunther, Kap Hwan Kim. Container Terminals and Automated Transport Systems, Springer, 2005. http://link.springer.com/content/pdf/bfm%3A978-3-540-26686-0%2F1.pdf.

3. Consolidated Grade-Crossing Corridor Safety/Grade Separation Programs

Texas Application of Strategy/Technology

Population and economic growth in Texas will continue to increase freight volumes moving on all modes in the state. Class I railroads in Texas are expected to see substantial increases in train counts, and many larger and mid-sized urban areas will experience safety and economic development conflicts that accompany higher train and vehicular traffic. Smoothing highway-rail conflicts might require consideration of corridor-based approaches for improving grade-crossing safety and separating roads and railroads (grade separations). Addressing collections of grade-crossing improvements might improve rail and truck throughput.

Issues Addressed

- Intercity Freight Corridors.
- Urban Freight.

Strategy/Technology Profile

Considering highway-rail grade-crossing improvements on a corridor basis has the following benefits:

- Reviewing crossings on a corridor basis aids planners in considering overall rail and highway traffic patterns.
- Aggregating crossings and rail segments can justify the expensive process of modeling rail operations to estimate operational improvements; combining crossing closures, separations, and at-grade improvements can bring railroads to the table to share necessary data.
- Collecting projects into a program can consolidate public benefits in relieving crossing delays and improving safety for cars and trucks more than a project at a time, which helps justify the public investments needed for grade separations.

This approach is most effective when the analytical rigor of a program of multiple projects is matched with a variety of dependable funding sources.

Keys to Successful Implementation

Many regions have addressed crossings on a corridor basis:

- The North Carolina Department of Transportation pursued a sealed corridor approach to improve passenger rail services (*8*).

- The original Alameda Corridor in Los Angeles was designed in part to remove multiple grade crossings.
- The Gulf Coast Rail District has studied corridor-based rail and roadway improvements.

Texas should consider the following in applying this approach:

- Stable, dependable funding sources are necessary to achieve program goals and complete projects; they motivate partners to commit to the program over time.
- Completing rail operations modeling is time consuming and expensive but necessary to achieve private railroad benefits and financial contributions for the program.
- Public-sector involvement may be needed to mediate between multiple railroads and local communities in planning crossing improvements.

Challenges to Implementation

Grade separation projects are expensive and usually orphaned from regular highway funding programming. However, failing to secure funding can sap energy from program-planning partners. The Alameda Corridor-East (ACE) program (discussed below) depended at first on federal earmarks and then used state capital programs and local-option transportation funding. Large-scale programs or projects need multiple funding sources but require some kind of state or local funding to be successful.

Success Story

The ACE Construction Authority was created in 1998 by the San Gabriel Valley Council of Governments to secure funding and manage construction of new train control systems, 39 grade-crossing safety improvements, and 22 grade separations for a total cost of $1.863 billion. Planned safety improvements are completed, 14 grade separations are completed or in construction, and $1.652 billion in federal, state, local, and private funding has been committed. This “joint powers authority” entity is unique to California, but similar entities like the Lone Star Rail District and the Gulf Coast Rail District have been created in Texas to plan and construct passenger and freight rail projects.

Measures of Effectiveness

The ACE project is estimated to reduce transportation emissions by 221 tons per year, as well as to reduce train-related vehicle delays, which are expected to grow by 211 percent between 2010 and 2035.

Time Required (scale of 1 to 5, where 5 is most time)

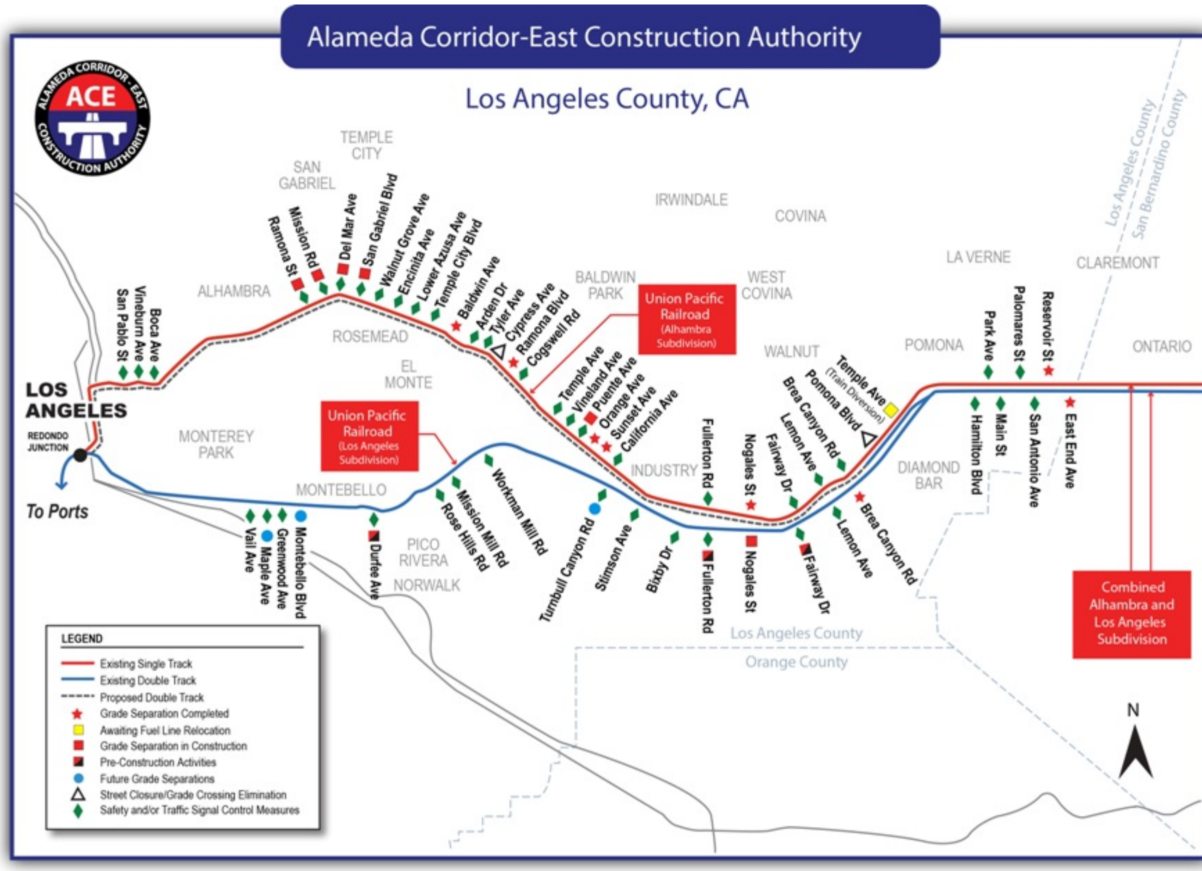
4

Dollars Required (scale of 1 to 5, where 5 is most expensive)

5

Supplemental Information

- The Alameda Corridor-East Construction Authority—http://www.theaceproject.org/.
    - Figure A-3 provides an overview map of the ACE projects.



Alameda Corridor-East Project Area

Figure A-3. Map of the Alameda Corridor-East Project Area.

4. Freight Rail Public-Private Partnerships

Texas Application of Strategy/Technology

Freight and passenger rail operations in major urban areas—or at choke points like bridges or at-grade intersections—are so interrelated and complex that no single operator can afford to tackle the problem. This is particularly the case if more than one railroad would benefit from doing so. In these cases, the public sector can leverage funding and project planning to bring about major infrastructure improvements by combining projects, describing benefits, and assigning relative cost sharing—perhaps even in constructing and operating the new facilities.

Issues Addressed

- Intercity or Long-Distance Freight Corridors.

Strategy/Technology Profile

Public-private partnerships (P3s) can leverage multiple partners to address complex or thorny infrastructure issues. Careful modeling of rail and roadway operations can identify long-term benefits from projects. These benefits can, in turn, inform relative financial contributions of the public and private sectors. By eliminating choke points and removing highway-rail conflicts, P3s can add capacity to freight rail networks, accommodating future freight flows without increasing truck traffic on congested roadways.

Keys to Successful Implementation

Successful freight rail P3s include the Tower 55 project in Fort Worth (*9*), the Alameda Corridor in Southern California (*10*), the Sheffield Flyover in Kansas City (*11*), the Colton Crossing Flyover east of Los Angeles (*12*), and the Chicago Region Environmental and Transportation Efficiency (CREATE) Program (*13*). Implementation issues to consider include:

- Projects may require a special-purpose governmental entity to oversee the projects (or a public agency could manage the project).
- Project partners could pay user fees to use the new facility and thus retire revenue bonds used to fund capital improvements.
- The public sector can play an important role by mediating between multiple users and beneficiaries of the projects.

Challenges to Implementation

P3 challenges include:

- Project partners have to consider project risks including cost escalations, revenue shortfalls, and unpredictable public funding.
- Projects require extensive planning to identify relative benefits and justify financial contributions.
- All partners need to maintain commitment to the project since project champions will change within the partnership over the life of the projects.
- Public-sector partners must bring financial contributions to be able to leverage private funding and motivate private participation.

Success Story

Chicago, the nation's busiest rail hub, sees 1,300 trains moving 37,500 railcars daily—nearly one-fourth of the nation's freight rail traffic. After a massive snow storm on January 1, 1999, Chicago's mayor and the chair of the Surface Transportation Board convened a group of Chicago's major stakeholders to come up with improvements to rail operations in the region. The effort produced the CREATE Program, a $3.8 billion collection of grade-crossing improvements, grade separations, rail-to-rail flyovers, and rail track and signal improvements along four major corridors. There have been 22 projects completed, 10 are under construction, and 18 are in design or environmental clearance (*13*).

Measures of Effectiveness

Once fully implemented, the CREATE project will eliminate 2,400 hours per day of delays for motorists, save 3.4 million gallons of diesel fuel annually, remove 36,000 metric tons of CO_2 per year, and save 120 lives and 16,800 injuries over 30 years. The project will speed rail traffic, divert freight from trucks, and reduce grade-crossing conflicts and delays (*13*).

Time Required (scale of 1 to 5, where 5 is most time)

5

Dollars Required (scale of 1 to 5, where 5 is most expensive)

5

Supplemental Information

- More CREATE documents:
  - Feasibility study on projects: http://www.createprogram.org/linked_files/final_feasibility_plan_orig.pdf.
  - *Trains Magazine* June 2015 story on Chicago: http://www.createprogram.org/in_news/7-2015.pdf.
- Figure A-4 provides an overview map of the CREATE projects.

Figure A-4. CREATE Overall Project Map

5. Natural Gas-Fueled Heavy-Duty Highway Freight Transportation

Texas Application of Strategy/Technology

Texas's economy and environment could potentially benefit from using natural gas fuel in freight vehicles. Converting trucks, locomotives, ferries, and even fixed equipment such as seaport cranes to natural gas fuel would:

- Benefit Texas via reduced emissions of NO_x and particulates through improved compliance with the Environmental Protection Agency's (EPA's) air inventory emission reduction and compliance policy.
- Dramatically increase markets for Texas's natural gas production and retail purchase volumes, ultimately benefiting the natural gas exploration and production industry of the state.
- Potentially reduce long-term fuel/maintenance costs and increase equipment asset life for both public and private companies operating freight-related equipment.

Four major applications of natural gas for freight vehicles were identified for further study.

Strategy/Technology Profile

Switching long-distance trucks to natural gas fuel has both benefits and challenges. Reduced vehicle maintenance and longer asset life will contribute to fewer overall numbers of heavy-duty vehicles required to perform the same amount of freight delivery in dense corridors. Refueling points will be limited to corridors where high vehicle density exists because of the high capital required to install natural gas refueling stations. Natural gas use in over-the-road freight transportation will impose restrictions on the utility of these trucks given the limited availability of refueling points on the existing network. Reduced range could lead to increased numbers of trucks on roadways.

Currently in Texas, the Clean Transportation Triangle (CTT) program administered by the Texas Commission on Environmental Quality (TCEQ) provides grants for creation of natural gas fueling stations in the 63 CTT-eligible counties of the state. The state's Alternative Fueling Facilities Program (AFFP) provides additional natural gas facility incentives in the 18 nonattainment counties and El Paso County. If the State of Texas offers additional incentives for purchase of new natural-gas-fueled trucks, it could facilitate the deployment of converted fleets of commercially owned and operated heavy-duty trucks. With the growth of the commercial freight fleets, alternate-fuel station providers will likely expand the installation of refueling stations to make a profit via increased market share.

Keys to Successful Implementation

Natural gas has been used to fuel heavy-duty, long-distance trucks for 30 years. Only in the past five years has the price of diesel fuel been high and natural gas plentiful and affordable enough to attract the attention of fleet operators. Keys to successful implementation include the following:

- OEM natural gas engines supplied in new, recognized heavy-duty OEM trucks.
- Engine performance comparable to diesel.
- Industry-recognized reduced engine maintenance of consumables (e.g., lube oil, fuel filter, oil filter, engine bearing life increase).
- Overall reduced emission output.
- Fuel tax equality with traditional diesel trucks.
- Competitive fuel-provider network.
- Industry-recognized long-term fuel availability.
- LNG/CNG fuel station infrastructure.

Challenges to Implementation

Fuel tax disparity based on volume measure of natural gas compared to traditional diesel is a marked disincentive to using natural gas. The disparity amounts to an increase of fuel tax for using LNG of 32 percent based on 1 gallon of LNG at 85,000 BTU compared to diesel having 125,000 BTU. The added tax reduces the basic fuel price savings component of the economic benefit, which results in a disincentive for potential fleet users to invest in substantial fleet conversion to natural gas.

Success Story

The Ports of Los Angeles and Long Beach require the registration of clean vehicles prior to allowing their use for container drayage. California Cartage Company (CCC), the largest port drayage firm in North America, owns the largest fleet of NG drayage tractors in the nation, allowing them open access to the ports. Their development project to meet the Clean Vehicles Program of the Ports of Los Angeles and Long Beach obtained $13 million in federal, state, and local air quality grants to launch the project with 132 LNG drayage tractors. CCC's ultimate goal is to have 400 LNG drayage tractors. The company's driver fuel costs were substantially reduced by switching to LNG fuel.

Measures of Effectiveness

A system of natural gas fueling stations is currently being built on the major Texas highways commonly referred to as the Texas Triangle (I-10, I-45, and I-35), but the system has not been in place long enough to provide good operational/efficiency data.

Suggested metrics to assess the effectiveness of this strategy include the following readiness assessments on a 1–5 Likert scale:

- Fuel cost reduction—3.
- Reduced maintenance cost—3.
- Reduced emissions—3.
- Expanded business base—4.
- Driver satisfaction—4.
- Monetary cost sharing—5.
- Implementation time—4.

Time Required (scale of 1 to 5, where 5 is most time)

4

Dollars Required (scale of 1 to 5, where 5 is most expensive)

5

Supplemental Information

- California Cartage Company—http://www.gladstein.org/gna-casestudies/cal-cartage/.
- Natural Gas Vehicles of America—http://www.ngvamerica.org/vehicles/for-fleets/over-the-road/.
- Port of Los Angeles Drayage Truck Registry—http://www.portoflosangeles.org/ctp/ctp_pdtr.asp.

6. Natural Gas-Fueled Locomotive

Texas Application of Strategy/Technology

Texas's economy and environment could potentially benefit from using natural gas fuel in long-haul railroad locomotives. Converting locomotives to natural gas would likely dramatically increase natural gas production and wholesale purchases, ultimately benefiting the natural gas exploration and production industry of the state. Freight railroad companies would benefit from reduced fuel/maintenance costs and increased asset life. Shippers would benefit through reduced transportation costs. Locomotive manufacturers (e.g., GE Transportation in Fort Worth, Texas) would benefit through increased production demand and diversity of new locomotive technology. The State of Texas and the railroad operators would benefit via reduced emissions of NO_x and particulates through improved compliance with EPA's air inventory emission reduction and compliance policy.

Strategy/Technology Profile

Natural gas alternate-fuel use in railroad freight transportation using current designs would substantially increase long-haul range without refueling stops. This may substantially increase productivity and improve existing railroad capacity. Typical long-haul corridors are:

- Los Angeles/Long Beach to Houston and beyond.
- El Paso to Ft. Worth and beyond.
- Houston and San Antonio to Amarillo and the Wyoming coal fields, etc.

Texas locations could serve as major fuel supply points for these corridors—one-stop-shopping for fueling trains in either direction. Trains could potentially fuel with LNG in Houston and operate without refueling until they reach California. The same Houston waypoint could fuel trains operating all the way to the East Coast. By economic necessity, refueling points would likely be limited to corridors where a high train volume exists. This is a result of the high capital required to install natural gas refueling stations.

Keys to Successful Implementation

The use of liquefied natural gas as fuel in railroad locomotives has been successfully demonstrated since 1985 on over-the-road and long-haul coal-train revenue services. Environmental proponents have strongly advocated the use of LNG for railroad locomotives since the technology was first demonstrated in the mid-1980s. Only in the last five years has the price of diesel fuel been high enough and natural gas plentiful and affordable enough to attract economic attention of fleet operators. Keys to successful implementation include the following:

- OEM natural gas engines and conversions available to the industry, GE, and EMD from recognized OEM suppliers.
- Engine performance comparable to diesel.
- LNG fuel station infrastructure.
- Overall reduced emission output complying with U.S. EPA regulation.
- Competitive fuel-provider network.
- Industry-recognized reduced engine maintenance of consumables (e.g., lube oil, fuel filter, oil filter, engine bearing life increase).
- Industry-recognized long-term fuel availability.

Challenges to Implementation

Railroad companies traditionally cite interchanging locomotives on through trains as a major impediment to converting to natural gas as locomotive fuel. Additionally, railroads state they must have the freedom to use their locomotives throughout their railroad system; thus, the availability of LNG fuel must be widespread before successful railroad implementation. All railroads must be able to refuel LNG locomotives or face stalled trains that have run out of fuel.

The lack of existing locomotives capable of burning natural gas implies railroads would have few LNG-capable units; yet, railroads must invest heavy capital to build LNG plants and fuel stations that cannot be efficiently used until more locomotives become available. The railroad industry's Class I railroads are heavily investing in the development of operational and safety standards for interchanging locomotives. The major issues of concern are (a) the uncertainty of the price of diesel fuel, and (b) the recognized long-term availability of natural gas supplies.

Increases or decreases in hydraulic fracturing and production price of natural gas may introduce new uncertainties into railroads continuing to support the LNG conversion initiative. Nevertheless, the financial incentive of reducing operating fuel costs may continue to sway management to seek LNG as the principal long-haul locomotive fuel.

Success Story

Several demonstration programs have occurred in the United States and Canada over the past several decades, and one continues to be operating. Despite several successful tests, the Federal Railroad Administration (FRA) is currently developing regulatory practices, and the impact of those policies is as yet unknown. The following three figures present successful demonstration tests.

Figure A-5. The first worldwide natural-gas-fueled locomotive to operate in revenue service from October 1984 to May 1988 between Minneapolis, Minnesota, and Superior, Wisconsin.

Figure A-6. The first worldwide LNG fueled locomotive to operate in regular-revenue coal-train service from September 1991 to February 1996 between Decker, Montana, and Alloueuz Coal Dock, Superior, Wisconsin.

Figure A-7. Canadian National ElecroMotive Diesel SD40-2 locomotives with tender converted to use natural gas fuel with diesel pilot operated from September 2012 to November 2013 between Edmonton and Ft. McMurry, Alberta, Canada.

Measures of Effectiveness

Suggested metrics to assess the effectiveness of this strategy include the following assessments of how ready the technology is for implementation:

- Fuel cost reduction—4.
- Interoperability with existing locomotive fleet—5.
- LNG fuel availability—1.
- Fuel compatible locomotive availability—2.

Time Required (scale of 1 to 5, where 5 is most time)

4

Dollars Required (scale of 1 to 5, where 5 is most expensive)

4

7. Passenger Rail Cargo Delivery

Texas Application of Shared-Use Rail for Cargo Delivery

Congestion along many of Texas's major intercity corridors and urban networks poses a significant issue in delivering cargo, especially regarding time-sensitive package delivery. Several existing intercity passenger rail routes and urban passenger rail systems exist in Texas. Additionally, planning is ongoing for high-speed rail between major Texas urban areas. Using these passenger rail systems for cargo deliveries and adopting high-speed rail freight could mitigate the above issues and may offer an additional revenue source.

Issues Addressed

- Intercity or Long-Distance Freight Corridors.
- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

There are few reports that explain the technical profile of passenger rail and high-speed rail freight. According to one paper from the Australasian Railway Association, four integration options of high-speed passenger rail and high-speed freight rail are possible, as shown in Figure A-8.

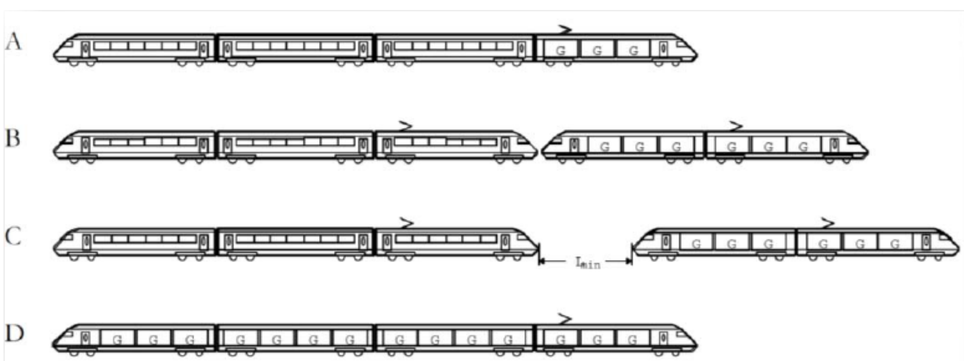


Figure A-8. Integration Options (Source: ARA).

- **Option A** is the highest level of integration and transports freight in the same train as passengers.
- **Option B** indicates a multiple-coupled integration of passenger trains and freight trains. In this case, the freight train can be de-coupled at night, which increases the usefulness of rolling stock.
- **Option C** not only maximizes the benefits of Option B but also deals with capacity problems by operating freight trains in the shadow of passenger trains. Also, this integration option separates the stops for loading and unloading from the passenger trains.
- **Option D**, adopted by the TGV's La Poste service, introduces fully independent freight trains. This option needs additional network capacity (*14*).

Keys to Successful Implementation

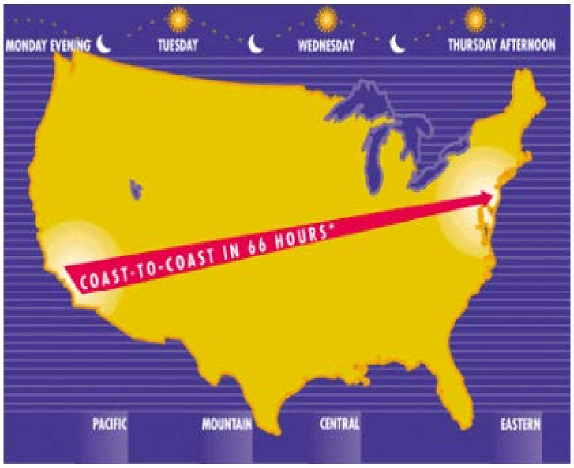
Most of all, financial support is crucial in implementing passenger rail cargo delivery. These dollars can be used in making new and improved infrastructure to alleviate congestion, improve inter-modality, and enhance market accessibility. Also, financing is needed to "ensure interoperability between national networks, finance investment and fixed maintenance and renewal costs, and facilitate use of nonpeak slots" (*15*, *16*). A passenger rail system's first priority should be to move people efficiently and safely, so any cargo operations should occur without detrimental impact on passenger travel.

Challenges to Implementation

In the United States, Amtrak mostly operates on freight rail infrastructure; this is entirely the case in Texas. Freight railroads would most likely oppose passenger movement of cargo on their network because it is a direct competitor and may impact available capacity on their network. Additionally, facilitating freight on scheduled passenger trains does not provide a significant amount of time to load and unload the cargo while the train is stopped for passengers. Finally, package-delivery companies like FedEx and UPS have extensive networks in place throughout the state, which would make it difficult to capture existing package-delivery business. This service would likely be a niche market.

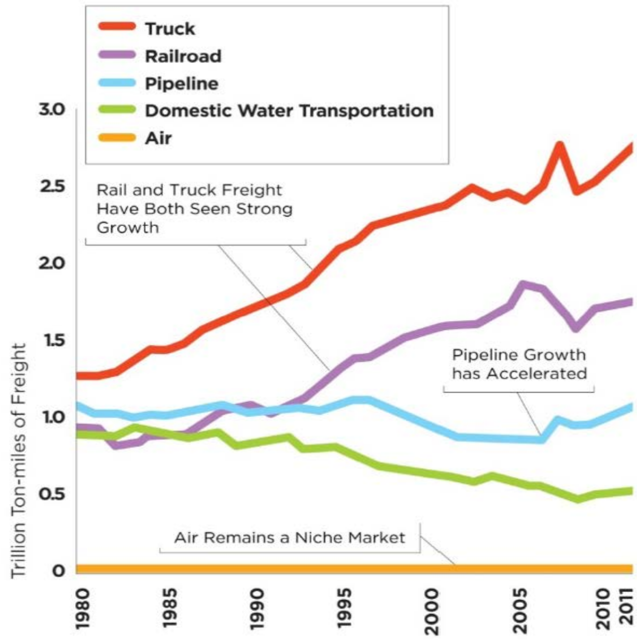
Success Story

Amtrak previously offered mail and express cargo delivery service using dedicated passenger train cars. The maximum speed of these trains can reach 125 km/h and even 145 km/h in some places. No longer in service, it took approximately 66 hours to operate coast-to-coast express freight haul. Figure A-9 presents an advertisement map from Amtrak. Compared to the truck delivery time of five to six days, rail could be a timesaving way to deliver cargo. Amtrak now offers small-package and less-than-truckload shipping services between more than 100 cities (*17*). Hauling freight by road still makes up most of the freight market, but the rail-based freight market continues to grow, especially when it comes to time-sensitive express freight, as shown in Figure A-10 (*18*).



Source: (17)

Figure A-9. Amtrak Offered Express Freight Transport Coast to Coast in 66 Hours.



Source: (19)

Figure A-10. U.S. Ton-Miles of Freight (in Millions).

Measures of Effectiveness

The main measures for determining the feasibility of a cargo service on a passenger rail system are cost effectiveness, ability to reduce congestion, and connectivity to major cargo distribution points, such as airports. High-speed rail freight is defined as "faster than by truck—cheaper than by air." According to one report in reference to Amtrak, express freight can contribute to the economic improvement in passenger rail by holding 40 percent of the total revenue (*18*).

Time Required (scale of 1 to 5, where 5 is most time)

3

Dollars Required (scale of 1 to 5, where 5 is most expensive)

4

8. Railroad Infrastructure Relocation

Texas Application of Strategy/Technology

Relocating major urban railyard operations to new facilities outside urban areas—or constructing rail bypasses around urban areas—could improve freight rail operations and the quality of life within urban areas. However, relocating rail operations may also affect trucking operations servicing existing rail locations, making truck trips longer or more circuitous. Increased levels of vehicular traffic over crossings and population expansion along rail corridors and around railyards may make such changes necessary in the long run. This is especially true in Texas's largest urban areas of Dallas, Houston, and San Antonio; however, other smaller urban areas—such as El Paso and the rail corridor between Austin and San Antonio—have either experienced relocation of rail infrastructure or have considered it recently.

Issues Addressed

- Intercity or Long-Distance Freight Corridors.
- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

Development around major rail corridors and railyards within urban areas can cause constraints on rail operations, as well as backups and congestion on nearby roadways. Rail operations can also create conflict with adjacent land uses in the urban area where development has encroached on railroad property. Often, the need for increased rail operational capacity and the desire to reduce traffic conflicts may make viable the option of relocating rail infrastructure to an area outside the constrained urban location. Rail infrastructure relocation generally requires a public-private partnership to move freight rail operations outside urban areas because of the necessity for constructing new rail infrastructure or consolidating existing rail infrastructure to a less-constrained location. Moving also allows for construction of new, larger, more-modern railyards away from incompatible land uses. New railyards may also choose to use alternative fuels/electric power for cranes and other service vehicles, resulting in decreased emissions. Other motives for rail infrastructure relocation include:

- Reduced conflict at grade crossings.
- Opportunity to convert former rail property to urban housing.
- Adaptation of the infrastructure to commuter and light-rail passenger service.
- Construction of trails or roadway expansion.

Keys to Successful Implementation

A TTI report completed for TxDOT Project 0-5322 in 2007, *Rail Relocation Projects in the U.S.: Case Studies and Lessons for Texas Rail Planning*, identified numerous examples of rail bypass routes and other types of rail infrastructure relocation (*20*). The report also includes several case studies and best-practice recommendations, which include:

- Public/private-sector participants' understanding of each stakeholder's needs and requirements.
- Establishment of common goals and appropriate project scope.
- Estimation of the full public and private benefits and costs so that implementation costs can be appropriately allocated.

Challenges to Implementation

Rail infrastructure relocation raises several challenges:

- Rail relocation is generally a very costly and time-consuming process.
- Substantial public-sector investment to achieve a rail relocation project could raise objections as an unfair advantage to the relocated railroad(s).
- Rail relocation project benefits accrue over the long term, complicating benefit-cost analysis for the project.
- Brownfield redevelopment issues (e.g., sites with potential contamination concerns) relocated to yard reuse may prove costly.
- Operations over the new route may or may not benefit freight railroad operations.

Success Story

The report on TxDOT Project 0-5322 includes several case studies of rail relocation projects throughout the United States over the past four decades. Rail infrastructure relocations of various types are highlighted in these case studies. One rather instructive example would be the Lafayette Railroad Relocation Project that consolidated four railroad tracks through downtown Lafayette, Indiana, into a single, grade-separated, triple-tracked rail corridor. The project occurred in phases over a 29-year period (1974–2003). Rail operations along two urban streets were relocated to a route along the Wabash River, and a historic rail station was relocated and restored to improve Amtrak service. Overall, the project removed 42 at-grade crossings in the city, allowing for improved mobility of both automobiles and trains. The railroad company's participation in the project consisted mainly of transferring its right of way in the existing rail corridors in exchange for right of way and rail infrastructure that had been built by the project on city-owned lands along the new, consolidated, riverfront right of way. Realized benefits included:

- Increased traffic safety by removing 42 at-grade crossings in the city.
- Consolidated rail traffic through the city into a single corridor.
- Increased train operational speeds from 10–15 mph on the older, in-street corridors to 50 mph on the new, consolidated rail corridor.
- Constructed several new grade-separated highway bridges.
- Converted one former highway bridge into a bicycle-pedestrian bridge over Wabash River.

- Moved and restored historic rail station building to serve as multimodal terminal/event plaza.
- Opened downtown area for redevelopment (*20*).

Measures of Effectiveness

Effectiveness of rail infrastructure relocation projects is generally measured through a variety of benefit-cost analysis calculations. Operational improvements for rail and highway users are taken into account, as are economic development impacts; however, quality-of-life benefits are often hard to measure, and the changes in truck patterns resulting from relocation of freight yards are not always quantified. In order to be successful, the project must be undertaken in a manner that provides benefits to all stakeholders and involves a variety of funding sources.

Time Required (scale of 1 to 5, where 5 is most time)

5

Dollars Required (scale of 1 to 5, where 5 is most expensive)

5

Supplemental Information

- Jolanda Prozzi, Rydell Walthall, Megan Kenney, Jeff Warner, and Curtis Morgan. *Public Use of Rail Right-of-Way in Urban Areas*. Report PRC 14-12 F, Texas A&M Transportation Institute, College Station, Texas, December 2014. Available: http://tti.tamu.edu/documents/PRC-14-12-F.pdf.

9. Truck Platooning

Application of Truck Platooning in Texas

From 2010 to 2014, the population of Texas increased by 7.2 percent (*21*). Since freight is a demand-driven activity, the increment in population causes more freight movement (*22*) and, subsequently, accelerates fuel emissions, congestion, and accidents. Main connector corridors are expected to be severely congested, and statewide VMT of trucks will increase by 123 percent by 2035 (*23*). Three major areas—El Paso, Houston-Galveston-Brazoria, and Dallas–Fort Worth—are currently classified as nonattainment areas under the U.S. Clean Air Act (CAA) (*24*). Moreover, commercial motor-vehicle-involved crashes cause a significant number of fatalities and injuries (*25*). Adopting truck platooning technology is expected to mitigate these phenomena.

Issues Addressed

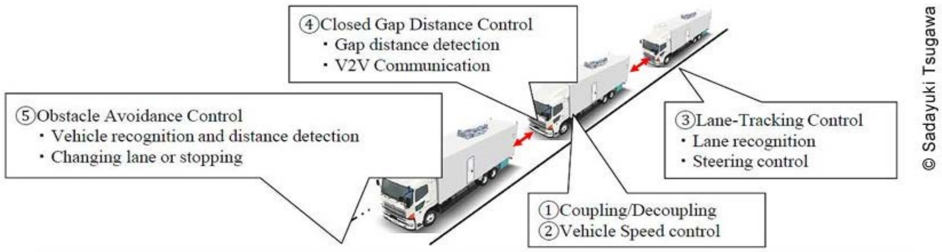
- Intercity or Long-Distance Freight Corridors.

Strategy/Technology Profile

As an extension of Cooperative Adaptive Cruise Control (CACC), truck platooning uses radar and vehicle-to-vehicle (V2V) communications to control vehicles laterally and longitudinally by maintaining constant gaps between the trucks (*26*). V2V and vehicle-to-infrastructure (V2I) in platooning can effectively prevent crashes, improve controlled mobility, and provide performance measures regarding environmental sustainability (*27*).

A V2V communication system is based on wireless communication and dedicated short-range communication (DSRC) devices. DSRC enables trucks to communicate with each other and to identify other road users and objects to avoid potential road hazards ahead (*28*). Related specifically to safety, six V2V applications were developed for a heavy truck platform:

- Intersection-movement assist.
- Forward-collision warning.
- Emergency electronic brake light.
- Blind-spot warning/lane-change warning.
- Bridge-height inform.
- Curve-speed warning (*29*).



		Ahead Vehicle	Following Vehicle
Coupling/decoupling		Semi-auto	Semi-auto
Gap distance within platoon			10m
Control	Lane-keeping	Machine vision	Machine vision
	Vehicle speed	ACC ・Laser ・Radar(76GHz)	CACC ・Laser ・Radar(76GHz) ・5.8GHz V2V Communication
	Gap distance		
	Obstacle avoidance	Emergency Braking	

Source: (29)

Figure A-8. Truck Platooning System.

Keys to Successful Implementation

Since the leading vehicle in a truck platoon is operated manually by a human, the driver’s capabilities and limitations should be considered (*30*). Additionally, platooning crucial stakeholders in the supply chain must maintain a positive view of truck platooning as a strategy. Unlike applications of new technologies and strategies in the industrial sector, the public sector must publicize this system on the road, and it needs to adjust or introduce new regulations and legislations regarding implementation (*26*). General guidelines for success include the following:

- The lead vehicle should be driven by a professional and well-trained driver, which is an important factor in ensuring safety during implementation of the technology (*31*).
- Either public funding must be secured or a financial incentive for developing and implementing platooning as a strategy should be in place.
- Regulations need to be established regarding the type of vehicle and driver’s license for the lead vehicle driver.
- Road infrastructure (e.g., roundabouts, bridges, and on/off ramps) should be redesigned to accommodate the system.

The following two figures demonstrate what truck platoons look like and how they would communicate.

Source: (32)

Figure A-11. Semi-autonomous Trains of Vehicles.

Source: (33)

Figure A-12. Basic Feature of Truck Platooning.

Challenges to Implementation

There are several implementation issues related to truck platooning. These include:

- The slow development of infrastructure to accommodate the strategy.
- Changing state laws and regulations.
- Interactions among a mixture of connected and non-connected vehicles on the road (*28*).

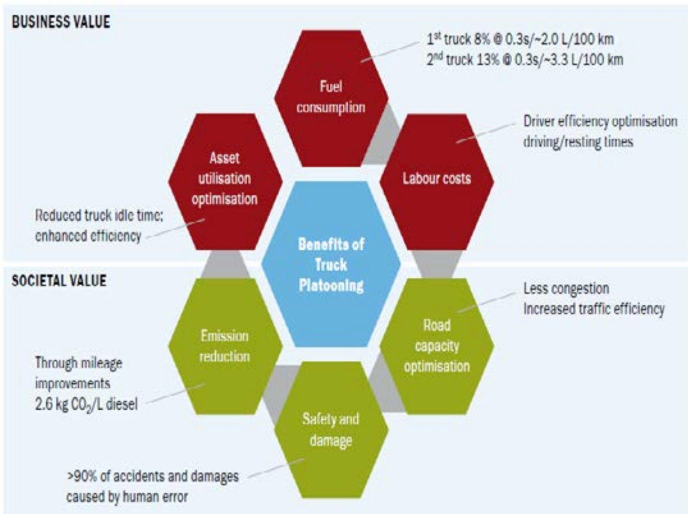
Germany's truck platooning project, KONVOI, had no plans for constructing new infrastructure, so the system design and operational concept were significantly constrained. Also, the minimum allowable following distance was below the legally required levels, so the regulations needed to be changed. The presence of non-connected vehicles on public highways—which forced the platooning vehicles to vary their speeds when drivers cut in and out—lowered the effectiveness of platooning, especially when regarding fuel consumption (*34*).

Success Story

Research has been done on truck platooning continuously since the mid-1990s. Europe has developed truck platooning projects like Chauffeur 1 and 2, KONVOI, SARTRE, and COMPANION. In the United States, California PATH and the Federal Highway Administration have pursued a project in collaboration. Recently, Peloton Technology tested a truck platooning system with CR England under the supervision of NACFE. This test was mainly focused on fuel efficiency by using the SAE test protocol with which CR England has extensive experience. For example, CR England has determined that—assuming a 36-foot following distance traveling at 64 mph—the leading truck can save 4.5 percent of its fuel consumption, while the following truck can save an average of 10 percent of its fuel (*35*).

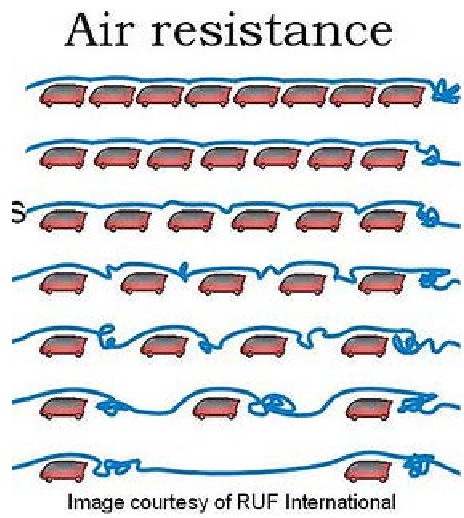
Measures of Effectiveness

Research shows that truck platooning is beneficial in terms of fuel savings (see Figure A-13). According to the SARTRE project, the leading vehicle and the following vehicle can save up to 8 percent and 16 percent fuel, respectively (*36*). Moreover, the Energy ITS project concluded that fuel consumption can be improved by 14 percent for a three-truck platoon (*37*). Peloton Technology also verified that energy can be saved 4.5 percent for the lead truck and 10 percent for the rear truck (*33*). These results are based on the reduction in aerodynamic drag on the trucks in the platoon, as demonstrated in Figure A-14. Additionally, by increasing road capacity, truck platooning can contribute to decreasing CO_2 emissions up to 4.8 percent with a 4-meter gap when the penetration of platooning of heavy trucks is 40 percent (*38*).



Source: (26)

Figure A-13. Benefits of Truck Platooning.



Source: (39)

Figure A-14. Aerodynamic Drag Reduction.

Time Required (scale of 1 to 5, where 5 is most time)

3

Dollars Required (scale of 1 to 5, where 5 is most expensive)

4

Supplemental Information

There are some issues that still need to be resolved. Communication systems that enable truck platooning rely heavily on wireless networking. A highly reliable and accurate transmission system is mandatory. In addition, one of the proposed benefits of truck platooning is that the strategy can mitigate traffic congestion. This claim, however, needs further research to validate it. In theory, congestion could actually be worsened due to manufacturers increasing the gap between trucks to avoid liability issues and the limitations of current V2I communication systems (*28*).

10. Adaptive and Advanced Signal Control Systems (AASCSs)

Texas Application of Strategy/Technology

AASCSs could help to alleviate bottlenecks due to traffic congestion, mainly during peak hours, and thereby improve the flow of commercial freight from/to a freight village (FV).

Issues Addressed

- Intercity or Long-Distance Freight Corridors.
- Urban Freight Delivery.

Adaptive and Advanced Signal Control Systems Strategy/Technology Profile

These systems coordinate the traffic flow on arterials across a metropolitan area by continually adjusting signal-timing parameters based on current volumes. Advanced signal control systems include centralized control of traffic signals and coordinated signal operations across neighboring jurisdictions.

Keys to Successful Implementation

The following are some elements that should be considered in order to achieve a successful implementation:

- Securing good local support from the provider, including software actualizations and training for the operators.
- Having sufficient staff to operate and provide maintenance to the AASCS network (usually, more engineers than technicians are needed).
- Preparing the infrastructure (e.g., detection and communication) to implement the system.
- Conducting a pilot project involving a large area.
- Coordinating the use of other intelligent transportation systems in conjunction with the AASCS in order to gain the most benefits.

Challenges to Implementation

The main challenge to these systems is operational costs. On average, the cost of installation is approximately $65,000 per intersection. Once installed, there are costs to operate and maintain both the hardware and software of the system, as well as the infrastructure, the maintenance for which may be more costly owing to the higher infrastructure needed.

Success Story

In 1989, Toronto embarked on a communications reconfiguration project (the COM Project) designed to reduce traffic control system communication costs by approximately 60 percent to 70 percent. The network-wide system reconfiguration involved approximately 1,850 signalized intersections connected to approximately 130 specially developed communication multiplexers designed to connect the main traffic signal system (MTSS) and AASCS with the central computers via high-speed circuits. The reconfigured communication system design pivoted on the application of central computers and software for the multiplexing/demultiplexing logic. This eliminated the requirement of costly, annual system-maintenance contracts (*40*).

Measures of Effectiveness

The Split Cycle Offset Optimization Technique (SCOOT) used in Toronto was an adaptive-signal control system that quickly updated signal timings to meet the needs of changing traffic volumes and patterns. Some of the results were:

- Traffic flow speeds increased 3 to 16 percent.
- Rear-end conflicts reduced 24 percent.
- Ramp queues reduced 14 percent.
- Vehicle delay reduced 6 to 26 percent.
- Vehicle stops reduced 10 to 31 percent.
- Intersection delays reduced 10 to 42 percent.

Following the successful demonstration project, Toronto was able to expand its system to 250 intersections. It was estimated that the cost of the investment was covered with system benefits in just two years (*40*).

Time Required (scale of 1 to 5, where 5 is most time)

3

Dollars Required (scale of 1 to 5, where 5 is most expensive)

5

11. Automated and Driverless Trucks

Texas Application of Strategy/Technology

In congested urban areas, trucks and delivery vehicles compete with passenger vehicles for road capacity. Automated and driverless trucks can potentially travel faster, closer together, and in unison, thereby using existing road capacity more efficiently and improving fuel mileage. Improved fuel efficiency will reduce emissions—the sector's carbon footprint—and will reduce vehicle operating costs. Since automated and driverless trucks use sensors and vehicle-to-vehicle (V2V) communication to detect approaching objects and weather conditions, it is also argued that automated vehicles are safer than vehicles operated by humans (*41*).

Issues Addressed

- Urban Freight Delivery.

Strategy/Technology Profile

The National Highway Traffic Safety Administration (NHTSA) defines automated vehicles as those with "at least some aspects of safety-critical control function occur without direct driver input" (*42*). NHTSA rates automated vehicles (AVs) by five levels (0 to 4). Level 3 has self-driving capabilities but requires a driver to take control during some modes of operation (e.g., in a construction zone in urban conditions). Level 4 AVs are completely self-driving and require no human (*42*). Using GPS and advance sensors, these vehicles can self-maneuver around obstacles to reach their destinations.

Source: (44)

Figure A-15. Driverless CyberCar Developed in Portugal.

Businesses (construction companies and Google) and governments (military) are testing various types of AVs. The U.S. Army and Lockheed Martin are testing automated vehicle convoys (*43*). These large trucks can easily negotiate static and mobile obstacles in congested urban settings. Similarly, CyberCars are fully automated vehicles that can be effectively employed in last-mile deliveries of small packages in city centers. They can also transport problem goods, such as containerized waste and cash, without a driver (*44*). Figure A-15 presents the CyberCar vehicle.

Keys to Successful Implementation

Various types of AVs (e.g., CyberCars, Google's driverless car) are currently in the experimental phase in the United States, Europe, and Japan. It is reported that these vehicles will be able to provide door-to-door freight delivery or garbage collection in the future (*45*). An important characteristic of these small AVs is that they operate on the existing road infrastructure and within urban environments.

DHL, a freight logistics company, foresees that the concept of automated urban delivery can evolve into the self-driving parcel. In this scenario, an automated truck would deliver parcel-size autonomous vehicles near their final destination. These self-driving parcels would then automatically travel to their final destination. Once the self-driving parcel reached its destination, the consumer would unload its content and send the self-driving parcel back to the delivery service company (*41*).

Challenges to Implementation

The key challenges that remain include the regulatory environment, public acceptance, and issues of liability. Currently, the regulatory environment in most countries does not allow for the operation of autonomous, self-driving vehicles. A number of countries—including the United States, the United Kingdom, and New Zealand—are currently reviewing their road-traffic regulations. Research in Germany and the United States has also found that most people have mixed feelings about self-driving vehicles. Although some people recognize the comfort that autonomous driving can provide, the majority of people still believe they make better decisions than a computer. Finally, it is unclear who will be liable if a self-driving vehicle is involved in a traffic accident—the person inside the vehicle, the vehicle owner, or the manufacturer. Thus, insurance terms may ultimately determine the rate of adoption of AVs.

Success Story

One of the first automated passenger movers (ParkShuttle) has been piloted in the Netherlands to provide a link between a metro station and a business park in Rotterdam. The ParkShuttle can carry six seated passengers and four standees. The ParkShuttle is driverless and automatically travels on a separated ground-level asphalt track (*46*). Figure A-16 provides a depiction of the ParkShuttle. A similar system could potentially evolve for making urban freight deliveries.

Source: (46)

Figure A-16. ParkShuttle in Rotterdam.

Measures of Effectiveness

The small size of existing AVs (e.g., cybercars) limits their loading capacity, but they may be more efficient and practical than larger trucks for smaller business-to-consumer and business-to-business deliveries within dense urban areas. It is believed that AVs can increase transportation safety, productivity (*44*), and mobility while reducing negative environmental impacts (emissions) and congestion. If AVs are powered by electricity, a country can further reduce its dependence on fossil fuels (*45*).

Time Required (scale of 1 to 5, where 5 is most time)

5

Dollars Required (scale of 1 to 5, where 5 is most expensive)

5

12. Commercial Motor Vehicle (CMV) Only Lanes

Texas Application of Strategy/Technology

The growing number in both automobiles and trucks traveling on U.S. highways has caused more traffic congestion and increased the likelihood of truck-auto related crashes. This growth in crashes is expected to continue in the foreseeable future. Separation of vehicles by way of CMV-only lanes is one solution to ever-increasing highway congestion and system reliability. CMV lanes are intended to provide for the more efficient movement of goods and improve safety. This approach can be used in areas where freight delivery has a significant impact on public safety and traffic congestion.

Issues Addressed

- Urban Freight Delivery.

Strategy/Technology Profile

The purpose of CMV facilities is to promote safer traffic flow, reduce congestion, and increase freight-hauling productivity. Shippers will have the option of traveling routes with more reliable trip times, especially during peak periods. This should improve the efficiency of travel on the road, especially in the movement of high-value, time-sensitive commodities. Improvements in truck productivity and operational efficiency may provide sufficient added value that truckers and shippers would be willing to pay to build and operate the highway lanes. Automobile road users will have a reduced interaction with trucks and less congestion.

Keys to Successful Implementation

There are several key factors for successful implementation of CMV lanes. These factors include:

- Reduce travel time and increase freight movement efficiency.
- Provide use for longer combination vehicles.
- Improve safety and reliability by separating automobiles and trucks.
- Free up general-purpose lanes by linking facilities like inland ports to primary port facilities with CMV lanes.
- Maintain some minimum level of usage for CMV lanes in order to avoid criticism about underutilization from those traveling in the general-purpose lanes.

Challenges to Implementation

The challenges to implementing CMV lanes include:

- The high level of investment required (perhaps the biggest challenge).
- Funding mechanisms for multistate collaboration.
- The need to ensure that benefit-cost for CMV lanes has a greater utilization rate than alternative HOV/HOT lanes at limited time periods.
- The lack of public support if new bonds are to be paid with public tax revenues.
- The need to determine the corridors or segments with sufficient truck demand.
- Right-of-way acquisitions.
- The fact that removing existing lanes to create CMV lanes will reduce public support.
- Underutilization.

Success Story

One of the most successful applications of dedicated truck lanes is the New Jersey Turnpike, a limited-access facility that has successfully improved operations by separating types of vehicle traffic. A 32-mile segment of the roadway has been expanded into two separate roadways, resulting in a dual-dual facility. Large trucks are limited to the outer roadway, but passenger vehicles may travel on either the inner or the outer roadway. Each of these facilities provides very limited access, and the available access is through independent ramps for the inner and outer roadways. Using gates, operators can limit access to a particular roadway as needed to manage demand or in the event of an incident. The result is a roadway that operates efficiently because turbulence in the traffic flow is minimized. Studies in Atlanta and other cities also examined CMV-only lanes, finding that the high costs of a separate facility for trucks only were a high barrier to entry (*47*).

Measures of Effectiveness

There are several key measures of effectiveness of CMV lanes. These factors include:

- Operational efficiency.
- Improved freight productivity.
- Reduced environmental impacts.
- Travel time reliability changes for the corridor as a whole, and in the CMV lane.
- Reduced number of incidents caused by truck breakdowns or tire/load debris in road.

Time Required (scale of 1 to 5, where 5 is most time)

4

Dollars Required (scale of 1 to 5, where 5 is most expensive)

4

Supplemental Information

It is difficult to assess funding needs until it is determined whether new lanes are needed, existing lanes must be improved, or existing roadways can be used as is. Differences in capacity assumptions between the truck-only lane and mixed-flow lane or HOV/HOT alternatives and the omission of the mixed-flow or HOV/HOT alternatives in the performance evaluation in some of the reviewed studies result in the findings being inconclusive or inadequate in assessing the relative performance benefits of truck-only lanes against mixed-flow or HOV/HOT alternative lanes with similar capacity.

13. Compressed Natural Gas and Liquefied Natural Gas

Texas Application of Strategy/Technology

Urban freight delivery vehicles contribute to congestion, pollution, noise, safety concerns, and the general degradation of the quality of life in urban areas. Compressed natural gas (CNG) and liquefied natural gas (LNG) trucks are seen as a more environmentally benign mode for urban freight deliveries.

Issues Addressed

- Urban Freight Delivery.

Strategy/Technology Profile

Natural gas is a colorless, odorless, and flammable gas extracted during crude oil production. Two types of natural gas can be used in vehicles:

- **Compressed Natural Gas**—Natural gas under high pressure to increase its energy density.
- **Liquefied Natural Gas**—Natural gas cooled to low temperatures to form a liquid with a higher energy density. LNG is typically used in medium- and heavy-duty freight vehicles (*48*).

Types of natural gas vehicles for medium- and heavy-duty freight transportation are:

- **Dedicated Vehicles**—Run exclusively on natural gas, work well with set routes and a centralized fueling station, and acceptable for hospitality, parcel service, and food and beverage delivery.
- **Bi-fuel Vehicles**—Can switch between natural gas and diesel, which reduces concerns about locating natural gas refueling stations.
- **Dual Fuel**—Runs on natural gas but uses diesel for ignition, can run solely on diesel if needed, and is suitable for fleets that need range and fuel flexibility. Traditional diesel-fuel vehicles can be converted to dual-fuel vehicles.
- **Mixed Fuel**—Blend of CNG with diesel or other fuels. Can run on 90 percent CNG while still having the operational benefits of diesel.

Keys to Successful Implementation

- Develop the refueling infrastructure necessary to allow wide-spread utilization of the technology.
- The price of the fuel needs to remain cheaper than diesel fuel, as it is at the current time.

- LNG should be taxed at a rate equivalent to the tax on diesel, but the tax should be based on energy produced, not volume. (A gallon of LNG produces 58 percent of the energy of a gallon of diesel, so taxing both based on volume will make LNG more expensive) (*49*).
- To encourage the purchase of alternative fuel trucks, the 12 percent Federal Excise Tax should not be applied or could be reduced when alternative fuel trucks are purchased.

Challenges to Implementation

Natural gas is cheaper than diesel, but there are few refueling stations. LNG is produced and stored at very low temperatures and requires the use of protective gear during handling. Also, it can be difficult to locate leaks when LNG does not contain an odorant.

Refueling infrastructure is more limited for LNG than CNG (*48*). In Texas in 2014, there were 70 public and 36 private CNG stations, and 13 public and two private LNG stations (*50*). Not all of the public-fueling stations are equipped and designed for large trucks and heavy-duty vehicles, and some CNG stations lack the compression to fill the vehicles in a timely manner (*48*). According to Westport Innovations Inc., fuel availability is the greatest deterrent to building natural gas fleets (*51*). Natural gas delivery vehicles are more expensive than similar diesel heavy-duty vehicles, not only because it is a new technology that has not generated considerable demand but also because of the complexity of the components and fuel storage systems (*48*). Large natural gas fuel tanks cost around $30,000 each (*51*).

Success Story

In 2011, United Parcel Service (UPS) added 48 new LNG trucks to its long-haul fleet (*52*). UPS plans include the addition of 700 LNG tractors and LNG fueling stations in Dallas (*53*). Currently, UPS has LNG fueling stations in Las Vegas, Phoenix, and Ontario, California, and will also add them in Memphis and Nashville. UPS has approximately 16,000 LNG tractors in its small-package and freight fleet. UPS also has about 1,000 CNG package-delivery vehicles (*53*). Figure A-17 shows refueling of each type of configuration.

In 2012, Walmart was one of the first companies to receive the Cummins Westport ISX 12G 400-hp engine and currently operates it on CNG in Fontana, California (*54*).

Source: (53).

Figure A-17. Refueling—Left: CNG truck; Right: LNG truck

Measures of Effectiveness

The Westport 15L produces 21 to 27 percent less greenhouse gas emissions than a regular diesel engine but performs just as well (*51*). Since natural gas is cheaper than diesel, Westport estimates that if vehicles travel 125,000 miles a year, costs can be recovered in about two years, if the price difference between diesel and natural gas stays the same. Natural gas burns cleaner than gasoline or diesel, resulting in emissions benefits (*49*).

Time Required (scale of 1 to 5, where 5 is most time)

3

Dollars Required (scale of 1 to 5, where 5 is most expensive)

4

14. Electric Delivery Trucks and Dual-Mode, Hybrid Diesel/Electric Trucks

Texas Application of Strategy/Technology

Diesel-powered urban freight vehicles in high-traffic freight corridors greatly contribute to pollution by releasing both greenhouse gas emissions and particulate matter. Particulate matter is harmful to human health and is linked to asthma, heart disease, respiratory diseases, and premature death (*44*). Conventional diesel trucks are noisy, subject the driver to vibrations, and smell of diesel. Changing propulsion to onboard or overhead catenary-provided electric or hybrid-electric trucks in high freight density corridors—such as those between ports and urban rail/truck yards—has the potential to reduce fuel use and address many of the pollution issues associated with conventional trucks.

Issues Addressed

- Urban Freight Delivery.
- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

Onboard, Electric-Powered Trucks

AMP Electric Vehicles, based in Cincinnati, builds delivery trucks with several different power trains including gas, propane, compressed natural gas (CNG), and all electric. Its 200-kilowatt electric motor uses a 60-kilowatt-hour lithium-ion battery pack to power its specially designed vehicle called Workhorse. United Parcel Service purchased 18 all-electric trucks for use in Houston in February 2015 (*55*). The U.S. Postal Service is considering using AMP vehicles to replace its fleet (*56*). In 2016, makers of large trucks will be subject to corporate average fuel economy emissions regulations similar to those on passenger vehicles, which could lead to an increased interest in electric and other fuel-efficient trucks (*55*).

Dual-Mode Hybrid-Electric/Diesel Trucks

Siemens has developed an eHighway system that delivers electricity to electric-powered or electric-hybrid trucks. Similar to a streetcar, energy is transferred from overhead lines to the motor of the truck, but the truck is not fixed to the overhead lines and can automatically connect or disconnect from the system. The trucks are in electric mode when on the eHighway system, and they switch to diesel or mechanical drive when no overhead catenary exists. In comparison to a diesel engine, an electric-traction motor is twice as mechanically efficient, and half as much energy is needed to move the same load (*57*). Electric vehicles can also use regenerative braking.

Keys to Successful Implementation

AMP's Workhorse truck is intended for predictable daily use and has a range of about 60 miles, but a range extender can extend the battery life (*55*). As a result, range limitations may restrict the use of this truck if distribution centers are not centrally located. This type of truck has generally the same volume of a conventional gas/diesel-powered delivery truck and would work best on traditional U.S. streets. Some electric delivery trucks in Europe have been designed in smaller configurations in order to take up less space in urban areas while parked/making deliveries. Fully electric vehicles may also reduce noise, pollution, and other detrimental features of conventional truck operations within the urban core.

Hybrid/dual-mode electric trucks such as the eHighway system may selectively take advantage of using external electric power provided by overhead catenary wires (similar to some trolley/passenger rail services) and then retracting their connections and proceeding on diesel power to a destination outside the electrified corridor. Costs to implement such a corridor (e.g., right of way, construction, electrical infrastructure and power, and maintenance of electrical infrastructure) must be fully budgeted and accounted for in planning. Creation of such a corridor can serve to consolidate routes of dual-mode trucks able to use the external electric power into a recognized, freight-centered corridor.

Challenges to Implementation

Electric trucks of both types are still in early testing; however, they generally share many of the same challenges. Costs of transitioning from current fleets of conventional trucks to electric trucks tend to be high, but government regulations demanding higher fuel efficiency and pollutant reduction may make this change more compulsory. The current reduced range of electric trucks is a limiting factor that would have to be accounted for, while ROW availability for specialized, electric overhead, catenary-equipped, truck-only lanes will limit potential trip miles using electric power for hybrid trucks until a more robust infrastructure is completed. Catenary systems may also be difficult to implement in long stretches due to:

- High infrastructure cost (capital and maintenance).
- Height restrictions and/or limited ability to operate other tall vehicles/equipment underneath catenary wires in the port environment.
- Opposition to the visual blight that would accompany large-scale implementation of catenary supports/power wires within an urban area.

Success Story

The South Coast Air Quality Management District will lead the first demonstration of the eHighway system at the ports of Long Beach and Los Angeles in July 2015. During a year-long demonstration, 1 mile of a well-traveled corridor will be installed with the system, with up to four trucks running at a time. Contact-line systems have been successfully used for more than 100 years, and it is likely that applying trucks to the system will be equally successful. Investment and maintenance costs could be reasonable because a system could be installed on existing roads without much traffic disruption, and the cost of installing gantries and sub-station connections is predicted to be $8–9.6 million per mile (*57*). The two-way 1-mile system in Los Angeles is estimated to cost $13.5 million (*58*).

Measures of Effectiveness

According to AMP Electric Vehicles, its electric trucks cost $0.30 per mile to run, whereas a conventional truck costs $1 per mile in gas and maintenance (*56*). Operators will potentially save on fleet maintenance if they use electric trucks because the electric trucks do not have conventional transmissions, which are a source of regular maintenance for vehicles that spend the majority of time in stop-and-go traffic (*55*). The Ports of Los Angeles/Long Beach pilot test of the eHighway system in 2015 should provide some measures of the effectiveness of this technology.

Time Required (scale of 1 to 5, where 5 is most time)

4

Dollars Required (scale of 1 to 5, where 5 is most expensive)

4

Supplemental Information

The following figures demonstrate these technologies.

Source: (58)

Figure A-18. Side-by-Side Picture of Dual-Mode Truck in Electric and Diesel Modes.

Source: (57)

Figure A-19. Siemens' eHighway System.

15. Electric Truck Designs

Texas Application of Strategy/Technology

Urban freight delivery vehicles contribute to congestion, pollution, noise, safety concerns, and the general degradation of the quality of life in urban areas. Urban trucks fueled by diesel operate in congested traffic and typically make frequent stops, which increases fuel consumption and emissions (e.g., particulate matter). Particulate matter is harmful to human health and is linked to asthma, heart disease, respiratory diseases, and premature death (*44*). Electric or hybrid-electric trucks are seen as a more environmentally benign mode for urban freight deliveries.

Issues Addressed

- Urban Freight Delivery.

Strategy/Technology Profile

Electric trucks use an electric motor for propulsion and have a battery to store energy. Electric trucks can be classified as:

- **Hydraulic Hybrid-Electric Vehicles**—Powered by an internal-combustion engine that provides electricity for the electric motor. Regenerative braking systems charge the electric battery during braking and operate a hydraulic pump that provides extra torque during acceleration; while the engine is idling, power is typically switched to the electric components to conserve fuel.
- **Plug-In Battery Electric Vehicles (aka All-Electric Vehicles)**—Powered by electricity stored in rechargeable battery packs.
- **Plug-In Hybrid-Electric Vehicles**—Powered by both an electric motor and an internal-combustion engine. A battery provides energy for the electric motor. The battery is charged by an external electricity source (usually at the depot or truck yard) (*48*).

Keys to Successful Implementation

A number of companies (e.g., Frito-Lay, FedEx, Coke, and PepsiCo) have piloted electric delivery-truck fleets in urban markets in the United States. United Parcel Service (UPS) purchased 18 all-electric trucks from AMP Trucks in Ohio for use in Houston in February 2015 (*55*). The UPS pilot project aims to demonstrate that the all-electric vehicles are comparable in performance to the similar-sized diesel delivery vehicles, but with lower emissions and fuel consumption (*59*). AMP's specially designed vehicle—called the Workhorse—uses a lithium-ion battery pack to power the vehicle. The Workhorse is intended for predictable daily use and has a range of about 60 miles, though an extender can be used to extend the range (*55*). The AMP Workhorse is shown in Figure A-20.

Source: (55)

Figure A-20. AMP Workhorse Electric Delivery Truck.

Challenges to Implementation

Electric-vehicle penetration into the marketplace is still largely limited by vehicle cost and, more specifically, battery costs. Although battery costs are declining, the International Energy Agency predicts that electric vehicles will not be able to compete cost-wise with traditional internal-combustion engine vehicles until 2020 (*48*).

The availability of charging infrastructure—specifically the availability of retail charging options—also affects the adoption of electric vehicles. More prevalent retail charging stations could increase the adoption of electric delivery trucks because they would extend the range of these vehicles. As of June 30, 2014, according to the U.S. Department of Energy's Alternative Fuels Data Center, Texas has 1,841 (369 private and 1,472 public) electric charging stations. Texas ranks second behind California in terms of the total number of EV charging stations (*48*).

Success Story

PepsiCo's Frito-Lay North America division operates the largest commercial fleet of all-electric trucks, with 269 all-electric trucks operational in the United States (*60*). Frito-Lay's largest deployment of all-electric trucks (more than 100) is in California. Grant funding from the Mobile Source Air Pollution Reduction Review Committee in the South Coast Air Quality Management District—the California Energy Commission—and the Hybrid Truck Bus Voucher Incentive Project from the California Air Resources Board (administered by CalStart) facilitated the deployment of Frito-Lay's all-electric trucks in California (*61*). Charging of the electric truck is presented in Figure A-21.

The benefits of all-electric trucks include lower fuel consumption, noise pollution, and CO_2 emissions. Frito-Lay reported that the deployment of 269 electric trucks will eliminate an estimated 600,000 gallons of fuel annually. In addition, the all-electric delivery trucks:

- Can run up to 80 miles on a single charge.
- Have zero tailpipe emissions.
- Emit 75 percent less greenhouse gases than diesel.
- Operate virtually silently, reducing noise pollution.
- Provide a long-term economically viable solution to traditional fuel sources (*60*).

Source: (62)

Figure A-21. All Electric Frito-Lay Delivery Truck.

Measures of Effectiveness

Electric vehicles tend to be best suited for urban fixed-route, return-to-base delivery applications. Hybrid-electric delivery vehicles are more fuel efficient than internal-combustion engines, thereby resulting in fuel cost savings. Hybrid-electric vehicles are also quieter, emit fewer tailpipe emissions, and tend to have lower maintenance costs because of their relatively smaller engine (*48*).

Battery electric vehicles tend to have an average range of 80 to 100 miles per charge, while the all-electric range of plug-in hybrid-electric vehicles tend to be lower (i.e., 10 to 50 miles) depending on vehicle type, weight, and driving patterns. Battery and plug-in hybrid-electric vehicles are more efficient and have lower emissions than hybrid-electric vehicles but require a higher initial investment (*48*). According to AMP Electric Vehicles, its all-electric trucks cost $0.30 per mile to operate, whereas a conventional truck costs $1 per mile in gas and maintenance (*56*). Maintenance costs are also reduced because electric trucks do not have transmissions, a major source of regular maintenance costs for vehicles that operate in stop-and-go traffic (*55*).

Time Required (scale of 1 to 5, where 5 is most time)

2

Dollars Required (scale of 1 to 5, where 5 is most expensive)

4

16. Ethanol Fuel Delivery Vehicles

Texas Application of Strategy/Technology

Urban freight-delivery vehicles contribute to congestion, pollution, noise, safety concerns, and the general degradation of the quality of life in urban areas. Urban trucks fueled by diesel operate in congested traffic and typically make frequent stops, which increases fuel consumption and emissions (e.g., particulate matter). Particulate matter is harmful to human health and is linked to asthma, heart disease, respiratory diseases, and premature death (*44*).

Issues Addressed

- Intercity or Long-Distance Freight Corridors.
- Urban Freight Delivery.

Strategy/Technology Profile

Ethanol is an alcohol fuel made from organic waste, such as corn, sugar cane, rice, sugar beets, and yard clippings (*48*). In the United States, ethanol is commonly produced from Midwestern corn. E10 is gasoline containing 10 percent ethanol and has become the standard motor fuel. E85 is fuel that is more than 51 percent ethanol by volume. Diesel ethanol/e-diesel contains 10–15 percent ethanol and can be used in heavy-duty vehicles, particularly if a fleet is centrally fueled (*48*).

Keys to Successful Implementation

- Refueling infrastructure.
- Cheaper price for fuel, compared to diesel.

Due to Congressional mandates requiring the blending of renewable fuels such as ethanol—and the fact that most vehicles and refueling infrastructure cannot handle much ethanol—ethanol production has exceeded consumption since 2010. Requiring renewable fuel use was intended to help the environment, decrease costs, and improve fuel security, but some believe it led to an increase in gasoline prices. E-diesel has a lower flash point than regular diesel; therefore, it is more flammable. The higher flammability can be addressed through vapor recovery systems and fuel-tank design (*48*).

Challenges to Implementation

There are currently 131 public and 12 private ethanol (E85) fueling stations in Texas (*50*). Most U.S. refueling stations are in Midwest corn-producing states (*48*). E-diesel has several attributes that are not advantageous:

- It does not lubricate fuel-injection components as well as regular diesel.
- It can reduce engine performance.
- It is difficult to achieve a stable blend of diesel and ethanol (*48*).

E-diesel is not widely used in commercial vehicle fleets. The cost of producing ethanol is higher than the cost of producing petroleum-based fuels (*63*). The organic source for ethanol is an ongoing issue. To create enough ethanol so that it is competitive with petroleum, a tremendous amount of organic biomass is needed. Farms already use such waste to feed animals, condition soil, and burn for fuel, and some organic waste is used in making buildings and paper; therefore, it might not be feasible or economical to produce ethanol on the large scale needed to fully impact freight transportation needs (*64*).

Success Story

In 2011, UPS introduced 45 ethanol-powered delivery vehicles to Brazil, and currently there are 50 in that country (*53*). In the 1990s, Archer Daniels Midland piloted four trucks running on 95 percent ethanol and 5 percent gasoline (see Figure A-22). A small amount of lubricant, Lubrizol, was added to the ethanol to make it as lubricating as conventional diesel. The project was funded by the U.S. Department of Energy and managed by the Illinois Department of Commerce and Community Affairs. The average fuel economy of the trucks was 8 percent less than a diesel truck, which may be due to how the engines were reformatted to run on ethanol (*65*). The trucks in the program had filters, oil, and oil filters that were different from those used on diesel trucks, and with few ethanol trucks on the market, those items could be more expensive than the same items required for diesel trucks. The Archer Daniels Midland trucks encountered some technical difficulties, but they were able to show that a fuel that is 95 percent ethanol can power larger trucks.

Source: (65)

Figure A-22. Archer Daniels Midland Ethanol-Powered Truck.

Measures of Effectiveness

Ethanol has a lower energy content than gasoline, but it has a higher octane rating, so it can increase engine efficiency and performance (*63*). In the Archer Daniels Midland pilot project, the ethanol-powered trucks had lower particulate matter and NO_x but higher hydrocarbon and carbon monoxide emissions than a diesel truck (*65*).

Time Required (scale of 1 to 5, where 5 is most time)

3

Dollars Required (scale of 1 to 5, where 5 is most expensive)

4

17. Fully Automated Vehicles (FAV): European Experience

Texas Application of Strategy/Technology

Control-assistance systems can partially relieve the driver of some of the tasks of driving, while fully automated systems can change the driver's role more significantly, turning it into more of a supervisory or customer-service assignment than manual labor (thereby reducing accidents and congestion and saving fuel costs). Also, automated long-distance freight transport can drastically increase the capacity of the highway network. Several urban areas and major freight generators in Texas could benefit.

Issues Addressed

- Urban Freight Delivery.
- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

Autonomous vehicles (AVs) are classified into three different levels: low autonomy, medium autonomy, and high autonomy.

- **Low autonomy**—Vehicles that operate in dedicated environments equipped with sensors and beacons to ensure functionality. These vehicles drive on determined routes and are not able to make any kind of intelligent decisions.
- **Medium autonomy**—Vehicles that also drive in adjusted areas but have an intelligent system on board that allows them to change their routes (e.g., in the event the road is blocked).
- **High autonomy**—Vehicles that are able to drive entirely independently in any kind of traffic situation.

Keys to Successful Implementation

In order to get the most the benefit from this technology, the following action framework should be considered:

- **Legal framework for the use of AVs**—This consideration is essential to make AVs legal participants in traffic and to cover the question of liability in case of casualties or damage.
- **Data security**—Autonomous transport combined with smart mobility will create another sector with associated personal data. Misuse and data theft must be prevented.
- **Solutions for changes in affected occupational areas**—Automation of transport will lead to a society built on services rather than labor. People that lose their jobs in the process—an effect of automation whose consequences for society and the economy must not be underestimated—must be reinstated in similar or related roles or compensated accordingly.

Challenges to Implementation

Currently, the limitations of this technology are more economic than technical. Thus, it is necessary to work together with all stakeholders and create synergies with users and manufacturers to find more economical and efficient ways to implement this technology in the daily operations.

Success Story

The goal of the Flying Carpet project in the Netherlands is to facilitate the implementation of AVs between Groningen's city center and Groningen airport. The so-called Flying Carpet will be an AV that transports passengers from their car to the departure and arrival areas. The study has come to the conclusion that the Flying Carpet is legally feasible if safety is guaranteed. Measures to help guarantee safety include operation in private areas, at a speed limit of 5 km/h, within an area having safety sensors, camera systems, dedicated lanes, and certified traffic control systems. It is economical so far only as a test lab, where supporting the development of technical/legal knowledge and marketing outweighs the financial criticism. The technical feasibility has proven to be the least important obstacle since existing technology can be implemented.

Measures of Effectiveness

AVs have the potential to reduce the number of road accidents considerably, thereby also reducing the high economic and social costs associated with them. An intelligent, integrated transport system could bring people quickly from one point to another and allow for more public space, reduce pollution, and even provide more effective routes to save fuel. Such a system could also enhance line-haul capacity resulting from automatic longitudinal control, reduce lane width due to the automatic lateral steering control, and reduce driving stress and fatigue.

Time Required (scale of 1 to 5, where 5 is most time)

5

Dollars Required (scale of 1 to 5, where 5 is most expensive)

5

Supplemental Information

CityMobil2 is a European Union project with 45 partners, including 12 different European cities and coordinated by the University of Rome, working on fully automated urban-road mobility. The goal is to create a common legal framework that covers autonomous transport, the implementation of real autonomous systems in cities, and the socio-economic effects that come with vehicle automation. The project has developed fully automated vehicles to be tested in public.

18. Geographically Focused Incentives for Off-Hours Delivery

Texas Application of Strategy/Technology

Geographically focused incentives for off-hours delivery can be used in urban areas where freight delivery has a significant impact on public safety and traffic congestion. Historically, congestion has been tackled mostly from the supply perspective by enhancing infrastructure or operations. However, as has been widely documented, in the long term, the supply-side approach increases demand for transportation that brings the situation to the same place where it started. An alternative is to influence users' behavior to bring demand to the level that infrastructure can optimally accommodate.

Issues Addressed

- Urban Freight Delivery.

Strategy/Technology Profile

Incentives are offered to urban receivers of freight based on their geographic location. These may be either one-time incentives or ongoing programs. Such incentives might include targeted one-time incentives (e.g., tax considerations), carrier discounts, business support (e.g., tax preparation services for small businesses), and public recognition. Government might also assist businesses with setting up technologies/systems that enable off-hours delivery without the need for staff of the receiving business to be present.

Keys to Successful Implementation

Policy initiatives that target the receivers (i.e., actual decision makers) are more effective than policies that focus on the carriers that play a secondary role. Geographically focused incentives are more effective than incentives that target the entire urban area.

Challenges to Implementation

The biggest challenge may be to convince receivers of the benefits of off-hours delivery. While the benefits to the public are clear, the benefits to businesses are not so easy to see. The second major challenge will be to determine the type and amount of incentives to offer.

Success Story

The benefits of off-hours delivery have been proven in selected test cases, most notably in Manhattan. Participants expressed a high level of satisfaction with the pilot, with some businesses continuing their new off-hours delivery practices even after the pilot incentives expired. However, the role that incentives might play has not been put to the test.

Measures of Effectiveness

Suggested metrics to assess the effectiveness of this strategy:

- Percentage of trucks switching to off-hours delivery.
- Percentage of deliveries switching to off-hours delivery.
- Budget required to provide incentives to the receivers.

Time Required (scale of 1 to 5, where 5 is most time)

2

Dollars Required (scale of 1 to 5, where 5 is most expensive)

3

19. Hazardous Material Vehicle Location Status/Shipment Tracking

Texas Application of Strategy/Technology

With respect to HazMat transport, TxDOT's historical role has been primarily to review local requests for designating hazardous material highway routes and developing transport systems that facilitate freight movements, including HazMat. With these roles in mind, technologies that facilitate availability of information about the roadways used for HazMat shipments—and the corresponding origins and destinations of these shipments—will have the most direct relevance for TxDOT. Technologies that track vehicle location status may support this information, if made available to TxDOT.

Issues Addressed

- Intercity Corridor.
- Urban Freight Delivery.

Strategy/Technology Profile

Two types of technologies may be useful for providing vehicle location information:

- Networked RFID/GPS/GLS systems.
- Intelligent video tracking and surveillance systems.

Radio Frequency Identification (RFID) is not a new technology, but its applications for tracking HazMat shipments and integration with global positioning systems (GPSs) and global locating systems (GLSs) are recent and developing innovations. Different commercial packages use RFID and fixed-location detectors to relay data about vehicles and cargo to information hubs. The identification of shipment contents, status of shipment integrity, and corresponding locations can thus be tracked remotely when vehicles equipped with RFID pass through location detectors. GPS technology enhances the ability to track vehicle locations in real time. Depending on the vendor and technology application, timelines for technology development and implementation range from currently available and deployed to near term (within five years).

Similarly, the technologies underlying intelligent video tracking and surveillance have been available for some time, but their application to tracking HazMat shipments is more recent. The primary application of these systems has been for remote identification and tracking of individuals, but it can also be used for vehicle identifiers (e.g., truck ID numbers, license plates, etc.). Thus, the systems are similar to license plate readers (LPRs). Timelines for technology development and implementation are currently available, with continuing improvements over the near term.

Keys to Successful Implementation

Technology systems must be robust to withstand harsh, real-world operating environments and environmental conditions, as well as meet cost thresholds and provide sufficient payback/return on investments. Systems must also integrate with third-party platforms. An industry source cites a policy of not employing owner-operators or subcontractors as a key factor for implementing satellite-based communications and tracking systems (*66*). For TxDOT, keys to successful implementation will require obtaining access to HazMat transport information from private carriers and incorporating this information into TxDOT's planning and operations.

Challenges to Implementation

Challenges for implementation include improving user friendliness and using input from end-users to enhance functionality, as well as withstanding real-world conditions as noted above. Development costs for new technologies can be substantial, and future developments may require regulatory requirements as key drivers for encouraging innovation and implementation. Recent systems rely on battery power and require battery monitoring and replacement. For TxDOT, challenges for implementation will be obtaining access to HazMat transport information from private carriers and incorporating this information into TxDOT's planning and operations.

Success Story

Multiple systems are currently available from vendors and already implemented by HazMat carriers. The USDOT Pipeline and Hazardous Materials Safety Administration (PHMSA) is also currently testing e-systems through the Paperless Hazard Communications Pilot Program.

Measures of Effectiveness

One vendor lists performance measures for an integrated RFID/GPS/GIS system developed for tracking HazMat shipments, including vehicle tracking and the ability to provide each vehicle's information with its contents in real time; tag read rate; tag read distance; frequency; interferences (e.g., from metal, liquids); security; ability to produce actionable data to enforcement and governing authorities; and ease of use (*67*).

A Transportation Research Board report identifies factors determining the state of readiness for implementing electronic shipping paper systems as follows: stakeholder buy-in; data entry requirements; information flow parameters/limits; support of multimodal shipments; degree of in-transit visibility; adequacy of standards; interoperability with other electronic commerce systems; and data/communications security (*68*).

Supplemental Information

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20. Hydrogen Fuel Cell

Texas Application of Strategy/Technology

Urban freight-delivery vehicles contribute to congestion, pollution, noise, safety concerns, and the general degradation of the quality of life in urban areas. Urban trucks fueled by diesel operate in congested traffic and typically make frequent stops, which increases fuel consumption and emissions (e.g., particulate matter). Particulate matter is harmful to human health and is linked to asthma, heart disease, respiratory diseases, and premature death (*44*). Like electric vehicles, hydrogen fuel-cell vehicles are quiet and hardly vibrate when in operation.

Issues Addressed

- Intercity or Long-Distance Freight Corridors.
- Urban Freight Delivery.

Strategy/Technology Profile

Hydrogen fuel-cell vehicles are powered by the conversion of chemical energy into electrical energy, rather than the conversion of chemical energy into mechanical energy. Individual fuel cells are assembled into a fuel stack, and the vehicle has many of the components of electric vehicles but without battery storage. Most hydrogen for transportation use comes from fossil fuels through a process called fuel reforming (*48*). This means that processing of fossil fuels is still required to produce hydrogen for fuel cells.

Keys to Successful Implementation

- Refueling infrastructure.
- Cheaper price for fuel, compared to diesel.

California has 10 public and eight private hydrogen fueling stations (*69*), and 200 fuel-cell cars, buses, and heavy-duty trucks are on the roads (*48*). American Recovery and Reinvestment Act funding was used to support innovations in the fuel-cell industry and pilot projects involving freight (*70*). In 2015, FedEx added 15 hydrogen fuel-cell-powered cargo tractors at the FedEx World Hub in Memphis. The tractors are fueled on site using a 15,000-gallon liquid hydrogen fueling infrastructure. FedEx also uses fuel cells in 35 electric forklifts at a freight facility in Springfield, Missouri (*70*).

Challenges to Implementation

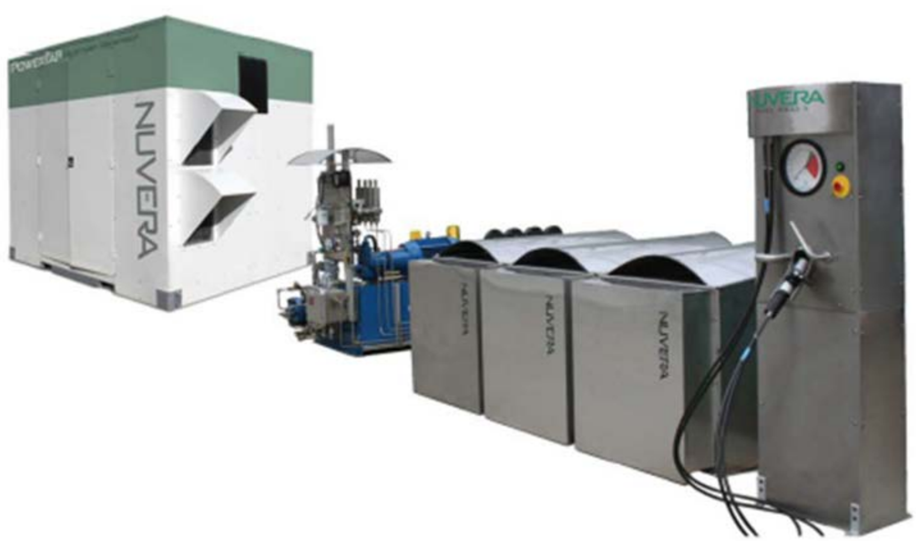
There are currently no public and only one private hydrogen fueling stations in Texas (*50*). Since the technology is quite new, fuel-cell vehicles are more expensive than traditional vehicles, and the infrastructure for producing and distributing hydrogen for vehicles is not well developed. Furthermore, hydrogen is costly to produce. More fueling stations and a hydrogen-distribution network are necessary to make hydrogen fuel-cell vehicles viable. Components of fuel-cell vehicles are sensitive to extreme temperatures, can degrade under high heat, and require some humidity to perform well. Fuel-cell vehicles can travel 300 miles on one tank of fuel, but it is difficult to store more hydrogen without occupying a lot of space. Fuel-cell stacks can last from 29,000 to 75,000 miles, but conventional car batteries can last up to 150,000 miles (*48*).

Success Story

Fuel cells are used as range extenders in the medium- and heavy-duty vehicle sector. PlugPower is developing fuel-cell technology to extend the range of U.S. Postal Service, UPS, and FedEx delivery trucks, which will help double the range of the trucks (*48*). PlugPower has provided fuel-cell-range extenders for 20 FedEx electric delivery trucks (*71*).

PlugPower uses fuel-cell components in refrigerated trucks that can keep items cold when the engine is turned off, which reduces emissions and the consumption of oil (*72*). The fuel cells can be used in place of a diesel generator, but the trucks will still run on diesel. The trucks use transport refrigeration units (TRUs). The vehicles are much quieter than conventional trucks, so deliveries can theoretically be made at any time of day. This technology is being developed for Sysco in Long Island, New York, with funding from the U.S. Department of Energy and the New York State Energy Research and Development Authority (*72*). Diesel engines for cooling cost $20,000–$30,000, and manufacturers are hopeful that a fuel-cell cooling unit could cost $40,000 (*73*).

Fuel-cell-powered TRUs were implemented at the HEB food distribution center in San Antonio, which also uses fuel-cell-powered forklifts. Hydrogen for fueling the vehicles is generated onsite from natural gas and water using Nuvera's PowerTap™ hydrogen generator and refueling system , as shown in Figure A-23 (*74*).



Source: (74)

Figure A-23. Nuvera PowerTap Hydrogen Generator (Left) and Hydrogen Station (Right).

Measures of Effectiveness

Fuel-cell vehicles can be 40 to 70 percent energy efficient, and those that operate only on hydrogen have hardly any emissions (*48*). Hydrogen contains three times more energy per unit of weight than regular gasoline. The byproducts of hydrogen fuel cells are heat and water, with few greenhouse gas and particulate emissions. Fuel cells used in refrigerated trucks can save 10 gallons of fuel per day (*73*).

Time Required (scale of 1 to 5, where 5 is most time)

2

Dollars Required (scale of 1 to 5, where 5 is most expensive)

3

21. Innovative Urban Delivery Modes: Reception Boxes

Texas Application of Strategy/Technology

Last-mile attended urban delivery is the final segment in the delivery of a relatively small shipment (parcel) to the home of consumers or businesses. It is the most costly segment due to the inefficient use of manpower and resources. The delivery driver must go to each respective customer's residence (i.e., typically one item for each address), wait for reception and confirmation of the receipt of the item, and then continue to the next delivery. If the customer is not at home at the time of the delivery, the driver often must return to make the delivery. Attended urban delivery has become a concern in densely populated urban areas where delivery vehicles add to urban traffic congestion with associated safety and environmental impacts (*75*).

Issues Addressed

- Urban Freight Delivery.

Strategy/Technology Profile

Reception boxes are private delivery spaces that are reserved for registered consumers. They come in three basic forms: independent, retrievable, and shared. Independent boxes are installed at the consumer's residence, and delivery drivers can leave goods safely unattended. Retrievable boxes are equipped with docking mechanisms and can be retrieved by the delivery company after the goods have been removed by the consumer; they are not permanently installed in one location. Shared reception boxes are installed like independent boxes but are used by more than one consumer. They are located in apartment buildings or other densely populated residences (*75*).

Keys to Successful Implementation

TNT Express and CityLog have tested the BentoBox system in Berlin. The BentoBox consists of a fixed docking station with a touchscreen and removable modular trolleys that are consolidated at an urban distribution center. Once the courier inserts the trolleys into the docking station, an email or text message is sent to the customer. Customers can retrieve their packages from the secure boxes when it is convenient for them (*76*). Figure A-24 provides an image of the BentoBox and Cargo Cycle in Berlin.

Source: (76)

Figure A-24. BentoBox and Cargo Cycle in Berlin.

The Freight Urban Robot (FURBOT) is a variation on the BentoBox. The FURBOT's driver can pick up and drop off shipments at designated areas and then return for the empty containers. The system involves passcodes and lockboxes, but the kiosks can be moved and repositioned anywhere. Consumers use their passcodes to retrieve their commercial or personal goods. FURBOT vehicles are loaded and unloaded at urban distribution centers located near drop spots (*77*). FURBOTs and the technology are still in the test phase.

Challenges to Implementation

Reception boxes require significant investment and planning (*75*). They need to be constructed at buildings (BentoBox), or delivery companies need to deliver the reception boxes along with the consumer's goods (e.g., FURBOT). Reception boxes thus work best in dense population centers. Furthermore, reception boxes used for urban grocery deliveries need to be refrigerated, which adds to the costs.

Success Story

In the BentoBox pilot in Berlin, it was demonstrated that the BentoBox system was functionally reliable and allowed the bundling of orders, which reduced the number of courier trips in the test area. The orders were transported by light commercial vehicles and cargo cycle, which reduced noise, reduced greenhouse gases and particle emissions, and used the existing infrastructure more efficiently (*76*).

Similarly, a mathematical model for a suburb of Lisbon, Portugal, revealed that the load factor of boxes intended for multiple receivers was 88 percent in the case of the tested FURBOT, whereas the load factor in historic European city centers (such as Lisbon, Portugal) is 30 percent (*77*). This would indicate that lower numbers of boxes could be needed/provided to service the demand for product delivery.

Measures of Effectiveness

Reception boxes increase the efficiency of urban deliveries because items can be securely delivered without the need for someone to receive the package. This strategy has the potential to reduce the number of urban delivery trips because a driver will not have to make multiple trips and trips within a neighborhood can be combined. Thus, the strategy provides flexibility in the delivery and receipt of packages in urban areas through the use of secure drop-off locations (*76*).

Time Required (scale of 1 to 5, where 5 is most time)

2

Dollars Required (scale of 1 to 5, where 5 is most expensive)

3

22. Innovative Urban Delivery Modes: Collection and Delivery Points

Texas Application of Strategy/Technology

Last-mile attended urban delivery is the final segment in the delivery of a relatively small shipment (parcel) to a consumer's home or a business. It is the most costly segment due to the inefficient use of manpower and resources. The delivery driver must go to each respective customer's residence (i.e., typically one item for each address), wait for reception and confirmation of the receipt of the item, and then continue to the next delivery. If the customer is not at home at the time of the delivery, the driver often must return to make the delivery. Attended urban delivery has become a concern in densely populated urban areas where delivery vehicles add to urban traffic congestion with associated safety and environmental impacts (*75*).

Issues Addressed

- Urban Freight Delivery.

Strategy/Technology Profile

Collection and delivery points (CDPs) are a more efficient solution to making attended last-mile deliveries in densely populated urban areas. CDPs are typically located in well-traveled commercial areas that are easily accessible by consumers and delivery drivers. Drivers make one delivery to a CDP for multiple consumers, reducing travel times and costs. Consumers do not receive their deliveries at their residence but at convenient locations nearby or on their commute. Consumers receive notification that their delivery has arrived and how and where to retrieve it. All packages are stored in secured locks (e.g., with passcode identification) (*75*).

Keys to Successful Implementation

DHL implemented and is operating its Pack Station (*78*) program in Germany. DHL's Pack Station is a pickup and drop-of kiosk located in popular commercial areas, as shown in Figure A-25. Consumers receive and ship packages via locked compartments. Consumers receive notification that their package has arrived at a convenient, preselected kiosk. Consumers have a set time window to retrieve their packages. DHL makes one stop to pick up and drop off packages without needing to go door to door (***Error! Bookmark not defined.***). CDPs are most successful if located in areas that already generate consumer trips so that consumers can pick up their packages while doing their other shopping (*75*).

Source: (*78*)

Figure A-25. Collection and Delivery Point (DHL Pack Station) in Germany.

Challenges to Implementation

CDPs require a capital investment to provide the kiosks (*75*). Kiosk locations are also fixed and may be inconvenient for some consumers. The locations may also experience fluctuating demand but cannot be moved after construction. Furthermore, kiosks must also have adequate loading areas for DHL trucks to maneuver (***Error! Bookmark not defined.***). This option is only effective if the kiosk is in a convenient location for consumers and if delivery drivers limit their trips to only CDPs.

Success Story

Amazon Lockers have been introduced to urban areas in the United States, an example of which is shown in Figure A-26. The lockers enable customers to have items ordered through Amazon sent to a locker location (such as a convenience store, hardware store, or grocery store) instead of to their home or office (*79*). Once the order is delivered to the Amazon Locker, the consumer receives an email that the order is ready for pickup. The email also contains a unique code to access the locker that contains the order. Orders are typically available for pickup for three days after the date of delivery (*80*).

Source: (80)

Figure A-26. An Amazon Locker.

Measures of Effectiveness

CDPs can be used for last-mile delivery in areas with a high population density (*75*) and are particularly useful for the business-to-consumer deliveries required by Internet commerce/e-commerce. CDPs increase the efficiency of urban deliveries because items can be securely delivered without the need for someone to receive the package. This strategy has the potential to reduce the number of urban delivery trips because (a) a driver will not have to make multiple trips, and (b) trips within a neighborhood can be combined (*76*).

Time Required (scale of 1 to 5, where 5 is most time)

2

Dollars Required (scale of 1 to 5, where 5 is most expensive)

3

23. Ramp Metering

Texas Application of Strategy/Technology

Ramp meters minimize congestion on freeways by reducing demand, increasing speed and volume, and breaking up the platooning effect between vehicles. This system improves traffic conditions not only on the motorway but also on the parallel arterial and on the whole corridor network, which may be used by the exiting trucks of a freight village or high-density major freight generator to access the connecting roads more efficiently. Paired with other traffic control technologies, this method could potentially be used to improve freight flow throughput through an urban area.

Issues Addressed

- Intercity or Long-Distance Freight Corridors.
- Urban Freight Delivery.

Strategy/Technology Profile

Ramp meters are traffic signals located at freeway on-ramps to control the flow of vehicles onto the freeway. Based on a predefined or variable signal cycle, vehicles are allowed to enter the freeway only on a green indication. The rate is determined through either real-time or historical knowledge of the freeway capacity and the demand of the on-ramps. An efficient ramp-metering strategy improves traffic conditions not only on the motorway but also on the parallel arterial and the whole corridor network. This is even more so the case when non-recurrent congestion caused by traffic incidents is present.

Keys to Successful Implementation

Ramp-metering systems can only be successful if they receive public support from political leaders, enforcement agencies, media, and the motoring public. To the users, ramp meters are often seen as a constraint on a roadway normally associated with a high degree of freedom. Thus, it is important to avoid overselling the benefits of ramp metering. Agencies should also explain the difficulties of mitigating freeway congestion problems, educate the public on the cost effectiveness of management techniques such as ramp metering, and provide realistic and measurable expectations. In addition to the aforementioned factors, there are other important considerations for implementing this technology:

- Adequate personnel and continuous training and updating for system operation and maintenance are needed to ensure continued efficient operations.
- Incremental implementation of individual sections, rather than a total system launch, should be considered.
- Selection of an adequate algorithm (RWS strategy, ALINEA strategy, or FUZZY logic) is necessary.
- Unification and standardization of software used is important.

Challenges to Implementation

The main challenge is the risk of saturating the surrounding roads with too many ramps, thereby slowing the traffic flow and creating bottlenecks. To avoid this, onsite feasibility studies should be conducted to determine the characteristics of the ramps needed to best facilitate freight movement using ramp metering.

Success Story

In 2008, HERO was a USD $1 million pilot project at six consecutive inbound on-ramps on the Monash Freeway (six-lane dual carriageway carrying in excess of 160,000 vehicles per day with up to 20 percent commercial vehicles that experiences long periods of congestion between three to eight hours a day) in Melbourne, Australia. The economic payback period of the pilot project was just 11 days. The results showed an increase of traffic throughput and a reduction of travel times. The successful implementation and evaluation of HERO led to its rollout during 2009–2010 at 64 sites across the entire 75-km route of the Monash-CityLink-WestGate Highway.

Measures of Effectiveness

This strategy is used to maximize the efficiency of the freeway, improve mobility, and thereby minimize the total delay in the transportation corridor. Ramp metering attempts to ensure that the total traffic volume entering a freeway segment—plus the entering ramp traffic—remains below the capacity of that freeway segment. Ramp metering also has the potential to prevent freeway congestion by delaying its onset and to initiate smoother, safer merging operations to improve safety by reducing rear-end and sideswipe collisions.

Time Required (scale of 1 to 5, where 5 is most time)

2

Dollars Required (scale of 1 to 5, where 5 is most expensive)

4

24. Short-Haul Rail Movements within Urban Areas

Texas Application of Strategy/Technology

In coming years, city planners and developers are likely to encourage denser development of residential and retail properties in urban areas. This trend will coincide with increasing congestion on major highways used for freight delivery from exurban distribution centers to smaller-scale retail stores within the denser developments. The rail lines retained by many city centers could be used as rail-served transloading hubs to transfer trailers or containers from distribution centers to trucks for last-mile delivery to retail stores. This practice could reduce overall urban truck traffic, freeing up highway capacity and reducing truck-related emissions.

Issues Addressed

- Urban Freight Delivery.

Strategy/Technology Profile

The technology involves using relatively short-haul intermodal rail moves from distribution centers into major urban areas. The intermodal containers could be standard 40-foot or shorter 20-foot units, and either dry or refrigerated. Intermodal transfers could be accomplished at either end of the rail trip with lift trucks or with specialized truck-mounted equipment. Such rail moves involve shorter, faster intermodal trains on a regular schedule (*81*).

Keys to Successful Implementation

In Europe, shippers were motivated to reduce freight operation emissions and saw short-haul rail service as a means of reducing carbon footprints. This integrated service could be provided by a third-party logistics (3PL) firm, or as in another application in Switzerland (see below), where the retailer took over ownership of the entire freight operation. In two different applications in Switzerland (including a 212-mile rail journey of beer from Donat to Daillens), the rail move was facilitated by a new truck-rail technology.

For this to be considered in Texas, the following elements would need to be in place:

- Available freight rail-line capacity into city centers for short intermodal trains (line capacity as well as track conditions).
- Rail lines into city centers with sufficient connections to rail-served warehousing or yards.
- Real estate suitable for development as rail-truck transloading facilities.
- Increasing levels of chronic highway congestion that restrict truck trip frequencies from distribution centers.

Challenges to Implementation

Recent conversations with both the Port of Houston and the Union Pacific Railroad indicate that Texas Shuttle intermodal service operated twice weekly from Barbours Cut Container Terminal and the Dallas Intermodal Terminal has not experienced the kind of growth necessary to increase its frequency. Urban and intercity congestion may not currently be dire enough to move short-haul shipments to rail. Short-haul rail may wait until congestion reaches more critical stages to justify the cost to carry out multimodal exchanges, purchase necessary equipment/rolling stock, and build or restore infrastructure.

Success Story

Since 2013, a large supermarket chain in Switzerland has used a 42-mile-long railway link to transfer refrigerated containers from a distribution hub outside Geneva to a transloading facility in the center of Geneva. From there, containers are delivered to one of 42 stores in the city center. The system is facilitated by proprietary technology that includes truck-mounted racks to transfer the 20-foot containers from a chassis to intermodal railcars. Prior to implementation, the retailer was frustrated by unreliable delivery times from its distribution center into the older, crowded city center (*82*). Figure A-27 provides images of the container transfer and train.

Source: (82)

Figure A-27. Left: Truck-Mounted System Transferring Container from Train to Truck. Right: Container Train on Way to Geneva.

Measures of Effectiveness

The Swiss Coop grocery chain estimates that it has reduced truck movements by 870,000 truck miles per year and reduced CO_2 by 1,128 tons per year. Use of its specialized truck equipment has reduced the footprint needed at the railhead for rail-truck transfers.

Time Required (scale of 1 to 5, where 5 is most time)

3

Dollars Required (scale of 1 to 5, where 5 is most expensive)

3

25. Truck-Only Roadway

Texas Application of Strategy/Technology

The use of truck-only roadways to quickly and efficiently connect important logistic centers and freight villages with high-demand nodes would increase service levels and decrease waiting times, drivers' fatigue and stress, accidents, and bottlenecks.

Issues Addressed

- Urban Freight Delivery.
- Major Freight Generators and Intermodal Exchange Areas.
- Intercity Corridors.

Strategy/Technology Profile

A truck-only roadway is a lane-management strategy to reduce the ever-increasing vehicle congestion on highway systems. The main purpose of this strategy is to completely separate trucks from passenger vehicles and be able to increase longer combination vehicle (LCV) operations. This system is especially critical in the movement of high-value, time-sensitive commodities.

Keys to Successful Implementation

In order to get the most benefits from this kind of infrastructure, the implementation of cooperative vehicle highway automation systems (CVHASs) is strongly suggested. The use of CHVASs such as automatic steering control systems would help reduce the width of lanes needed, and hence their construction and right-of-way costs. However, in order to gain this cost-saving advantage, it is necessary for the truck facility to be restricted to trucks with automatic steering (because drivers would not be able to steer their conventional trucks accurately enough to use the narrower lanes). Also, the use of automated vehicles could make it possible for them to operate in close-formation platoons of up to three trucks. In this way, a single roadway lane could accommodate about twice the volume of trucks as a conventional-technology truck lane.

Challenges to Implementation

The main challenge in implementing this solution is the construction cost. To generate income and return on investment, two schemes are suggested: (a) tolls paid only by large trucks—the fee paid is recovered by the carriers in the medium term due to their increased level of service; (b) tolls paid by non-freight vehicles in the same corridor—this toll would potentially be justified by people being able to travel without the safety risks from heavy trucks operating in the same traffic stream, by faster and more consistent speeds, and by the more relaxed environment made possible by the elimination of large trucks from general-purpose lanes.

Success Story

One of the best-known examples of separated lanes is on a 45-mile section of the New Jersey Turnpike. For this dual-dual section, the turnpike consists of four parallel roadways, each consisting of three 12-foot lanes. The inner roadways are designated for cars only, while the outer lanes are usable by cars and trucks. The turnpike is heavily used by trucks, which account for about 12 percent of average daily traffic and about 34 percent of revenue. In 2008, the state proposed a $2 billion project to extend the dual-dual configuration an additional 25 miles, including reconfiguration of seven interchanges (*47*).

Measures of Effectiveness

The benefits of this kind of infrastructure for trucking firms are associated with a lower risk of collision (72 percent to 89 percent of the resulting accidents between cars and trucks are caused by the former), ability to handle longer combination trucks, and also more efficient operations and consequent cost reduction. The benefits for passenger vehicles are related, with an increase in safer driving, less stress, and better traveling experience. Some studies suggest a benefit-cost ratio of 3.78. This ratio is increased to 5.32 when CVHASs, like time-staged automation, are implemented along with the truck-only roadways.

Time Required (scale of 1 to 5, where 5 is most time)

3

Dollars Required (scale of 1 to 5, where 5 is most expensive)

5

26. Truck-Only-Toll (TOT) Lanes

Texas Application of Strategy/Technology

The growing number of both automobiles and trucks traveling on U.S. highways has caused more traffic congestion and increased the likelihood of truck-auto related crashes. This growth in crashes is expected to continue in the foreseeable future. Separation of vehicles by way of TOT lanes, which are intended exclusively for authorized truck traffic in order to improve safety and provide greater system reliability, is one solution. The toll revenue collected would provide financing for maintenance and operation of the truck-only lane. This approach can be used in areas where freight delivery has a significant impact on public safety and traffic congestion.

Issues Addressed

- Intercity or Long-Distance Freight Corridors.
- Urban Freight Delivery.

Strategy/Technology Profile

The purpose of truck-only facilities is to promote safer traffic flow, reduce congestion, and increase freight-hauling productivity. Shippers will have the option of traveling routes with more reliable trip times, especially during peak periods. Automobile road users will have reduced interaction with trucks and less congestion. TOT should remain voluntary for drivers, who can use either the toll lane or general-purpose lane. Mandatory TOT lanes can be best used in major freight facilities such as seaports. If used in areas where the trucks have the option of taking alternate routes altogether, TOT lanes will be underutilized. Managed TOT lanes react to changing traffic conditions and operate under three strategies: limited-access locations, vehicle eligibility requirements, and/or pricing.

Keys to Successful Implementation

There are numerous keys to successfully implementing TOT lanes. These factors include:

- Reduce travel time and increase freight movement efficiency.
- Separate trucks from autos to improve safety and reliability.
- Encourage voluntary usage of tolled truck-only lanes.
- Use tolling as a way to finance the facility.
- Understand that TOT lanes are best for specific purposes such as at major freight facilities like seaports and rail stations, for through traffic, for long-distance local traffic and fixed-delivery schedules, and for congestion relief, safety, and time savings.
- Permit longer combination vehicles (LCVs) to travel along the TOT.
- Provide tax rebates or exemptions from federal and state fuel taxes for every mile on the TOT.

- Understand that the public will support the TOT lanes if most of the truck traffic is shifted to the TOT lanes, as long as this reduces congestion and increases safety.
- Troubleshoot the legal barriers in existence.
- Understand that truck-only lanes must maintain some minimum level of usage in order to avoid criticism about underutilization from those traveling in the general-purpose lanes.

Challenges to Implementation

The TOT lane implementation challenges include:

- Gaining support from the trucking industry (perhaps the biggest challenge).
- Addressing the high level of investment required and funding mechanisms for multistate collaboration.
- Addressing the lack of public support if new bonds are to be paid with public taxes revenues.
- Addressing mandatory usage of TOT lanes—if toll fees are higher than the economic benefits of using TOT lanes, then truckers will search for alternate routes, thus switching the congestion to other areas and eliminating the toll revenue benefits.
- Determining the corridors or segments with sufficient truck demand.
- Understanding that removing existing lanes to create TOT lanes will reduce public support.
- Addressing underutilization—trucks keep using the free lanes along with automobiles, thus creating more congestion.
- Acquiring right of way.
- Understanding that the benefit-cost for TOT lanes has to be greater than using HOV/HOT lanes at limited time periods.

Success Story

One of the most successful applications of dedicated truck lanes is the New Jersey Turnpike, a limited-access facility that has successfully improved operations by separating types of vehicle traffic. A 32-mile segment of the roadway has been expanded into two separate roadways, resulting in a dual-dual facility. Large trucks are limited to the outer roadway, but passenger vehicles may travel on either the inner or the outer roadway. Each of these facilities provides very limited access, and the available access is through independent ramps for the inner and outer roadways. Using gates, operators can limit access to a particular roadway as needed to manage demand or in the event of an incident. The result is a roadway that operates efficiently because turbulence in the traffic flow is minimized (*47*).

Measures of Effectiveness

There are several key factors in measuring the effectiveness of TOT lanes. These factors include:

- Congestion management.
- Economic development.

- Improved freight productivity.
- Reduced environmental impacts.
- Travel time reliability changes for the corridor as a whole, and in the truck-only lane.
- Reduced number of incidents caused by truck breakdowns or tire/load debris in road.

Time Required (scale of 1 to 5, where 5 is most time)

4

Dollars Required (scale of 1 to 5, where 5 is most expensive)

4

Supplemental Information

It is difficult to assess funding needs until it is determined whether new lanes are needed, existing lanes must be improved, or existing roadways can be used as is. Differences in capacity assumptions between the truck-only lane and mixed-flow lane or HOV/HOT alternatives and the omission of the mixed-flow or HOV/HOT alternatives in the performance evaluation in some of the reviewed studies result in the findings being inconclusive or inadequate in assessing the relative performance benefits of truck-only lanes against mixed-flow or HOV/HOT alternative lanes with similar capacity.

27. Unmanned Aircraft Systems and Their Use in the Freight/Logistics Industry

Texas Application of Strategy/Technology

The last few years have seen a rise in the use of unmanned aerial systems (UASs) for a variety of functions. These systems, which are also sometimes referred to as unmanned aerial vehicles (UAVs), are defined by the Federal Aviation Administration (FAA) as an “unmanned aircraft (UA) and all of the associated support equipment, control station, data links, telemetry, communications and navigation equipment, etc., necessary to operate the unmanned aircraft” (*83*). The emerging uses of UASs have proven promising across many industries in our economy, including the freight/logistics sector.

Issues Addressed

- Intercity or Long-Distance Freight Corridors.
- Urban Freight Delivery.

Strategy/Technology Profile

UASs already play a small role in the freight/logistics industry. A variety of technologies currently exist, including fixed-wing, tilt-wing, unmanned helicopters, and multicopters. Each of these comes with its own set of advantages and disadvantages, with some being more suitable for certain functions. UASs also range in cost and engine type, which drives characteristics such as range and payload capacity. These characteristics, in turn, drive function and use. While some of this technology exists today, it is still emerging, and the potential uses will continue to evolve.

Current and future uses of UASs in the freight and logistics industry include:

- Monitoring and patrolling tracks and pipelines.
- Serving law enforcement purposes.
- Making emergency deliveries/relief shipments during natural disasters.
- Delivering medicine to islands/remote locations.

Many companies continue to develop technologies and explore additional markets and uses for UASs in the freight/logistics industry. Amazon, Google, and DHL are among those working toward freight delivery for both urban and rural areas as well as first- and last-mile deliveries.

Keys to Successful Implementation

UASs have seen limited implementation to date, largely due to the monitoring and patrolling functions noted above. The FAA has oversight of this area, and the regulatory environment is still evolving along with the technology. Approval from the FAA is required for using a UAS for business purposes. Approval is done on an individual case basis for safety reasons.

Challenges to Implementation

While some UASs are currently used for limited purposes, operating them continues to be challenging due to the regulatory environment. Much of the future success and opportunity for UASs hinges on the evolving regulatory framework for them. The FAA is currently working on a proposed rule for UASs weighing less than 55 lb. Units larger than that will continue to abide by the FAA process for approval for business or commercial operations. This also involves safety concerns and integration issues associated with our civil airspace system. Individuals operating UASs as a hobby can do so if the UASs are less than 55 lb, maintain distances from populated areas, and maintain line of sight between the UAS and the operator.

Additional challenges to implementation are related to technology itself, including the battery life of the UAS and the ability to operate under various weather conditions.

Success Story

Currently, there are no UASs moving freight in Texas. However, BNSF is using UASs for monitoring and inspecting its rail network. This is a critical issue for the railroad given its 32,500 miles of track, which is currently inspected by a person twice a week. The use of this technology has significant safety and manpower implications that can provide operational efficiencies.

UASs are currently being deployed in a variety of roles across different industries. These industries include energy, agriculture, forestry, construction, real estate, environmental protection, and public safety/first response. With respect to freight, there are companies that continue to enhance and evolve the technology and viability of deliveries using UASs. Some of these are worth additional consideration to further examine the future viability of moving freight UASs and integrating them into our existing transportation and airspace systems. The current focus is on lightweight, short-range capabilities, which may be suitable for urban deliveries and hard-to-reach locales, as well as first- and last-mile challenges.

One military application has been met with success. Lockheed Martin and Kaman Aerospace Corporation have transformed Kaman's K-MAX lift helicopter into an unmanned aircraft. It has flown 750 hours in autonomous mode and can lift 6,000 pounds at sea level. It is expected to provide battlefield supply capabilities to the U.S. Marine Corps.

Measures of Effectiveness

While there are currently no freight moving applications of UASs, BNSF, a freight provider, has recently begun using them to patrol, monitor, and inspect its rail lines. There is a potential for significant savings related to manpower. There are also potential safety benefits associated with the ability to detect very small cracks using LIDAR. In addition, when inspecting tracks in person, railroad employees are often exposed to insects, snakes, and toxic vegetation that can have costly, adverse effects on the employee and company.

The current regulatory environment and political and social acceptance are the primary factors for seeing this technology deployed on a wider basis in the future. All things considered, the cost is not expected to be a large deterrent at this time, but that may change as the technology changes.

An economic-impact analysis of unmanned aircraft systems in the Unites States was conducted in 2013 for the Association of Unmanned Vehicle Systems International that estimated job creation, tax revenues to the states, and a total economic impact from 2015–2025.

In the case of UAS deliveries in high-density environments such as CBDs, benefits could include reduced delivery-truck trips and associated congestion/mobility and environmental benefits.

Time Required (scale of 1 to 5, where 5 is most time)

5

Dollars Required (scale of 1 to 5, where 5 is most expensive)

3

Supplemental Information

- Unmanned Aerial Vehicles in Logistics: A DHL Perspective on Implications and Use Cases for the Logistics Industry, 2014. http://www.dhl.com/content/dam/downloads/g0/about_us/logistics_insights/dhl_trend_report_uav.pdf.

28. Urban Delivery Sharing System (Uber-Type Dispatching for Freight Trucks)

Texas Application of Strategy/Technology

Last-mile-attended urban delivery is the final segment in the delivery of a relatively small shipment (parcel) to the homes of consumers or businesses. It is the most costly segment due to the inefficient use of manpower and resources. The delivery driver must go to each respective customer's residence (i.e., typically one item for each address), wait for reception and confirmation of the receipt of the item, and then continue to the next delivery. If the customer is not at home at the time of the delivery, the driver often must return to make the delivery. Attended urban delivery has become a concern in densely populated urban areas where delivery vehicles add to urban traffic congestion with associated safety and environmental impacts (*75*).

Issues Addressed

- Urban Freight Delivery.

Strategy/Technology Profile

In the sharing economy, technology (e.g., smartphone applications) connects independent contractors/individuals to consumers looking for a ride (Uber), a place to stay (e.g., HomeAway and Airbnb), completion of a household task (e.g., TaskRabbit), or collection and delivery of a parcel/package (e.g., UberCargo, Postmates, Piggyback, and Roadie).

Although many web-based and mobile applications have existed for many years to match shippers with trucking companies (e.g., Keychain Logistics [*84*], Cargomatic [*85*], Trucker Path [*86*], and MyDAT Trucker [*87*]), companies such as UberCargo, Roadie, Piggyback, and Sidecar are attempting to enter the urban delivery business. The idea is for drivers to pick up grocery items, parcels, or packages and then deliver them the same day to consumers (thereby competing with more established companies such as UPS and FedEx).

Keys to Successful Implementation

Companies such as Roadie, Piggyback, UberCargo, and Sidecar are fairly new to the urban delivery business. These companies market themselves as a faster and cheaper option for urban freight deliveries, but the business model has largely not been proven profitable. The success of this strategy requires a pool of reliable drivers that can provide a faster and less expensive alternative to existing parcel delivery services (UPS and FedEx).

Challenges to Implementation

UberCargo has existed for more than a year with modest success. One challenge has been the inability to insure high-priced items. For example, Uber's insurance policy only covers the value of an item up to $1,000. Similarly, it would not be profitable to pick up and deliver a very low-priced item (e.g., $4.99 package) across town. Finally, the issue as to whether drivers should be classified as full-time employees instead of independent contractors complicates the business model (*88*). On June 17, 2015, the California Labor Commission ruled that an Uber driver should be given the status of employee and not independent contractor. If this precedent is repeated in upcoming court cases, Uber's labor costs could increase by 30 percent since drivers would be entitled to health insurance and overtime pay (*89*).

Success Story

The shared-economy, same-day urban delivery services require the downloading of a mobile application. In general, it works like this: consumers use the application to post an item for pickup and a driver sees the post, accepts the delivery, picks up the item from the consumer, and delivers it. Consumers can also track the movement of their packages in near real time with the application. Roadie offers a variation to this standard door-to-door service by enabling Roadie users to meet and deliver or pick up packages at over 1,750 Waffle Houses in the United States (*90*).

Measures of Effectiveness

The shared-economy, same-day urban delivery services are fairly recent initiatives. UberCargo has been in existence for more than a year with modest success. Roadie began operations in January 2015. The profitability and effectiveness of the business model is, thus, largely untested. Although some have argued that these services could impact the market share of the established parcel delivery services, others have argued that freight will not necessarily be "uberized." Instead, established companies will introduce more mobile technology into their transactions (*91*).

Time Required (scale of 1 to 5, where 5 is most time)

1

Dollars Required (scale of 1 to 5, where 5 is most expensive)

1

29. Urban Truck Parking

Texas Application of Strategy/Technology

Inadequate parking for trucks and urban delivery vehicles results in trucks parking illegally or circling in an effort to find a parking space. In dense urban areas, this behavior adds to congestion and environmental and safety concerns. Research has demonstrated that if capacity is made available for trucks and delivery vehicles to legally park to deliver and collect items, both freight and passenger vehicles can move through urban areas more efficiently. A number of truck parking strategies exist that could improve the efficiency and lower the operational cost of the urban transportation network (*92*).

Issues Addressed

- Urban Freight Delivery.

Strategy/Technology Profile

Parking strategies to accommodate trucks and urban delivery vehicles in dense urban areas include:

- **Reallocating curb space for truck parking and loading activities.** New York City designated a number of curbside parking spaces for commercial vehicle usage (*93*).
- **Managing curb space**, which involves time-of-day restrictions (e.g., delivery windows) for truck parking, accommodation of delivery trucks in shared or flex spaces, and pricing of on-street loading bays (*93*). For example, in Chester, England, parking for freight loading and unloading can be used by handicapped placard holders outside of the posted delivery time windows (see Figure A-28) (*44*).
- Implementing a **parking reservation system** that allows delivery vehicle drivers to reserve a curbside parking space. For example, a parking space reservation system was piloted in Toyota City, Japan (*93*).

Source: (44)

Figure A-28. Delivery Windows for Truck Parking in Chester (England)

To address truck parking concerns in new urban developments:

- Developers of new office or retail developments could be required to develop off-street loading bays to meet future delivery-truck demand.
- Mixed-use developments could be required to include spaces for inner-city logistics/urban consolidation centers.
- On-street unloading could be required when off-street facilities are not available (*44*).

Keys to Successful Implementation

Truck parking strategies to adapt existing street design and loading areas to accommodate urban delivery trucks (e.g., reallocating curb space to urban delivery trucks, implementing delivery windows or shared usage) require careful planning, stakeholder coordination, and consideration of both positive and negative impacts to road users. In general, though, the costs associated with revising parking regulations are low and the implementation period is short. Increasing the number of truck parking and loading areas by reallocating curb space and/or implementing delivery windows is, thus, a potentially low-cost strategy to reduce congestion and improve traffic flow in an urban corridor. Resources are, however, required for revising signage and enforcing curbside parking regulations. On the other hand, constructing new parking facilities—or expanding existing truck parking facilities—may require higher upfront capital expenses (*93*).

Challenges to Implementation

Providing adequate truck parking in dense urban areas or older inner cities can be expensive if it requires modifying existing developments. Furthermore, the general supply of curbside parking space may be inadequate for both urban delivery vehicles and passenger vehicles such that relocating available curb space to urban delivery vehicles can negatively impact the customers of businesses in the urban corridor if those customers cannot find parking. Therefore, it is very important to reach out to public- and private-sector stakeholders when considering changing truck parking strategies and parking regulations. Finally, in some locations, it may not be feasible to accommodate delivery vehicles or trucks within the urban corridor (*93*).

Success Story

New York City reserved 40 out of 90 available metered parking spaces along Church Avenue in Brooklyn for delivery trucks on weekdays between 7:00 a.m. and noon. That delivery window was based on survey results that indicated that 65 percent of deliveries to the area occur before noon. After noon, a limited number of loading and unloading spaces are available on the north side of Church Avenue until 3:00 p.m. on weekdays. All other times, normal one-hour metered parking is available to all vehicles. Stakeholder outreach (e.g., to residents, businesses, transportation providers, and elected officials) and enforcement of the traffic laws and parking regulations were keys to the successful implementation of the parking strategies on Church Avenue. The implemented parking strategies resulted in improved travel speed and more reliable travel times along the corridor (*93*).

Measures of Effectiveness

Providing adequate truck parking and loading zones for urban deliveries—as well as off-street loading and unloading facilities in new developments—tends to reduce the operational costs of urban freight transportation and lessen road congestion (*44*). The latter is partly due to a reduction in traffic/parking violations (by removing the need to park illegally) and a reduction in miles traveled because delivery-truck drivers are not circling and looking for a parking space. A reduction in congestion and improved mobility in urban corridors can also improve air quality and lower greenhouse gases while enhancing safety (*93*).

Time Required (scale of 1 to 5, where 5 is most time)

2

Dollars Required (scale of 1 to 5, where 5 is most expensive)

1

30. At-Grade Separation Programs

Texas Application of Strategy/Technology

There are significant safety and mobility concerns where trains intersect with vehicles on public roadways and other trains on railroads. Operational restrictions around existing at-grade intersections can cause significant delays in rail and roadway corridors experiencing heavy traffic. In addition to safety impacts, communities are also burdened with delays, lost fuel, additional emissions, and increased noise impacts at these intersections. Corridors that contain multiple at-grade intersections can also impact economic development opportunities or hinder the performance of downtown regions. Removing these highway-rail and rail-rail intersections improves safety, increases mobility, and can enhance economic development for the local community.

Issues Addressed

- Urban Freight Delivery.
- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

This strategy involves developing an approach to eliminate critical at-grade highway-rail and rail-rail grade crossings. A systematic approach could eliminate:

- Single at-grade highway-rail grade crossings.
- Several highway-rail grade crossings along a corridor (e.g., by placing the rail line within a trench or consolidating rail operations, thus eliminating a rail corridor).
- Critical at-grade rail-rail intersections.

Removing these bottlenecks will improve freight flow on the roadways and the rail line while enhancing economic development opportunities for local communities.

Keys to Successful Implementation

In the past 20 years, public and private investors have recognized the importance of removing critical freight bottlenecks. Two noteworthy projects include:

- The Alameda Corridor project that trenched the rail line under crossing roadways in order to better facilitate container movements from the Ports of Los Angeles and Long Beach.
- The Kansas City Sheffield Junction project that separated major crisscrossing rail lines.

The success of these and many of the significant at-grade crossing projects around the nation revolves around effective partnerships between the public sector and private railroads. Several best-practice recommendations include:

- Understanding each stakeholder's need and requirements.
- Establishing common goals and project scope.
- Estimating the full public and private benefits and costs.

Challenges to Implementation

Effectively forming a public-private partnership (PPP) to implement a major at-grade separation project requires perseverance in overcoming major obstacles. Separation projects typically require major investments, especially if addressing a system of improvements.

Public and private entities often have different planning horizons and measures of effectiveness. A project identified by the public sector may make good sense from its perspective but may not meet the financial return requirements of a railroad. Additionally, some states may have laws and/or regulations that restrict their ability to use public funds for non-highway projects. Finally, a project may unfairly provide a competitive advantage for one railroad over another; therefore, the scope and private benefits need to consider all the needs of the various railroads involved.

Success Story

The Chicago Region Environmental and Transportation Efficiency (CREATE) Program will invest billions in critically needed capital improvements to increase the efficiency of the region's rail infrastructure. This will reduce train and auto delays throughout the Chicago area by focusing rail traffic on four rail corridors improved to handle passenger and freight traffic more efficiently (*13*). The 70 projects comprising the program include highway-rail grade separations, rail-rail grade separations, and rail infrastructure improvement projects. Figure A-29 shows the CREATE Program project map. The initial total estimated cost of the program was $1.533 billion, with the total initial estimated benefits calculated at $3.909 billion (see Table A-1) (*94*).

Source: (94)

Figure A-29. CREATE Program Projects Map.

Table A-1. Regional Economic Benefits of the CREATE Program.

Benefit Category	Benefit Quantity ($ Million)
Rail Passenger Service	
• Commuter time saved	$190
• New highway construction reduced	$77
Motorists	
• Reduced delays at grade crossings	$202
Safety	
• Highway accidents reduced	$94
• Grade-crossing accidents reduced	$32
Construction	
• Wages, materials, and other purchases (including 16,217 employee-years)	$2,194
Air Quality	
• Emission reductions (valued at CMAQ grant levels)	$1,120
Additional Benefits	
• Improved rail freight service to Chicago region	
• Enhanced delivery of emergency services	
• Increased lakefront land use	
• Facilitated reduced rubber-tire interchanges	
• Improved energy conservation	
Total Estimated Benefits	*$3,909*

Source: (*13*).

Measures of Effectiveness

To determine the feasibility of at-grade separation projects, calculate the cost effectiveness of the project by comparing project costs to benefits. Benefits accrue with, for example, improved traffic flow and operations, lessened air emissions, reduced motorist and train delay, increased safety, and increased economic development opportunities.

Time Required (scale of 1 to 5, where 5 is most time)

4

Dollars Required (scale of 1 to 5, where 5 is most expensive)

4

Supplemental Information

- USDOT TIGER Discretionary Grants Awards—http://www.transportation.gov/tiger.

31. Backscatter X-Ray Imaging

Texas Application of Strategy/Technology

Several inspection technologies that could increase the efficiency and safety at U.S. border crossing locations in Texas and at the same time reduce wait times that cause increased emissions and productivity losses to trucking, rail, and other freight logistics firms exist. Among the technologies to be examined in this area are:

- Backscatter X-ray Imaging.
- Electronic Screening of Trucks at International Border Crossings.
- License Plate Readers (LPRs).
- Photonuclear Gamma Ray Imaging.
- Radiation Portal Monitors.

Texas state agencies (e.g., the Texas Department of Transportation, Texas Department of Public Safety, etc.) can work with federal agencies to implement these technologies more effectively at the local level.

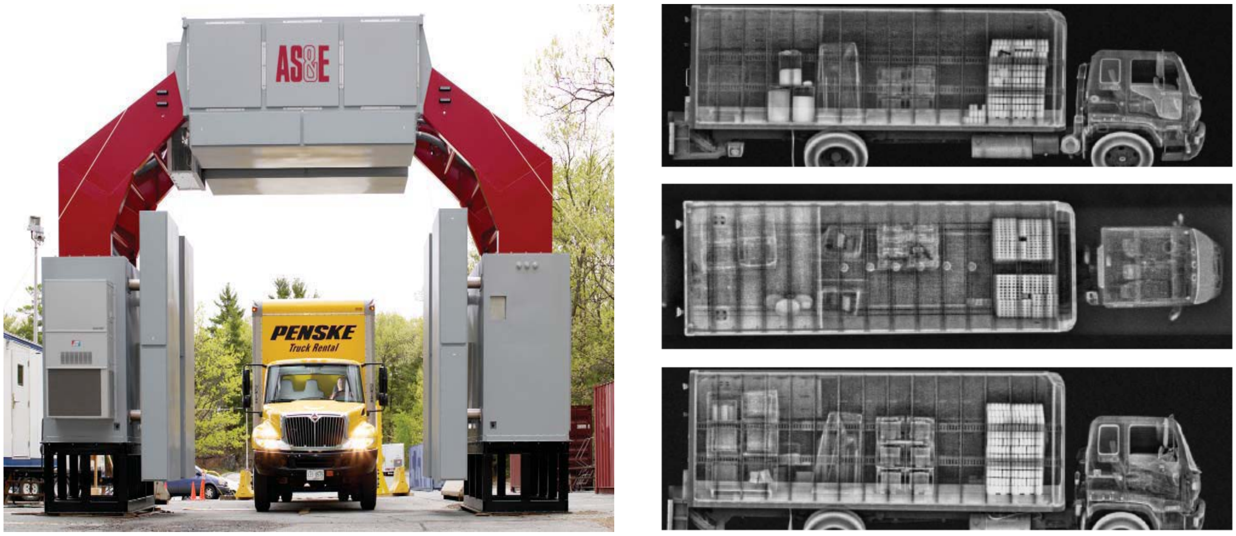
Backscatter x-ray imaging involves the use of a high-resolution x-ray that can detect dangerous and elusive threats such as organic explosives, plastic and metallic weapons, and radioactive devices such as dirty bombs and nuclear weapons of mass destruction.

Backscatter x-ray imaging at border ports of entry (POEs) will allow freight containers to be checked by customs officials without unloading the containers, which will speed up the crossing process. Backscatter technology also helps to eliminate human error from the customs check by providing an end-to-end scan of the shipping containers.

Strategy/Technology Profile

As trucks enter the United States, they are subjected to a primary inspection in which customs officials verify the driver and cargo against files electronically filed by the U.S. brokers. At this point, customs officials use their discretion to determine if the freight requires a secondary inspection. If a secondary inspection is required, the freight is directed to one of several secondary inspection stations, including backscatter x-ray imaging stations.

Once at a backscatter x-ray imaging station, the fright container is x-rayed from edge to edge. The backscatter imaging machine produces a high-resolution image that allows customs officials to confirm the contents of freight containers and flag any suspicious cargo. The backscatter imaging technology cuts down the time of secondary inspections by avoiding manual inspections and helps to eliminate human error by providing a high-resolution image of the container's contents. An example of the station and resulting x-ray are presented in Figure A-30.



(a) Z PORTAL Cargo Inspection **(b) X-Ray Image Taken by Z PORTAL**

Figure A-30. Z PORTAL Cargo Inspection Device and X-Ray Results.

Keys to Successful Implementation

Backscatter imaging technologies are primarily implemented at the southern border in cases that involve suspected narcotic transportation. Narcotic suspicions are easily verified or disqualified through backscatter x-ray images, which have reduced the time of secondary inspections. Backscatter imaging has also reduced the number of manual inspections, which has freed up dock capacity at the POE for other uses.

In order to implement this technology efficiently, it is necessary to adopt the necessary procedures:

- Employ more backscatter imaging machines at each POE.
- Properly train backscatter technicians to recognize contraband cargo.
- Increase the number of personnel available and qualified to operate photonuclear gamma ray imaging machines at each POE.
- Reconfigure the POE infrastructure to include space for backscatter imaging technology.

Challenges to Implementation

One challenge to the implementation of backscatter imaging technology is the infrastructure of border POEs. Backscatter imaging machines are not compatible with the original design of most POEs, which tend to have large dock spaces dedicated to labor-intensive secondary inspections. Incompatible infrastructure designs lead to the limiting of backscatter imaging machines, which hinders the efficiency of the POE.

Success Story

While backscatter imaging technology is only used on a limited basis, it has provided good results. Tucson, Arizona, sector border officials reported that within one month of deployment of a backscatter machine at a sector checkpoint, they identified 30 hidden compartments in vehicles being used to smuggle illegal drugs. The Border Patrol officials said that backscatter machines have been of great value to checkpoint officials for discovering hidden compartments (*95*).

Measures of Effectiveness

The implementation of backscatter imaging technology at border POEs has the potential to reduce secondary inspection time and eliminate human error in secondary inspections, which will reduce congestion at the POEs and reduce the amount of contraband entering the United States through these POEs.

There are no official statistics as to the impact of backscatter imaging technology since it is an emerging technology being implemented on a limited basis at certain land POEs.

Time Required (scale of 1 to 5, where 5 is most time)

3

Dollars Required (scale of 1 to 5, where 5 is most expensive)

5

32. Container Movement Software—Connecting Drayage Trucks with Terminals and Shippers

Texas Application of Strategy/Technology

Developed by the public and private sector, third-party software is being deployed to speed movement of cargo among intermodal nodes. The systems can consider dispatch scheduling, container status and location, driver availability, and traffic levels at both terminal gates and while en route—all to facilitate trucks moving the specific containers that shippers need. Some of these systems enable different kinds of container storage within terminals (so-called free-flow operations). Texas is one of three national test sites selected for a federal freight ITS system deployment.

Issues Addressed

- Urban Freight Delivery.
- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

There are two kinds of technologies for consideration: public and private.

- **Public Technologies**. The Federal Highway Administration (FHWA) has invested in the Freight Advanced Traveler Information System (FRATIS), a system that shares information among previously disconnected stakeholders—terminal operators, freight operators (shippers/receivers), and truck operators. Trucking companies are notified when containers are available, terminal operators know when trucks are coming, and truckers are informed of the best times to arrive. The systems take private and public data sets and apply algorithms to optimize freight movement among all parties.
- **Private Technologies**. Cargomatic is a private tech firm that has created software, accessible via computer and through smartphone apps, that connects truck operators with unused capacity with shippers. The system is being deployed to offer shippers easier container pickups at terminals and provide truckers with easier system access for improved dispatching and increased payments.

Keys to Successful Implementation

FHWA is currently deploying pilot tests of FRATIS in Southern California, Dallas–Fort Worth, and South Florida. Cargomatic is providing services in Southern California and New York City. Implementation best practices include:

- Multiple stakeholders determine the business case for participating in these systems. In Southern California, terminal operators and trucking firms agreed they both could benefit from information sharing.
- Southern California is piloting two very different approaches with varying levels of complication and public involvement. Metro areas in Texas may want to consider how to encourage private-sector freight ITS solutions that offer flexible approaches.
- The ITS solution needs to dovetail easily with stakeholder business practices. DFW FRATIS testing involves smaller motor carriers, the dispatchers for which are wary of trusting a computer optimization schedule over their own expertise. Systems need to enhance rather than replace internal practices.

Challenges to Implementation

Implementation challenges include:

- **Clarifying the Public Sector's Role**. As private firms offer open systems for connecting trucks and shippers and other firms offer sophisticated truck dispatching optimization software, the public sector's role in these systems is unclear. Perhaps the public sector should focus on providing access to real-time data they collect on public infrastructure conditions (e.g., congestion, construction, weather).
- **Ensuring Systems Meet Local Needs**. Systems need to be tailored to the kinds of trucking movements that occur in different metro areas. FRATIS has been deployed in a complicated port-truck environment and in a metro area with inland port-truck movements. Houston and Texas border cities, for example, would offer different challenges and potentially modified steps.

Success Story

The Port of Los Angeles is pilot testing both the FRATIS program (with the assistance and funding support of the Gateway Cities Council of Governments) and the Cargomatic system. Early implementation of both systems has generated positive feedback among participants and positive reception from the press (*96*, *97*). Formal evaluations of the FRATIS projects are underway by port officials and FHWA.

Measures of Effectiveness

FRATIS plans estimated benefits for both the public and private sectors:

- Public-Sector Benefits:
  - ITS sensors can connect with performance measurement systems for critical freight roadways.
  - Freight vehicles can generate traffic probe data.

- Air quality improvements occur through reduced waiting, safety, and regulatory compliance improvements.
- Private-Sector Benefits:
  - Pre-trip planning time savings.
  - Time savings from routing drivers around congestion.
  - Automatically matching loads.
  - Reduced empty truck-chassis movements (*98*).

Time Required (scale of 1 to 5, where 5 is most time)

3

Dollars Required (scale of 1 to 5, where 5 is most expensive)

2

Supplemental Information

The following two figures show screenshots from the Cargomatic app.

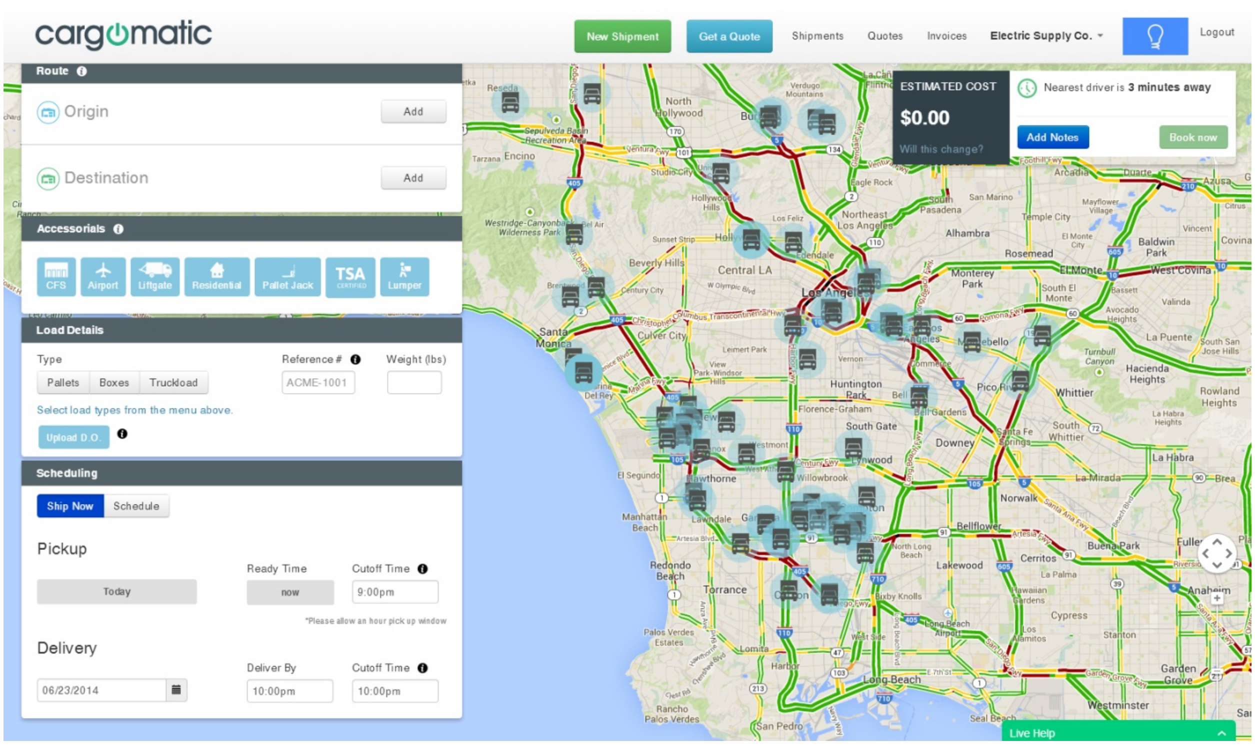


Figure A-31. Cargomatic App Screen Shot – Area Map.

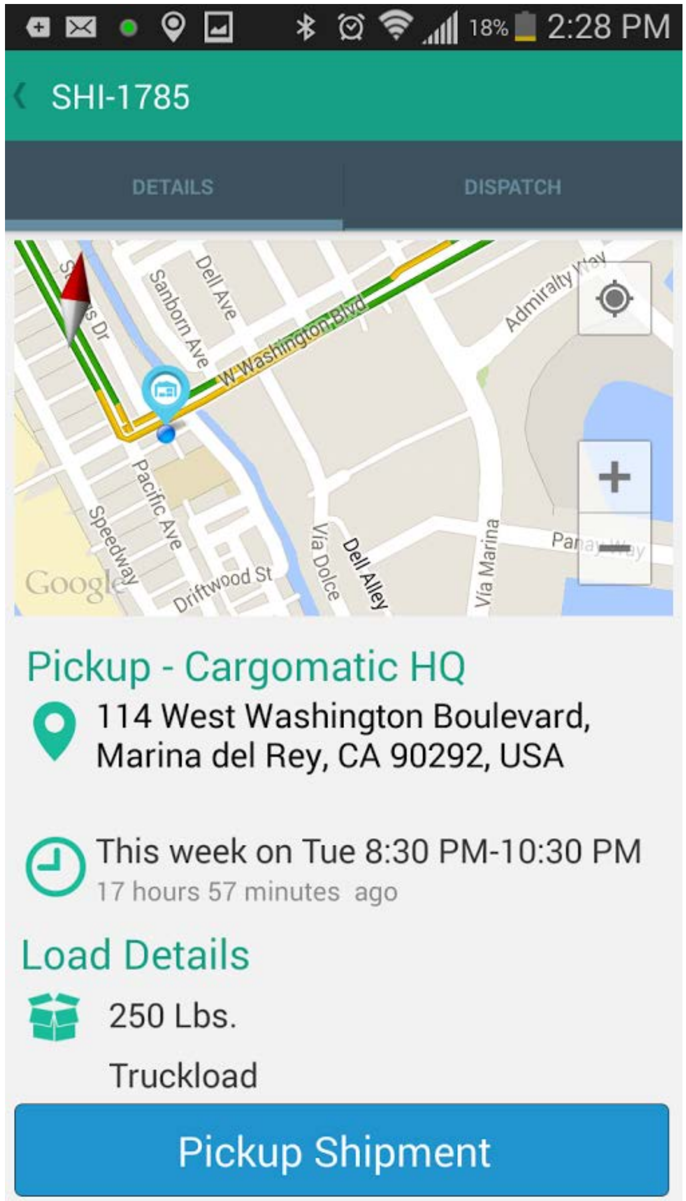


Figure A-32. Cargomatic App Screen Shot – Pickup Shipment Screen.

33. Container Sharing in the Seaport Hinterland

Texas Application of Strategy/Technology

Container sharing in the seaport hinterland would apply mostly to activity at the Ports of Houston and Freeport. Empty container movements are a major issue for users that move containerized cargo. The repositioning of empty containers causes remarkable expenses due to the fact that the costs for moving an empty container almost match the costs for moving a full container. Managing empty container moves more efficiently can create significant cost and time savings for users.

Issues Addressed

- Urban Freight Delivery.
- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

This strategy involves the development of a system to facilitate direct reuse of empty containers without an intermediate return of the box to the container depot.

Keys to Successful Implementation

It is important to have a way to equitably share potential profits/cost reductions such that each participant has a reason to continue. Research indicates that the benefits of container sharing rise if more trucking companies participate in a coalition.

Challenges to Implementation

Carriers may be reluctant to share market information on container positions and container quantities with competitors since it can reveal sensitive data concerning the demand and requirements of their customers.

Success Story

This strategy has only been tried in very narrowly defined instances. The port community at Los Angeles/Long Beach has implemented a virtual container yard (VCY). The VCY only includes trucking companies that move containers of the same shipping company.

In 1995, a large-scale experiment of eight participating shipping companies indicated that the grey box concept (where the coalition uses neutral containers apart from a company's container pool) including 1,500 containers led to a cost savings of $1.5 million for the coalition within four months.

Measures of Effectiveness

Suggested metrics for determining the effectiveness of this strategy are:

- Amount of empty container movements versus loaded containers, either as number of moves or miles moved.
- Reductions in emissions due to VMT by zero-emissions movers.

Time Required (scale of 1 to 5, where 5 is most time)

5

Dollars Required (scale of 1 to 5, where 5 is most expensive)

5

34. Creation of a Freight Village (FV) Facility

Texas Application of Strategy/Technology

The creation of a freight village (FV) facility that designates and co-locates freight-centric businesses in the same location stimulates the economic development of a region and the creation of new jobs. It also removes large-scale vehicle traffic from transitioning through the city to access other freight facilities, thereby preserving the roads, decreasing pollution, and improving safety.

Issues Addressed

- Intercity or Long-Distance Freight Corridors.
- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

A freight village is a defined area—with the best connections to air, sea, road, and rail modes of the transportation network—within which all activities are related to logistics and distribution of goods. These activities—including deconsolidation, warehousing, transshipment, and mid- and long-length transport (both for national and international transit)—are carried out by various operators, ideally with the best equipment for the transshipment between different transport modes. While FVs are intermediate destinations that facilitate the movement of goods to another destination, they also incorporate the functions of other logistics facilities. Freight villages provide the following benefits:

- Increase intermodal transportation.
- Catalyze regional economic activity.
- Improve local goods distribution.
- Promote efficient land use.

Keys to Successful Implementation of FVs

- **Intermodal capability**. A critical part of FVs is their transportation assets, such as highway connectivity and proximity to rail, air, or water transportation.
- **Existing demand**. A critical core of motor carriers, logistics firms, or freight forwarders must exist for a freight village to survive, and they must generate an adequate amount of freight movement.
- **Locational and demographical advantages**. The FV has to be close to a large population base that can provide consumers for goods and workers for the wide range of jobs available at the FV and its freight and logistics cluster.

- **International trade facilitation**. Facilitating international trade through foreign trade zone status is seen as a critical element of FVs and other large-scale logistics centers.
- **ITS infrastructure**. Sufficient telecommunications/telematics infrastructure to facilitate electronic information flows attached to coordination of freight movement within the FV is required.
- **Management plan**. The FV cannot succeed without capital funding, marketing, and cooperation among the public and private sectors.

Challenges to Implementation

The following main problem areas relating to intermodal terminals have been identified by the World Road Association:

- One of the most important challenges is to design the FV so that it possesses adequate access to the outside road network and sufficient truck parking and queueing capacity. If not, traffic jams can reduce the accessibility for pre- and post-haulage, and insufficient truck parking capacity can lead to trucks causing traffic jams with a negative impact on the public roads around the FV.
- Another big challenge is the resolution of internal conflicts between the stakeholders/tenants of the terminal, and finding ways to address the lack of communication between them.
- Public acceptance is a third challenge, mainly due to noise emissions from the terminal and the pollution from the incoming/outgoing traffic, which affects nearby urban areas often on a 24/7 basis.

Success Story

In terms of performance, the GVZ Bremen is the oldest, biggest, and highest-rated FV in Germany. This is a tri-modal, public-private partnership-funded facility featuring rail links on site, connections to two major highways, an inland waterway siding, and access to air transport capability through an international airport located 7 kilometers from the site. An additional link to the deep-water port is approximately 2 kilometers away (the distance to Bremen's city center is 8 kilometers). The overall size of the FV is 895 acres, and the facility hosts 150 different companies engaged in 20 different types of industrial and value-added or distribution activities.

Measures of Effectiveness

GVZ Bremen's FV reports that synergies and voluntary cooperation among companies located within the FV have developed. Furthermore, the facility has been able to reduce its truck trips to central Bremen by almost 15 percent by rationalizing the pickup and delivery of freight among all its members. Other measures to assess the effectiveness of an FV include:

- Shift of freight from roads to other modes.
- Reduction in traffic volume.
- Optimization of supply and disposal transport.

- Cost savings due to consolidation of transport.
- Traffic reduction in urban areas.
- Cost savings due to rationalization.
- Level of delivery service.
- Achievement of synergetic effects.

Time Required (scale of 1 to 5, where 5 is most time)

4

Dollars Required (scale of 1 to 5, where 5 is most expensive)

4

35. Customs-Trade Partnership Against Terrorism (C-TPAT)

Texas Application of Strategy/Technology

C-TPAT aims to achieve the balancing act of adopting measures that add security to the trade industry while not having a negative effect on the actual efficient flow of goods. This strategy is a coordinated effort between the U.S. Customs and Border Protection (CBP) and private companies. The two will coordinate in protecting the supply chain, identifying security gaps, and implementing specific security measures and best practices.

This strategy requires collaboration with the World Customs Organization and follows the Container Security Initiative, which provides standards for collaboration among international customs administrations that also participate in the international supply chain.

Strategy/Technology Profile

CBP will conduct a risk assessment of its private partners and assign a tier level based on their verified compliance with C-TPAT's security criteria. This level will be either Tier II or Tier III. Tier III partners are deemed the least threatening and are nine times less likely to be subjected to examinations on the border than non-C-TPAT members, as seen in Figure A-33.

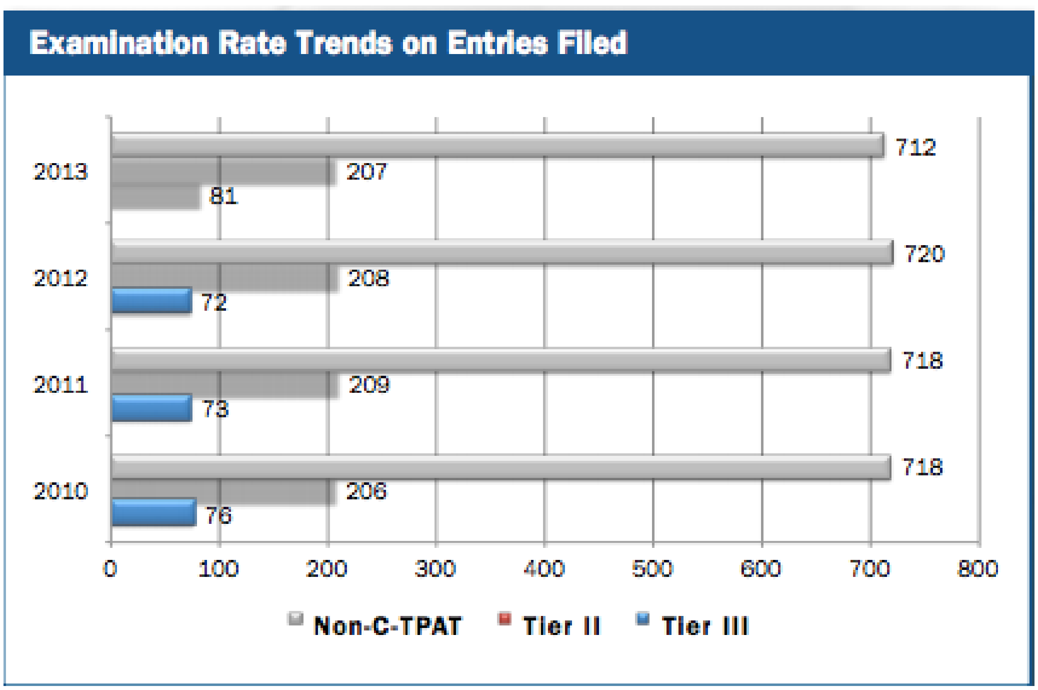


Figure A-33. Rates of Examination Between the Various Tiers.

Other benefits of being a partner with C-TPAT include (*99*):

- Front of the line processing.
- Expedited trade processing.
- Access to a C-TPAT supply chain security specialist.
- Access to the C-TPAT portal system.
- Eligibility to participate in the importer self-assessment.

Keys to Successful Implementation

The primary aspect of this strategy is the cooperation between CBP and the private sector. CBP will customize the program on a case-by-case basis with the goal of increasing security throughout all sectors of the international supply chain.

Private-sector organizations must also be cooperative with CBP's efforts in securing the international supply chain. This cooperation must provide a transparent supply chain. This strong cooperation makes it possible to identify best practices and minimum-security criteria.

C-TPAT personnel have to conduct validations and site visits in order to identify and address new risks that may arise over time. These audits must be conducted regularly in order to ensure a secure supply chain that also does not hurt trade.

Challenges to Implementation

Validation information must be consistently collected to document and uniformly apply decisions regarding C-TPAT members. A thorough records management system must be adopted and utilized so security specialists are updated and able to be flexible in response to the dynamic threats that evolve over time.

Measures of Effectiveness

The Government Accountability Office explains that CBP has developed performance measures for how C-TPAT facilitates the flow of commerce but has not developed performance measures to assess the effectiveness of how C-TPAT improves security throughout the supply chain.

There are measures for how C-TPAT has improved the efficient flow of cargo and benefited the private-sector partners. In a survey conducted by CBP, the median reported time savings was 373 person-hours annually. In this same survey, the median amount of savings was $5,350 annually for these companies. These savings ranged from $50 to $52,000,000.

Time Required (scale of 1 to 5, where 5 is most time)

2

Dollars Required (scale of 1 to 5, where 5 is most expensive)

3

Supplemental Information

- "Securing the Global Supply Chain: Customs-Trade Partnership Against Terrorism (C-TPAT) Strategic Plan." *U.S. Customs and Border Protection.* Accessed March 25, 2015. http://www.cbp.gov/sites/default/files/documents/ctpat_strat_plan_3.pdf.
- "Supply Chain Security: U.S. Customs and Border Protection Has Enhanced Its Partnership with Import Trade Sectors, but Challenges Remain in Verifying Security Practices." *Government Accountability Office.* April 25, 2008. Accessed March 25, 2015. http://www.gao.gov/products/GAO-08-240.

36. Dedicated Truck Lanes during Peak Port Freight Flows

Texas Application of Strategy/Technology

The Port of Houston's two container terminals operate Monday through Friday from 7 a.m. to 6 p.m. (in gate) or 7 p.m. (out gate). The number of trucks calling at each terminal exceeds 2,000 per day, and the port expects the number to double in the next 10 to 15 years.

However, the volume is not constant. It peaks with the arrival of large container ships and exacerbates already existing congestion. Additionally, container ships are getting larger, resulting in greater activity peaks. Port Freeport may face similar issues as its container traffic develops. Implementing dedicated truck lanes during peak freight flows would improve safety for non-commercial traffic and improve the overall throughput of the system. Changes in state demographics and international trade flows could also play a role in increased freight through the state's ports.

Issues Addressed

- Urban Freight Delivery.
- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

The high peak volumes are primarily an issue caused by inbound cargoes. Export cargoes accumulate for several weeks prior to a vessel's arrival and do not necessarily create traffic peaks. For import shipments, the port authority could set up a system where it notifies TxDOT of expected arrivals and cargo volumes of ships. Using empirical data, TxDOT could then calculate and determine how long and severe the traffic peak would be as a result of these arrivals. It could then activate dedicated truck lines using ITS signs and signals to alleviate the impact of these peaks.

Keys to Successful Implementation

This approach should target roadway segments with high levels of truck traffic and overall congestion. It may also need to target segments with high traffic-incident rates. It will have to compete with projects that are designed to make commuter travel easier; therefore, it must embody an improvement to general traffic conditions.

Challenges to Implementation

If tolls are assessed, trucks may reroute to other roadways unless they are mandated to use the dedicated lanes. If new lanes must be built, the cost could become prohibitive. For the public to buy into this approach, citizens must be convinced that safety levels will be increased and congestion will be reduced compared to the status quo.

Success Story

One of the most successful applications of dedicated truck lanes is located in New Jersey. The New Jersey Turnpike is a limited-access facility that has successfully improved operations by separating types of vehicle traffic. A 32-mile segment of the roadway has been expanded into two separate roadways, resulting in a dual-dual facility. Large trucks are limited to the outer roadway, but passenger vehicles may travel on either the inner or the outer roadway. Each of these facilities provides very limited access, and available access is through independent ramps for the inner and outer roadways. Using gates, operators can limit access to a particular roadway as needed to manage demand or in the event of an incident. The result is a roadway that operates efficiently because turbulence in the traffic flow is minimized (*47*).

Measures of Effectiveness

Suggested metrics to assess the effectiveness of this strategy include:

- Monitoring of AADT levels for dedicated truck lanes.
- Tracking of crash and fatality statistics for roadways with dedicated lanes.
- Assessment of level of service for the roadway with the dedicated lane and primary alternatives.

Time Required (scale of 1 to 5, where 5 is most time)

3

Dollars Required (scale of 1 to 5, where 5 is most expensive)

3

Supplemental Information

It is difficult to assess funding needs until it is determined whether new lanes are needed, existing lanes must be improved, or existing roadways can be used as is with only operational changes taking place.

37. FAST (Free and Secure Trade for Commercial Vehicles) Trusted Traveler Program

Texas Application of Strategy/Technology

FAST is a trusted traveler program that requires background checks to determine risk levels for commercial truck drivers. These commercial drivers are preapproved under the Customs-Trade Partnership Against Terrorism (C-TPAT).

FAST is open to truck drivers that operate in the United States, Canada, and Mexico. Drivers that are members of FAST are able to access special lanes that expedite the crossing of borders. These special lanes are capable of processing cargo and land border ports of entry.

Strategy/Technology Profile

As FAST shipments approach the port of entry, they enter the FAST lane at commercial crossings. A radio frequency identification (RFID) reader, installed in the booth, recognizes the unique identification number encoded on both the truck's windshield sticker tag and the driver's identity card and associates this information with import, carrier, and driver information already submitted electronically to the system. At the inspection booth, officers can confirm that fees have been paid, and a digital image of the driver along with biographical information is available for confirmation by the officer.

This process facilitates the flow of cargo by reducing the number of necessary inspections, which results in delay reductions at the border.

Keys to Successful Implementation

FAST lanes operate in 17 ports of entry on the southern border and 17 on the northern border. In Texas, the cities that have operating FAST lanes are:

- Brownsville.
- Laredo.
- El Paso.
- Pharr.

In order to implement these lanes, it is necessary adopt the following technologies and capabilities:

- RFID readers.
- Specialized lane for FAST truck drivers.

- Identification cards for the drivers.
- CBP officers to confirm the information that appears on the system.

For this strategy, RFID tags are given to FAST-approved carriers and must be mounted on the windshields. Each FAST lane must be equipped with RFID readers, supplied by ITS Services Inc., in order for this strategy to be effective for the freight border crossings.

Challenges to Implementation

One challenge to implementation is the funding and space at POEs for the extension of the FAST lanes into Mexico where trucks queue up for crossing into Texas. Recently, CBP has been coordinating with state departments of transportation and other agencies that contribute to the planning, funding, and construction of the facilities needed to support a FAST lane extension.

Success Story

Motor carriers that enroll in the FAST program can reduce border crossing time and also increase market share since large multinational shippers require a secure supply chain with FAST-enrolled carriers.

Measures of Effectiveness

A process that may result in truck drivers waiting hours at a border crossing can now take minutes because of these dedicated FAST lanes. There are no official statistics as to the impact of FAST. There are more than 77,000 carriers that are members of the program, but these carriers are only permitted to use FAST lanes if they are carrying goods from C-TPAT suppliers. Due to this, enrollment has decreased since 2008 (*100*). The Government Accountability Office also explains that CBP is limited in its ability to accurately quantify the impacts of staffing and supporting infrastructure on wait times (*101*).

Time Required (scale of 1 to 5, where 5 is most time)

5

Dollars Required (scale of 1 to 5, where 5 is most expensive)

4

38. Hi-Tech Yard Management Systems

Texas Application of Strategy/Technology

For terminals that have expansive yard operations, tracking the location of various assets and land-utilization patterns can be challenging. This is true for any transportation-based organization (e.g., large manufacturing centers or service staging areas), not just freight generators.

Issues Addressed

- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

One truly innovate technology that could be incorporated into yard management systems is unmanned aerial vehicles (UAVs), which can be used to track yard activity and asset locations. UAVs can take off and land from the same location automatically, with obstructions in the flight path automatically detected and avoided. Examples of UAVs include the following:

- Warehouse management systems (WMSs) oversee the activities within the four walls of the warehouse.
- Yard management systems (YMSs) provide visibility over shipments, inventory, and even security in a freight/logistics intermodal yard.
- Transportation management systems (TMSs) take over when trucks pull out of the front gate.

Yard applications are offered as standalone entities from software vendors, may come as part of larger WMS or TMS applications, or are integrated into enterprise resource planning (ERP) systems. For businesses with multiple locations, these systems can be integrated to provide an enterprise view.

Keys to Successful Implementation

UAS-based YMSs seem to be most applicable to larger enterprises. For example, a warehousing operation would likely need to have at least 250 truck parking spaces. A strong WMS needs to be in place for a YMS to make a big difference.

Challenges to Implementation

These systems will only work in yards of a certain size or larger. For warehousing operations, a minimum size of 250 truck parking spaces is needed. The firm needs to have a good grasp of available technology, which again points toward larger operations. Integration with other traffic management systems, such as FRATIS or TxDOT traffic monitoring, would also be desirable. Additional challenges to implementation are related to technology itself, including the battery life of the UAS and the ability to operate under various weather conditions.

Success Story

This technology is emerging and has not yet been largely documented in use. Potential applications and interconnection with TxDOT traffic management systems should be explored in future research.

Measures of Effectiveness

Suggested metrics to assess the effectiveness of this strategy include:

- Time spent locating equipment.
- Turn time for trucks.
- Utilization rate for equipment.
- Lost inventory write-offs.

Time Required (scale of 1 to 5, where 5 is most time)

2

Dollars Required (scale of 1 to 5, where 5 is most expensive)

3

39. Innovative Horizontal Transshipment Technique

Texas Application of Strategy/Technology

One basic problem with intermodal transport is the additional cost and time of the transfer from one vehicle to another or one mode to another. While unimodal transport can move from ramp to ramp without intermediate transfer of goods or loading units, intermodal transport necessarily includes two intermodal transfers. The use of innovative, transshipment techniques could increase the usage of intermodal transportation.

Issues Addressed

- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

Historically speaking, containers and swap bodies were not transferred horizontally. Because of their uneven bottom surfaces, the conventional means of horizontal transfer (such as conveyor belts or roller beds) were not applicable. Most current methods for horizontal transshipment show, in some important cost components, that costs per unit are almost twice those of the systems using vertical transport. However, there are new methods that have proven cost effective and more efficient than vertical transshipment techniques, mainly in several projects in Switzerland, Austria, and Hungary.

Keys to Successful Implementation

To successfully implement this technology, it is necessary to assess the current and future needs of the freight village (FV)/major freight generator, mainly due to the current restrictions of technologies used to handle special containers. Getting shippers to use new or non-standardized methods and equipment is often difficult due to expenses associated with transitioning.

Challenges to Implementation

The main challenge with this technology is the initial investment cost. Because of this, it is strongly suggested that the acquisition should be carried out both by the operators of the FV or major freight generator and the user companies.

Success Story

The Neuweiler Tuchschmid Horizontal Transshipment System (NETHS) is a typical system of its kind in Switzerland. The system contains two units. On the top of each of the units is a movable table on which the equipment for lifting and gripping is installed. The NETHS runs in a 4.25-meter-wide track, which is designed such that a normal gauge track can be situated in the middle. ISO-containers are handled from the top at the upper corner fittings. Swap bodies are gripped at the bottom with scissors arms. The system can operate in manual, semi-automatic, and fully automatic modes. Figure A-34 demonstrates the system.

Source: (102)

Figure A-34. Pictures of the Neuweiler Tuchschmid Horizontal Transshipment System (NETHS).

Measures of Effectiveness

The costs calculated for the horizontal transshipment demonstrate a break-even price level that is about 33 percent less compared to the presently adopted vertical techniques. In fact, the low costs of equipment, the automation of the system, and the small surfaces required are associated with low energy consumption and limited manpower requirements. In particular, the infrastructure investment costs of the horizontal solution are 40 to 60 percent less than the vertical solution; the technological costs are 25 to 35 percent less; and the management costs are about 30 to 40 percent less.

Time Required (scale of 1 to 5, where 5 is most time)

2

Dollars Required (scale of 1 to 5, where 5 is most expensive)

3

40. Intelligent Truck Control System

Texas Application of Strategy/Technology

Truck traffic around port terminals places a heavy load on the surrounding community. Managing the flow and routing of this traffic could increase the capacity of existing infrastructure, reduce emissions and noise pollution, reduce congestion, and lower the cost of freight handling throughout the state of Texas.

Issues Addressed

- Intercity or Long-Distance Freight Corridors.
- Urban Freight Delivery.
- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

The goals are to:

- Fuse data on trucks, cargoes, and drivers.
- Analyze capacity utilization of roads and terminals.
- Manage truck movements in and around the port.

Keys to Successful Implementation

For each port community, a champion and a project coordinator are necessary. This type of system crosses many political boundaries and operating entities. It is particularly important to convince trucking and freight interests that the effort and cost of developing such a system will yield tangible benefits.

Challenges to Implementation

This type of project covers a spectrum of political jurisdictions and industries, hence the need for a champion and/or project coordinator to make implementation successful. Trucking firms especially need to be convinced of the benefits of this system. They may fear that another level of regulatory or fiscal control is being imposed.

Success Story

The Kingdom of Jordan, with the assistance of the U.S. Trade and Development Administration, developed a customized intelligent truck control system at the Port of Aqaba. The government reports that congestion disappeared overnight, inland transport costs dropped 20 percent, and carbon emissions dropped by 5,000 metric tons annually.

Measures of Effectiveness

Suggested metrics to assess the effectiveness of this strategy include:

- Congestion on major arteries.
- Time trucks spend waiting at the port terminal, both inside and outside the gate.
- Relation of the above two metrics to tonnage handled.

Time Required (scale of 1 to 5, where 5 is most time)

3

Dollars Required (scale of 1 to 5, where 5 is most expensive)

3

41. International Border Crossing Electronic Screening of Trucks

Texas Application of Strategy/Technology

Vehicle inspection at ports of entry (POEs) is performed by the Federal Motor Carrier Safety Administration (FMCSA) inside the federal compound and by the Texas Department of Public Safety (TxDPS) at the border safety inspection facility (BSIF). FMCSA developed the International Border Crossing Electronic Screening of Trucks (IBC e-Screening) System to provide a data-driven (as opposed to random) approach to select commercial vehicles for inspection at international border crossings. The objective of the project was to plan, design, and test an alert-based system that targets unsafe carriers and expedites the flow of commercial traffic though international crossings (*103*).

The benefits of IBC e-Screening include:

- Screen carriers, trucks, trailers, and drivers without the need for an onsite enrollment process or manual data entry.
- Increase the number of full safety and compliance verifications through border crossings by reducing the time required to verify safety and compliance status of carriers, trucks, trailers, and drivers.
- Increase an officer's productivity by focusing limited resources on carriers, trucks, trailers, and drivers who are known to have a safety or compliance violation and who are not able to be identified electronically.
- Greatly reduce the time required to complete full safety and compliance verifications.

Strategy/Technology Profile

Motor carriers and other eligible parties are required to file an electronic manifest (e-manifest) with Customs and Border Protection (CBP) prior to a truck entering the United States through a land border crossing. With the IBC e-Screening System, a subset of data from the e-manifest is electronically transmitted to FMCSA and TxDPS BSIF officers prior to the truck's arrival at CBP. The subset of data includes key identifiers for the carrier, truck, trailer, and driver for each truck trip into the United States.

The IBC e-Screening system flags carriers/drivers before they reach the border. Such flagging considers the:

- Date of issue of Commercial Vehicle Safety Alliance (CVSA) decal associated with power unit.
- Insurance status/coverage.
- Carrier's federal operating authority status.
- Driver's violation status.
- Carrier's out-of-service status.

- Carrier’s safety status.
- Commercial driver’s license status and endorsements.

Figure A-35 shows the concept of how the system works and provides advanced screening results to the state’s officers. The figure shows the truck’s physical movement and the information flow. Figure A-36 illustrates the system interface that TxDPS officers use to receive safety history and status of carriers/trucks/drivers that are planning to enter, have entered the United States from Mexico, and/or have been inspected by FMCSA.

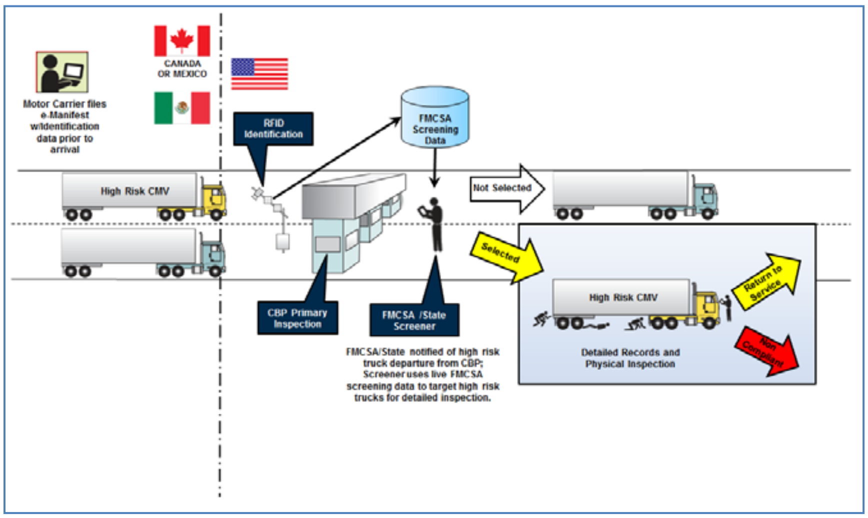


Figure A-35. International Border Crossing Electronic Screening of Trucks Concept.

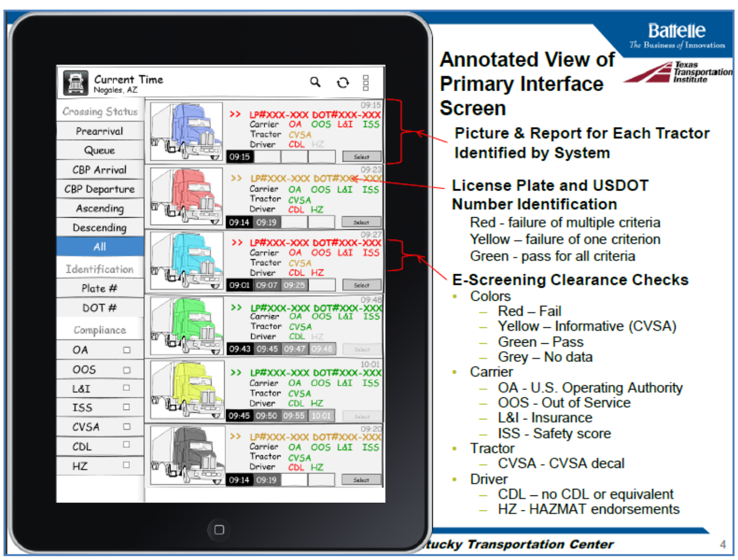


Figure A-36. System Interface That TxDPS Officers Use to Receive Safety History and Status of Carriers/Trucks/Drivers That Are Planning to Enter, Have Entered the United States from Mexico, and/or Have Been Inspected by FMCSA.

Keys to Successful Implementation

This system requires cooperation among all stakeholders operating at the border—most importantly CBP and FMCSA. The key elements to implementing this system are as follows:

- Effective database management.
- Implementation of detection equipment before truck arrives to inspection facilities to provide sufficient time for software to perform queries and send information back to inspectors.

Challenges to Implementation

The primary challenge of implementing this system is the coordinated effort between U.S. state and federal agencies. The truck database has to be up to date with maintenance service records and other carrier information at the truck level. The other challenge is to install and maintain roadside equipment in Mexico and the United States to assure it provides reliable information.

Success Story

There is not yet an example of this system being implemented, other than a pilot test that was performed in El Paso.

Measures of Effectiveness

There are no measures of effectiveness for this program since it has not yet been fully implemented. However, effectiveness would be measured by increasing the number of inspections of carriers that have safety issues.

Time Required (scale of 1 to 5, where 5 is most time)

5

Dollars Required (scale of 1 to 5, where 5 is most expensive)

4

42. ITS for Seaports

Texas Application of Strategy/Technology

Seaports represent a complex system of highly dynamic interactions between various handling, transportation, and storage units; unfortunately, those who rely on seaports for moving freight often suffer from incomplete knowledge of what the future holds. As a transport node, a seaport:

- Focuses on a number of different means of transport (e.g., maritime, road, rail, IWW, pipe).
- Renders a variety of services (e.g., stevedoring, handling, forwarding, logistics, etc.).
- Operates in different dedicated facilities (e.g., bulk, ferry, container terminals, storage areas and warehouses, and land and sea infrastructure connections).

The wide external interconnections between a port and its surroundings need proper coordination and control.

Issues Addressed

- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

ITS installations can be designed to accomplish several objectives simultaneously. First, they can serve as a coordinating resource for the multiple documents required for a cargo movement to take place by government agencies, terminal operators, agents, etc. Second, they may serve as access control. Third, ITS may focus on the internal workings of the terminal, tracking movements and documentation requirements inside the fence. Finally, ITS may be used in conjunction with automated equipment within the terminal.

Keys to Successful Implementation

This approach requires a thorough understanding of a number of sensor technologies and automated equipment types. The ability to tie data together into a meaningful whole is critical. Building on what other ports around the globe have already accomplished could yield significant benefits in terms of decreasing start-up times, false starts, and overall costs.

Challenges to Implementation

The large number of available technologies and automated equipment will make this approach feasible only in those instances where seaports have the resources to investigate, test, design, and implement these technologies effectively.

Success Story

The Port of Charleston has a high-level document-handling system in place called ORION. Gate access systems are in place at a number of ports around the globe. Almost every container terminal in North America and Europe has some kind of terminal management system in place for its internal operations. Several ports are using automated terminal equipment as part of their ITS approach (e.g., Hamburg, Rotterdam, and Singapore).

Measures of Effectiveness

Suggested metrics to assess the effectiveness of this strategy include:

- Turn time for users.
- Tons handle versus labor hours.
- Congestion indices at terminal gates.
- Customer satisfaction with processes.
- Number of exceptions processed for freight transactions.

Time Required (scale of 1 to 5, where 5 is most time)

5

Dollars Required (scale of 1 to 5, where 5 is most expensive)

5

43. License Plate Readers (LPRs)

Texas Application of Strategy/Technology

Customs and Border Protection (CBP) has deployed license plate readers at land ports of entry (POEs) to automatically read license plates as they enter the primary inspection area of these POEs. In 1993, the U.S. Customs Service signed a contract to install LPRs at various POEs. By 1998, LPRs were deployed to an additional 34 southern LPOEs.

CBP officers now spend less time manually inputting information, which reduces inspection times and improves the accuracy of information collection. This practice also allows officers to interact with vehicle occupants rather than having to focus on recording basic information.

Strategy/Technology Profile

Before commercial vehicle traffic crosses the border, it must provide CBP a cargo manifest one hour prior to arrival. Automated LPRs assist in the verification of vehicles when approaching the border. When commercial vehicles arrive at the primary border crossing lane, LPRs will read license plates and run checks through law enforcement databases. After the license plate is read, CBP officers may conduct a search of the vehicle based on the license plate information.

Depending on the results of the search during primary inspection, CBP officers may decide to run more extensive searches in vehicle secondary inspection for processing. The data from the LPR system are also combined with data obtained from radio frequency identification readers to provide border personnel with a comprehensive vehicle/passenger identification system.

Keys to Successful Implementation

There are a few keys to the successful implementation of LPRs on the border:

- Integrated system with other databases.
- Operators to ensure privacy policies.
- Computer storage to keep track of the large number of license plates that are being read by the LPR.

In order to be successfully implemented, LPRs must be connected with law enforcement databases and the systems must be completely integrated with other systems in order to automate this exchange of information and make it simple for CBP officers to make critical decisions when processing searches in primary and secondary inspection. In other states, the implementation of this technology also requires operators to ensure that the information the operator collects is protected according to standard privacy policies.

As more license plates are read and stored in the system, it is more difficult to run scans that search for security threats, and it will become increasingly more time consuming.

Challenges to Implementation

There are three primary challenges to the implementation of LPRs along the border:

- Privacy.
- Safeguarding of information.
- Coordinating with Mexican authorities regarding the management of information and information exchange.

Texas law does not allow installing LPRs on roadways other than toll roads. In order for Texas to implement a system in roadways serving land POEs, the law would need to be changed. Privacy concerns remain a large challenge to the implementation of LPRs. Organizations are worried about the government tracking the exact movements of vehicles and not protecting this information from being accessed by competitors. Certain studies have presented conclusions that there appear to be concerns about Mexican agencies being unable to protect data recorded by U.S. agencies, which can result in the corruption of this technology.

Success Story

As mentioned above, the law does not allow for the installation of LPRs at non-toll roadways; therefore, there are no success stories at the Texas state level. However, the technology has proven to be successful in identifying vehicles before they reach an inspection point at the federal compound approaching the border crossing.

Measures of Effectiveness

There are no measures of effectiveness for this program since it has not yet been fully implemented. However, effectiveness would be measured by increasing the number of inspections of carriers that have a record of prior safety issues.

Time Required (scale of 1 to 5, where 5 is most time)

4

Dollars Required (scale of 1 to 5, where 5 is most expensive)

5

Supplemental Information

- RAND Corporation. “License Plate Readers for Law Enforcement: Opportunities and Obstacles.” https://www.ncjrs.gov/pdffiles1/nij/grants/247283.pdf.

44. Natural-Gas-Fueled Towboat

Texas Application of Strategy/Technology

Texas's economy and environment could potentially benefit from using natural gas fuel in marine freight movement on coastal and river waterways. Converting river towboat engines to dual fuel (DF) of diesel/natural gas would dramatically increase the market for natural gas production and wholesale purchases, ultimately benefiting the natural gas exploration and production industry. Towboat operators would benefit from reduced fuel/maintenance costs and increased asset life. Texas and the densely populated regions surrounding ports would benefit via reduced emissions of NO_x and particulates. Productivity involving waterway freight movement should neither suffer nor be particularly enhanced by adoption of DF.

Strategy/Technology Profile

Using DF in towboats would merely extend an existing, proven practice in locomotives and trucks already in place today to a new mode. Large river towboat engines are generally the same ones used in railroad locomotives as designed by ElecroMotive Diesel (EMD). Technology for the conversion of the EMD has been repeatedly demonstrated in successful operation of the DF systems currently produced by Energy Conversions Inc. of Tacoma, Washington. The U.S. Coast Guard (USCG) has developed standards and regulations in conjunction with the Long Island Ferry system to implement the safe use of natural gas on board marine vessels. The American Board of Shipping (ABS) has been developing marine vessel natural gas safety standards in conjunction with USCG for the safe use of natural gas on board U.S.-registered (Jones Act) marine vessels.

Keys to Successful Implementation

The use of liquefied natural gas (LNG) as fuel in towboats has not yet been successfully demonstrated like it has in rail locomotives and trucks. Harvey Gulf International Marine developed an offshore vessel (OSV) that uses dual-fuel technology and LNG as the natural gas storage medium. This first of eight of these systems has been awarded the ABS's "ENVIRO+, Green Passport" certification. Harvey states that the only effective solution for complying with the U.S. Environmental Protection Agency (EPA) emission regulations governing marine engines in their class is using natural gas. Keys to successful implementation include the following:

- Original equipment manufacturer (OEM) dual-fuel engines and conversions should be available from recognized OEM suppliers to the industry.
- Engine performance must be equal to diesel.
- LNG fueling infrastructure must exist.
- Overall reduced emission output must comply with U.S. EPA regulation.
- Competitive fuel-provider network must exist.

- Industry-recognized reduced engine maintenance of consumables (e.g., lube oil, fuel filter, oil filter, engine bearing life increase, etc.) must exist.
- Industry-recognized long-term fuel availability must exist.

Challenges to Implementation

The main challenge to implementation is the cost of conversion and the lack of willingness to change fuel sources without a completed test proving this technology in the waterway environment. The U.S. Maritime Administration is currently beginning such a study to prove natural gas/DF use in this environment. Fuel availability in the operating environment would be another challenge because natural gas fueling stations may not be readily available at ports and terminals.

Success Story

The development of regulation by USCG and ABS has facilitated implementation of natural gas as fuel in the marine towboat industry. Harvey Gulf's commitment to using natural gas in all its new OSVs helps to validate the economic viability of the technology. Several demonstration programs for NG-fueled river towboats are in the development stages and are expected to be announced in the near future. The U.S. Maritime Administration has released requests for proposals for demonstration projects, with proposals due in the summer of 2015.

Measures of Effectiveness

Suggested metrics to assess the effectiveness of this strategy include the following estimates of readiness for implementation:

- Fuel cost reduction—4.
- Interoperability with existing fleet—5.
- LNG fuel availability—3.
- Emission compliance with U.S. EPA for the application—5.

Time Required (scale of 1 to 5, where 5 is most time)

5

Dollars Required (scale of 1 to 5, where 5 is most expensive)

5

45. Off-Peak Incentive Program for Container Terminals/Extended Gate Hours

Texas Application of Strategy/Technology

The Port of Houston's two container terminals operate Monday through Friday from 7 a.m. to 6 p.m. (in gate) or 7 p.m. (out gate). The number of trucks calling at each terminal exceeds 2,000 per day, and the port expects the number to double in the next 10 to 15 years. Additionally, ships are getting larger, resulting in greater activity peaks. Port Freeport may face similar issues as its container traffic develops. Incentivizing shippers and receivers to do business outside normal business hours helps smooth traffic, improve air quality, reduce congestion, and speed up turn times in terminals.

Issues Addressed

- Urban Freight Delivery.
- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

In this strategy, the port would charge beneficial cargo owners for each container (TEU) that moves during normal (peak) business hours but will not assess a fee for off-peak transactions. Peak hours would most likely be defined as 3 a.m. to 5 p.m. Monday through Friday.

Keys to Successful Implementation

A number of ports have extended their gate hours during the week, but few have implemented measures to move traffic to off-peak hours. Extended gate-hour programs have been initiated at Port Metro Vancouver (2014); Los Angeles/Long Beach (2005); and Virginia Port Authority, Savannah, New Orleans, and Charleston (limited). Only Los Angeles/Long Beach and Vancouver impose fees. A program was attempted at New York/New Jersey but was terminated due to lack of demand. Keys to successful implementation include the following:

- Fees must be based on cost-recovery or targeted-diversion levels, not income potential.
- Labor, shippers, and trucking firms must all have a voice.
- Threat of legislative or regulatory intervention is a strong driver.
- Labor needs to support the program.

Challenges to Implementation

- Customs availability must be adequate.
- Chassis providers, steamship lines, and shippers and consignees must extend their workdays to match the new port hours.

Success Story

In Los Angeles/Long Beach, 55 percent of the traffic has been moved to off-peak hours. Implementing the strategy also reduced total turn time for trucks. Savannah decreased truck turn times even though container volumes doubled. The question in Texas is whether congestion and/or air quality are perceived as having reached critical levels. There is no technical reason why the program cannot succeed here in Texas.

Measures of Effectiveness

Suggested metrics to assess the effectiveness of this strategy include:

- Percentage of truck trips using extended gate hours.
- Terminal processing time.
- Queue lengths outside the gates.

Time Required (scale of 1 to 5, where 5 is most time)

3

Dollars Required (scale of 1 to 5, where 5 is most expensive)

2

Supplemental Information

The main cost of this strategy is the development of an accounting system to assess and collect fees. For a description of the most developed program, see www.pierpass.org.

46. On-Dock Rail

Texas Application of Strategy/Technology

For many ports, on-dock rail (i.e., rail track located on the dock immediately next to the waterfront) offers a vital link to efficiently move goods directly between ships and trains to get the goods to major distribution centers. Having up-to-date on-dock and near-dock rail able to accommodate all the discretionary cargo that must be moved to and from a port's hinterland is a big priority for U.S. seaports.

Issues Addressed

- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

On-dock rail refers to rail spurs that run alongside the vessel and allow for the direct transfer of cargo between the vessel and the rail car. It is often built into new container terminals, but many existing terminals need a retrofit that will enable on-dock rail movements to occur.

Keys to Successful Implementation

For the approach to work, there must be an efficient connection to freight rail lines that can get the cargo out of the port to a remote destination quickly. Of course, this presumes that a large number of movements take place where the distance is great enough for rail movements to be effective.

Challenges to Implementation

Funding is the biggest challenge. On-dock rail is expensive, and ports attempting to modernize or deal with the ever-increasing size of oceangoing vessels tend to be cash strapped.

Success Story

A significant number of U.S. seaports report that they have on-dock rail and that it is a critical component of their infrastructure. The most innovative and highest volume on-dock rail project is the Alameda Corridor project in the ports of Los Angeles/Long Beach.

Measures of Effectiveness

Suggested metrics for determining the effectiveness of this strategy include:

- Average time between discharge of cargo from vessel and its departure from the terminal (or conversely time from arrival at terminal to loading onto vessel)—dwell time.
- Amount of cargo moving by rail.

Time Required (scale of 1 to 5, where 5 is most time)

2

Dollars Required (scale of 1 to 5, where 5 is most expensive)

5

Supplemental Information

Figure A-37 provides two images of on-dock rail.

Figure A-37. Images of On-Dock Rail.

47. Photonuclear Gamma Ray Imaging

Texas Application of Strategy/Technology

Photonuclear gamma ray imaging is a high-resolution imaging technology that can fully penetrate cargo containers and any concealment devices to detect chemical signatures. This technology can detect dangerous and elusive threats, including organic explosives, plastic and metallic weapons, and radioactive devices such as dirty bombs and nuclear weapons of mass destruction.

Photonuclear gamma imaging at land ports of entry (POEs) will allow freight containers to be checked by customs officials at a rapid rate without unloading the containers. Photonuclear gamma ray imaging technology also helps to eliminate human error from the customs check by providing an in-depth scan of the shipping containers and detecting chemical signatures.

Strategy/Technology Profile

As trucks enter the United States, they are subjected to a primary inspection in which customs officials verify the driver and cargo against information electronically filed by the U.S. brokers. At this point, customs officials use their discretion to determine if the freight requires a secondary inspection. If a secondary inspection is required, the freight is directed to one of several secondary inspection stations, including photonuclear gamma ray imaging stations.

Once at a backscatter x-ray imaging station, the fright container is imaged from end to end. The photonuclear imaging machine produces a high-resolution image that allows customs officials to confirm the contents of freight containers and flag any suspicious cargo. The photonuclear gamma ray imaging technology cuts down the time of secondary inspections by avoiding manual inspections and helps to eliminate human error by providing a high-resolution image of the container's contents.

Keys to Successful Implementation

Photonuclear gamma ray imaging technologies are primarily implemented at the southern border in cases that involve suspected narcotic transportation. Narcotic suspicions are easily verified or disqualified through photonuclear gamma ray images, which have reduced the time of secondary inspections. Photonuclear gamma ray imaging has also reduced the number of manual inspections, which has freed up dock capacity at the POE for other uses.

In order for Texas to implement this technology efficiently, it would be necessary adopt the following procedures:

- Employ more photonuclear gamma ray imaging machines at each POE.
- Properly train photonuclear gamma ray imaging technicians to recognize contraband cargo.

- Increase the number of personnel available and qualified to operate photonuclear gamma ray imaging machines at each POE.
- Reconfigure the POE infrastructure to include space for photonuclear gamma ray imaging technology.

Challenges to Implementation

One challenge to the implementation of photonuclear gamma ray imaging technology is the infrastructure of border POEs. Photonuclear gamma ray imaging machines are not compatible with the original design of most POEs, which tend to have large dock spaces dedicated to labor-intensive secondary inspections. Incompatible infrastructure designs lead to the limiting of photonuclear gamma ray imaging machines, which hinders the efficiency of the POE.

Success Story

This technology has not yet been implemented at land POEs.

Measures of Effectiveness

The implementation of photonuclear gamma ray imaging technology at border POEs has the potential to reduce secondary inspection time and eliminate human error in secondary inspections, which will reduce congestion at the POEs and reduce the amount of contraband entering the United States through these POEs. There are no official statistics as to the impact of photonuclear gamma ray imaging technology since it is an emerging technology that is being implemented on a limited basis at certain land POEs.

Time Required (scale of 1 to 5, where 5 is most time)

4

Dollars Required (scale of 1 to 5, where 5 is most expensive)

5

48. Port-to-Rail Intermodal Improvements

Texas Application of Strategy/Technology

Houston is the ninth busiest container port in North America and the largest on the Gulf Coast. A portion of the containers processed through the port are destined for regions outside the Houston metro area, including Dallas–Fort Worth. Moving more container freight directly from container ships to rail could reduce truck trips in the Houston region and on I-45. Expanded port-rail intermodal connections could direct more containers onto rail instead of trucks.

Issues Addressed

- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

Expanding the rail-handling capacity within container terminals would allow more containers to be moved from ships to rail near dockside, rather than trucked to another location, transloaded, and then shipped longer distances by truck or rail. This strategy requires coordination with ocean shippers to load containers with rail connections in mind. It also requires that container terminal operators contract with rail operators to switch intermodal cars onsite. More direct ship to on-dock rail movements would reduce drayage trucking movements within congested, nonattainment metro areas.

Keys to Successful Implementation

A number of West Coast ports have successfully integrated port-rail transfers, including the Ports of Los Angeles and Long Beach, California, and Vancouver and Prince Rupert, British Columbia. Shippers importing containers through these ports have been able to classify units destined for the Midwest or East Coast and divert those containers directly to rail. Port-rail connectivity requires:

- Sufficient rail capacity on or near docks.
- Careful management by third-party logistics companies (3PLs) to load and unload ships to facilitate on-terminal movement to rail.
- Sufficient and regular railcar volume to attract and retain high-performance service from railroads.

Challenges to Implementation

Union Pacific Railroad offers twice weekly shuttle service from Houston container ports to its Dallas Intermodal Terminal. However, container volumes into Houston may have to increase before sufficient numbers of cars can be moved by rail to common regional destinations (e.g., Chicago, Atlanta, or Ohio).

Houston's rail network would also need to offer time-competitive service to truck moves of containers, particularly within Texas.

In Los Angeles and Long Beach, about one-third of containers move to local destinations, but the overall volume is so much higher than Houston—by a factor of 9 to 10—that through-movements can be successfully captured by on-dock trains that do not require further switching or handling through regional railyards.

Success Story

The Port of Oakland has two yards operated by BNSF and UP and is developing additional rail capacity as part of redevelopment of the former Oakland Army Base into the Oakland Global Trade and Industry Center (OGTIC). This project will expand railyards at a former Army base into a new intermodal yard with storage capacity for unit trains moving in and out of other port railyards and additional manifest business generated by new warehousing operations in OGTIC. The $1.2 billion project is supported by the port, city, state, federal, and private funds.

Measures of Effectiveness

Oakland's new OGTIC could move more bulk commodities (e.g., grain, wheat, etc.) by rail to be transloaded to containers for ocean shipment. The port has also executed a master project labor agreement that enhances local hiring (50 percent of total project hours) and local apprenticeships.

Time Required (scale of 1 to 5, where 5 is most time)

3

Dollars Required (scale of 1 to 5, where 5 is most expensive)

3

Supplemental Information

More information the OGTIC can be found on the port's website (http://tinyurl.com/q43sla2), including a rail master plan (http://tinyurl.com/pxoj93e).

49. Precision Docking System

Texas Application of Strategy/Technology

The use of a precision docking system could significantly reduce the loading/unloading time in the daily operations of a freight village/high-density freight generator area.

Issues Addressed

- Urban Freight Delivery.
- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

A precision docking system is used to facilitate easy boarding and alighting of transit bus passengers; however, this technology could also be applied to support truck maneuvers in the loading/unloading process near warehouses and other facilities. Cost estimates (2004) for in-vehicle components ranged from USD $2,700 to $14,000 per bus depending on the number of units produced. These prices may have increased, but technology has also improved since that study was completed.

Keys to Successful Implementation

For successful implementation, it is necessary to have the support of the carriers and users of a freight village, taking advantage of scale economies and adapting this system in all the trucks that will have access to the freight village. Another key factor is to have proper distribution and size for the loading and unloading docks in order to maximize the benefits of this technology.

Challenges to Implementation

Major implementation difficulties are related to the initial cost of the investment, which can be very high if economies of scale are not exploited. Another challenge would be overcoming the poor planning and design of the loading/unloading areas, which may prevent the proper use of this technology.

Success Story

Although there is no literature related to the implementation of these systems to improve the operations of a freight village, there are several cases where these systems are implemented in urban transportation environments to reduce the time of loading/unloading passengers in densely populated cities (e.g., Chicago).

Measures of Effectiveness

Considering that these systems generate average savings of 7.5 seconds per docking—and considering that 1,179,167 trucks a year travel within a freight village with a high level of demand (e.g., Interporto Bologna, 2013: inbound 594,368; outbound 584,699)—it can be estimated that the time saved with these systems could be up to 2,456.6 hours a year, thus generating significant savings in time and money.

Time Required (scale of 1 to 5, where 5 is most time)

4

Dollars Required (scale of 1 to 5, where 5 is most expensive)

4

50. Radiation Portal Monitors (RPMs)

Texas Application of Strategy/Technology

After the events of September 11, 2001, a large concern throughout the nation's ports of entry (POEs) was the prevention of terrorist weapons—including weapons of mass destruction—from entering the country. Customs and Border Protection (CBP) must prevent the smuggling of these weapons across the border, while also facilitating the flow of legitimate trade for the U.S. economy. The deployment of portal monitors is an important component of "CBP's multi-layered strategy to prevent the introduction of nuclear and radiological materials into the country" (*104*).

Strategy/Technology Profile

Radiation portal monitors and the associated radiation-detection equipment have been deployed at all CBP POEs across the nation. These RPMs detect energy emitted from radiological material but do not emit any radiation of their own, so they are safe for travelers to pass through. These RPMs can be deployed as stationary inspection sites, as demonstrated in Figure A-38, or used as mobile units at the land POEs.

Source(105)

Figure A-38. Picture of a Stationary RPM.

With these monitors, it is possible to observe any threatening materials while also not contributing to excessive additional delays during border crossings. Use of this technology makes it possible to have truck drivers remain in their vehicles during the process, which allows for the more efficient flow of cargo while assuring security.

Keys to Successful Implementation

For a new technology to be implemented, it must be able to pass tests on CBP's interdiction system and meet additional criteria that CBP specifies on a case-by-case basis. This testing determines if normal operating conditions are actually improved by the new technology. Recently, a next-generation RPM was developed but failed the field validation tests. This failure resulted in the cancellation of the program that was envisioned to cost $2–3 billion to implement. At that cost level, in order to successfully implement newer RPMs, it must be proven that there is a "significant increase in operational effectiveness" (*106*). Figure A-39 provides criteria for demonstrating a significant increase in operational effectiveness.

Primary screening criteria	Secondary screening criteria
1. When special nuclear material is present in cargo without naturally occurring radioactive material, ASP's probability of detecting the material must be equal to or greater than that of the RPMs used by CBP. 2. When special nuclear material is present in cargo along with naturally occurring radioactive material, the ASP must increase the probability of detecting and identifying the material compared with CBP's currently deployed RPMs and handheld detectors. 3. When medical or industrial radiological sources are present in cargo, ASP's probability of detecting the sources must be equal to or greater than that of CBP's currently deployed RPMs. 4. When the only radiological source present in the cargo is naturally occurring radioactive material, the ASP must refer at least 80 percent fewer trucks for secondary screening than CBP's currently deployed RPMs.	1. When compared with CBP's currently deployed handheld detectors, ASP must reduce, by at least a factor of 2, the probability that special nuclear material is misidentified as naturally occurring radioactive material, a medical or industrial radiological source, an unknown radiological source, or no radiological source at all. 2. When compared with CBP's currently deployed handheld detectors, ASP must reduce the average time required to correctly release trucks from secondary screening.

Source: GAO summary of DHS documentation.

Source: (106)

Figure A-39. Criteria for Demonstrating a Significant Increase in Operational Effectiveness.

Challenges to Implementation

One challenge to the current generation of RPMs is that they can detect, but not identify, sources of radiation. This inability to detect sources means that the RPMs' alarms can be triggered by naturally occurring radiation. When the alarms are triggered, cargo is sent through a secondary screening that involves a CBP officer using a handheld radiation detector. This process can slow down the flow of traffic because of the many scenarios where a false alarm will be triggered. Newer generations of RPMs are designed to address this issue, but they are seen as costly and have not demonstrated a significant increase in operational effectiveness.

Success Story

Newer generations of RPM technology have not yet been implemented at land POEs.

Measures of Effectiveness

There are no current measures of effectiveness for RPMs, and their overall effect on freight transportation movement has not been fully assessed.

Time Required (scale of 1 to 5, where 5 is most time)

5

Dollars Required (scale of 1 to 5, where 5 is most expensive)

5

51. Semi-Automated Intermodal Facility

Texas Application of Strategy/Technology

High-tech design of an intermodal facility could result in much greater efficiency, including a reduction in noise and emissions. This design could be employed at any intermodal yard in Texas and may also have applicability to seaport container terminals.

Issues Addressed

- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

In this strategy, drivers self-check into a facility, cameras record the condition of equipment, and an electronic board notifies drivers of projected wait times and when they can proceed. For rail traffic, a car-tracking system eliminates the need for clerks to be out in the yard to verify trains. When a train enters the facility, it goes through a portal with a bank of cameras; an automatic equipment identification (AEI) reader records the car number; optical character cameras read the containers; and as the train passes through turnouts in the yard, axle counters record the number of axles. Electric cranes reduce noise and emissions. They can also self-power using braking capabilities of the machines to generate electricity when containers are lowered.

Keys to Successful Implementation

One key to a successful implementation is to carefully design and implement the interfaces between the various readers and tracking equipment. A good training program for those tracking and monitoring the information is also an important prerequisite given the nature of the readers and cranes to be used.

Challenges to Implementation

The biggest challenge is to be sure all of the technology works together in an integrated fashion. Also, because this is relatively new technology, good training and information oversight/management programs must be implemented and maintained.

Success Story

CSX Intermodal Terminals implemented this strategy at its Northwest Ohio Facility. According to CSX, "We're able to move traffic through Northwest Ohio, combine the destination traffic from multiple origins and create density to allow us to run a train from Northwest Ohio to all those points on the network. The efficiency of the terminal's new systems makes us more reliable, while allowing us to go to more places than we went before." The strategy was such a success that CSX plans to implement changes at all 35 of its existing intermodal facilities within three years.

Measures of Effectiveness

The potential metrics need to be thoroughly evaluated. Some suggestions include:

- Turnaround time for truck drivers.
- Rail cars handled per employee.
- Tonnage per employee.
- Estimated emissions reduction for yard equipment.

Time Required (scale of 1 to 5, where 5 is most time)

5

Dollars Required (scale of 1 to 5, where 5 is most expensive)

4

52. Traffic Signal Priority System

Texas Application of Strategy/Technology

Use of traffic signal priority systems for transit can reduce transit travel times, improve schedule adherence, improve transit efficiency, and increase road network efficiency as measured by person mobility. This strategy could also be applied in conjunction with other intelligent transportation systems in order to get the most out of the benefits. Even though these systems are normally applied in passenger buses, they could also be applied in important or delicate cargo trucks, perhaps near the entrance/exit of major freight generators or specialized freight villages. Many areas in Texas near such facilities could implement this technology.

Issues Addressed

- Intercity or Long-Distance Freight Corridors.
- Urban Freight Delivery.

Strategy/Technology Profile

Currently, traffic signal priority makes it possible for an instrumented bus or truck approaching an intersection during the final seconds of the green signal cycle to request an extension of it so that the vehicle can pass through before the signal turns red. The signal priority system is made up of four components:

- A detection system to know where the vehicle requesting signal priority is located.
- A priority-request generator that alerts the traffic control system that a vehicle would like to receive priority.
- A software that processes the request and decides whether to extend the green signal based upon programmed priority control strategies.
- A software that manages the system, collects data, and generates reports.

Keys to Successful Implementation

Signal priority systems have been in use in Europe since 1968 in countries such as Germany, Italy, the Netherlands, and France. The key that they have found to successful signal priority system operation is to give priority only to the level that is needed to minimize the travel delay. Existing systems give the priority signal as late as possible and cut the priority call immediately after the vehicle crosses the stop bar. Some other keys observed to ensure successful implementation are:

- Early stakeholder communication and involvement, and at least one leader for each party concerned.
- A simulation model is recommended to identify areas for opportunity and improvement.

- A pilot project before the final implementation to test the system and equipment and to provide a basis to measure the benefits and impacts.
- Installation, operation, and maintenance are all easier on standardized equipment, so they must be taken into account.

Challenges to Implementation

The main challenge for the use of signal priority systems with cargo-carrying trucks is the cost and ability to complete instrumentation in a broad number of the trucks.

Success Story

This system is currently used by the Brisbane City Council in Brisbane, Australia. It has transit priority schemes that hold a green signal on or change a signal to green for an approaching bus or tram. The original model was modified to include additional advance detectors at each intersection and include trucks. Existing detectors, located 150 meters before the stop line, are only activated by articulated trucks or B-doubles.

Measures of Effectiveness

In the case of Brisbane, the proportion of articulated trucks at the front of the intersection queues decreased from 6.6 to 5.7 percent and the proportion of B-doubles decreased from 2.0 to 1.6 percent thanks to this system. Installations in England and France have shown a 6 to 42 percent reduction in transit travel time, with only 0.3 to 2.5 percent increases in auto travel time. In Portland, this system helped to achieve an increase of 7.7 percent in vehicle speed during the AM peak and a 13.7 percent increase in vehicle speed during the PM peak.

Time Required (scale of 1 to 5, where 5 is most time)

2

Dollars Required (scale of 1 to 5, where 5 is most expensive)

3

Supplemental Information

The relevance of this system consists of its use in any of the following ways:

- Because of the complexity of some operations within freight villages, this system could be used to relieve internal traffic.
- This system could be implemented in the surrounding streets of the freight generator/freight village to prevent bottlenecks in the incorporation of the trucks to the road.

53. Truck Appointments at Freight Terminals

Texas Application of Strategy/Technology

The immediate application of truck appointments at freight terminals is for container terminals in Houston and Freeport. However, the strategy can also be used at intermodal terminals and any other freight traffic generator where trucks are the primary mode delivering to/carrying from the terminal. Terminals use computerized operating systems to manage their yards. Meshing those systems with online appointments will allow a terminal to match truck flow with equipment availability while reducing the chance a driver will have to wait because of yard inefficiencies (e.g., waiting for an import container to be retrieved from the bottom of a stack).

Issues Addressed

- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

Under this strategy, terminal managers establish appointment windows during which a specific truck must arrive and check in. These windows may be for more than just the terminal gates—they may also be for areas within the terminal. Under normal conditions, the terminal will not assess a penalty for missing the window, but a trucker who does not show up must make a new appointment, which usually is after free storage time expires and demurrage fees begin. This practice gives truckers strong incentive to meet their appointment window.

Keys to Successful Implementation

Winning acceptance of appointments from the motor carriers may hinge less on technology than on industry psychology and habits. For an appointment system to work, trucks that show up during an appointment window should have an expectation of achieving an efficient, reasonable turnaround time.

Challenges to Implementation

Motor carriers may question whether terminals can deliver the promised benefits. Trucker reaction in various ports proposing the use of appointment windows has ranged from skeptical to hostile. Ports should set turn times at a reasonable level before attempting to implement an appointment system. Terminals will have to decide how wide to make appointment windows, how much slack to build into the scheduling of trucks for the windows, and how to create a balance system of incentives and penalties for truckers and terminals. It is important to prevent a few truckers from scooping up all of the available slots and reselling them.

Success Story

Various forms of appointment systems already exist at ports including Los Angeles; Long Beach; New Orleans; Vancouver, British Columbia; Sydney, Australia; and Southampton, UK. At Port Metro Vancouver in British Columbia, truckers have two-hour appointment windows under a system that has been in place several years. Truckers observe that their service levels have improved significantly with the appointment windows.

Measures of Effectiveness

Suggested metrics for determining the effectiveness of this strategy include:

- Turn time for trucks.
- Waiting times outside the gates.

Time Required (scale of 1 to 5, where 5 is most time)

1

Dollars Required (scale of 1 to 5, where 5 is most expensive)

2

54. Underground Freight Transportation

Texas Application of Strategy/Technology

The goal of the underground freight transportation strategy is the development of alternative means of transport to make freight movement and operations more efficient. With the implementation of an underground system as proposed, the pollution levels and workload could be highly decreased and the service levels exponentially increased. The implementation of the strategy can connect two logistic nodes with high demand.

Issues Addressed

- Intercity or Long-Distance Freight Corridors.
- Urban Freight Delivery.

Strategy/Technology Profile

The idea is to create a system of small, automated vehicles to move goods through tunnels using minimal energy and labor. The system would initially serve to make small, last-mile shipments from the freight distribution hub to end-users. The system could be designed with any of the following technologies:

- Overhead conveyors that could transport pallets, boxes, carts, and other medium-sized products.
- Automated trucks equipped with multiple trailers.
- Rail-guided carts/vehicles.
- Medium- to large-sized capsules.

Keys to Successful Implementation

Since this strategy is a recent development and as yet largely untested, it is necessary to conduct a pilot project where only high-demand nodes are connected and then later replicate the model on a larger scale. Also, it is necessary to evaluate the real need for building an underground infrastructure because in many cases, the same level of effectiveness could be reached with an undisturbed but above-ground infrastructure. This was the finding of some TxDOT-funded research on implementing this type of technology previously, which later resulted in the design of the above-ground freight shuttle system.

Challenges to Implementation

In the case of using capsules for the development of this initiative, it would be necessary to build a specialized underground infrastructure with a high cost. However, it has been proven that this initiative would be cost effective in the medium and long terms, mainly because the tunneling needed would be less expensive than that needed for a subway or other large vehicle if the freight transport capsule were kept small in size, perhaps limited or based on pallet-sized loads rather than containers, although this would require more handling at each end to load and unload. Another challenge in the case of the capsules would be that a special market, where the pallet is the standard measure, would be needed.

Success Story

The CargoCap in Germany is a pilot project with fully automated transport vehicles (see Figure A-40). The computer-controlled caps travel in underground pipelines with a diameter of only 2 meters loaded with two euro-pallets each. For direct connection, the cargo is delivered directly to the recipient or to the immediate vicinity of a station by means of connection logistics with delivery vehicles. Only these stations provide connection to the surface. They may be located either right in the city centers near huge stores or immediately at the assembly line of a factory. Chicago also used an underground freight system to deliver mail in its downtown area prior to the 1930s.

Length	4000 mm
Width	1400 mm
Height	1600 mm
Weight empty	800 kg
Payload max.	1500 kg
Maximum speed	11 m/s (39,6 km/h)
Average speed	10 m/s (36 km/h)
Track gauge	800 mm
Slope max.	3%

Figure A-40. CargoCap Prototype and Specifications.

Measures of Effectiveness

A study was conducted in Japan on the feasibility of an underground freight system for Tokyo. The study estimates that NO_x and CO_2 would be reduced by 10 percent and 18 percent, respectively. A reduction of 18 percent in energy consumption and an increase of 24 percent in average travel speed are also predicted.

Time Required (scale of 1 to 5, where 5 is most time)

3

Dollars Required (scale of 1 to 5, where 5 is most expensive)

5

55. United States/Mexico Integrated Data Tracking System (IDTS)

Texas Application of Strategy/Technology

Historically, the United States Customs and Border Protection (CBP) has struggled with implementing an efficient way of recording commercial vehicle traffic wait times (*107*). The U.S.-Mexico Integrated Data Tracking System would require U.S. and Mexican customs to integrate their commercial traffic records in order to more accurately understand vehicle wait times. This information would then help private-sector organizations be able to create a faster supply chain when crossing the U.S.-Mexico border.

This system would also integrate the data that are recorded by the license plate readers at the border. This information would also help the secure transportation of cargo because it would allow U.S. CBP officers to more accurately identify suspicious vehicles because they are able to access Mexican databases. This would allow for more accurate selection criteria for determining which vehicles should be subjected to additional searches.

Strategy/Technology Profile

As commercial vehicles approach the border from Mexico, they must go through Mexican customs for an exit inspection. This action would be recorded in the IDTS. After the U.S. CBP officers processed the commercial vehicle, a time stamp would be added to this same vehicle in the same system. This wait time would be collected continuously and averages would be outputted on a website that could be accessed by the general public.

This strategy would require an integrated system that would continuously communicate between the Mexican and U.S. customs offices and be produced on a binational website.

As trucks got recorded in the system, they would also be queried through the various law enforcement databases on both sides of the border. If a flag were brought up on the Mexican side, it would be possible for U.S. customs officers to conduct additional inspections. The same would be true for southbound traffic.

Keys to Successful Implementation

This system would require capital investments and cooperation between U.S. and Mexican authorities. The keys to implementing this system are as follows:

- The development of infrastructure that could support this system (i.e., servers, computers, etc.).
- Coordination between U.S. and Mexican authorities in implementing these new systems.
- Training for customs officers of both governments to learn how to use these systems.

- Trust between U.S. and Mexican law enforcement agencies in terms of the management and collection of sensitive law enforcement databases.
- Effective database management that keeps the website secure and accurate for the utilization of private-sector organizations.

Challenges to Implementation

The primary challenge of implementing this system is the coordinated effort between U.S. and Mexican agencies. Distrust between the two governments may impede the successful implementation of this system. Concerns of this ultimately hurting U.S. national security should be expected to arise. However, the economic benefits of this system should outweigh the potential political costs.

Success Story

There is not a current record of this system being implemented, but there are instances of U.S. agencies coordinating with Mexican law enforcement and customs agencies. The most recent example is The Mérida Initiative (*108*). This initiative involves the coordinated efforts between Mexican and U.S. law enforcement agencies in combating drug trafficking.

Measures of Effectiveness

There are no measures of effectiveness for this program since it has not been implemented. However, the following are ways that may measure the effectiveness of the program.

- Conducting control trials that compare wait times at ports of entry (POEs) that have this system with POEs that do not use this system.
- Tracking how often private-sector organizations utilize this website.
- Recording successful searches and seizures that were directly due to the collaboration of U.S.-Mexico customs information sharing technologies.

Time Required (scale of 1 to 5, where 5 is most time)

4

Dollars Required (scale of 1 to 5, where 5 is most expensive)

4

56. United States/Mexico Pre-Clearance Pact

Texas Application of Strategy/Technology

A pre-clearance pact between the United States and Mexico would establish inspection stations within Mexico to inspect U.S.-bound cargo before reaching the port of entry (POE). A pre-clearance pact would permit American officials to establish customs facilities on the Mexican side of the border at highway checkpoints before the border, bus depots, train stations, and marine terminals. Pre-clearance of commercial cargo would expedite the crossing time at the POE and help alleviate the gridlock commonly associated with commercial POEs.

Strategy/Technology Profile

A pre-clearance pact between the United States and Mexico will create inspections stations in Mexican territory to inspect cargo trucks before they reach the border. This pre-inspection will not only reduce the crossing time at commercial POEs but also ensure that hazardous cargo does not reach the American border. The cargo will be inspected by U.S. CBP officials and sealed using tamper-proof technology. After inspection, the approved cargo trucks will travel along a secure route directly toward the nearest U.S. POE. Upon reaching the POE, these preapproved trucks will verify their identity and demonstrate that the cargo has not been tampered with before entering the United States.

Keys to Successful Implementation

A pre-clearance pact between the United States and Mexico will require an agreement between the two federal governments to allow U.S. CBP officials to operate within Mexican territory. Mexico's Congress passed a reform in April 2015 allowing international immigration and customs agents to carry firearms. This is a first step for the implementation of the pre-clearance process.

The keys to implementing this system are as follows:

- Identification of possible pre-clearance inspection sites.
- Acquisition of tamper-proof technology to ensure validity of pre-clearance inspections.
- Establishment of a secure route between pre-clearance inspection stations and U.S. POEs.

Challenges to Implementation

A pre-clearance pact would be contingent on Mexico allowing U.S. CBP officials to operate in Mexican territory. This has been a contentious issue in the past, primarily when it came to CBP officials carrying firearms on Mexican territory. In addition to the political challenges, pre-clearance inspections will have to include a secure route from the inspection station to the border to ensure the validity of the early inspection. Without a secure route, the cargo will have to undergo another inspection at the POE, rendering the pre-clearance pact useless.

Success Story

As the program has not been implemented, there are no success stories.

Measures of Effectiveness

There are currently no measures of effectiveness for land pre-clearance pacts. The United States has successfully implemented an air pre-clearance pact with eight Canadian airports, allowing passengers to be screened by U.S. CBP officials in the Canadian airport (*109*). This pre-screening eliminates the need for the passengers to pass through customs when they enter the United States. The U.S.-Canada pre-clearance pact has recently been extended to include land and maritime POEs. The U.S.-Canada pre-clearance pact can be used as a model for the creation of a U.S.-Mexico pre-clearance pact.

Time Required (scale of 1 to 5, where 5 is most time)

5

Dollars Required (scale of 1 to 5, where 5 is most expensive)

4

57. Zero-Emissions Container Mover System (ZECMS)

Texas Application of Strategy/Technology

This strategy would apply mostly to activity at the Ports of Houston and Freeport. A significant volume of containers is moved between the port terminals and nearby warehouses (or intermodal facilities). Moving to zero-emissions systems would significantly impact air quality in the urban area.

This strategy would be most applicable on heavily used routes, such as between ports, industrial estates, freight transport centers, and central transshipment terminals (i.e., short distances with high frequency of transports).

Issues Addressed

- Urban Freight Delivery.
- Major Freight Generators and Intermodal Exchange Areas.

Strategy/Technology Profile

The idea is to develop a zero-emission container mover system to shuttle containers between docks and a nearby intermodal container transfer facility or warehouse. Technologies that may be considered include electric guideways, zero-emission trucks, electrified rail, and magnetic levitation (maglev).

As an example, Siemens is conducting tests of an eHighway system in Los Angeles/Long Beach that provides electricity to selected traffic lanes using an overhead cable system. Specially equipped trucks are supplied with electricity in the same way as trams. The trucks use a hybrid drive system that can be powered by diesel, compressed natural gas, onboard batteries, or other energy sources.

Another example of a system able to operate on conventional roads is the dual-mode system called CargoTram from MegaRail, which has developed a new concept for the infrastructure, the CargoWay, and vehicles. The infrastructure is a simple steel structure with the necessary wires for automation and inductive power supply. There is a variety of rail-based systems, most notably the TTI Freight Shuttle system.

Yet another example is Combi-Road, a high-capacity, unattended, freight container transport system introduced in 1994. Containers are pulled on semi-trailers by electrically powered vehicles that ride on air-filled tires. The vehicle combinations ride in specially designed tracks constructed as separate roads or as extra lanes alongside existing motorways.

Keys to Successful Implementation

The key will be to prove that the implementation of the selected technology will indeed have a measureable effect on air quality and that it can be done without increasing the cost of doing business to the freight community.

Challenges to Implementation

For technologies needing right of way, there must be sufficient right of way already existing or available at a reasonable cost. This strategy probably will not work if it significantly increases the cost of doing business to the freight community. Either the system must save money for transportation providers and freight handlers or it must be subsidized by government at some level.

Success Story

Currently, there is not a specific success story since many of these technologies are awaiting testing and implementation to be proven. These technologies are being investigated and explored at a number of sites around the globe. In the United States, this is primarily taking place in Southern California.

Measures of Effectiveness

Suggested metrics include the following:

- Vehicle miles traveled by zero-emissions movers.
- Reductions in emissions due to VMT traveled by zero-emissions movers.

Time Required (scale of 1 to 5, where 5 is most time)

5

Dollars Required (scale of 1 to 5, where 5 is most expensive)

5

Supplemental Information

The following figures provides examples of zero-emissions technologies.

Figure A-41. Zero-Emissions Truck at Port of Los Angeles.

Figure A-42. CargoTram.

Figure A-43. Combi-Road.

Figure A-44. Freight Shuttle System.

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APPENDIX B. POTENTIAL GEOGRAPHIC LOCATIONS AND BARRIERS TO IMPLEMENTATION OF CANDIDATE STRATEGIES AND TECHNOLOGIES

Table B-1. Potential Locations and Barriers for Intercity, Long-Distance Corridor Strategies and Technologies.

No.	Strategy/Technology	Extent of Use	Location(s) of Use	Characteristics of Use (Conditions)	Texas Locations	Barriers to Implementation	Time	Dollars
1	**Airships/Aerial Transport**	Not yet implemented for freight: Some cases of passenger transport, exploration, and military use	• Urban freight delivery • Major freight generators	• No extensive infrastructure needed • Vertical takeoff and landing capable • Larger capacities than 747-8F aircraft	• Locations with limited access by conventional transportation modes (e.g., energy-producing regions)	• Unfamiliarity (changing mindset of traditional operators) • Inadequate funding • Shortage of personnel with experience	5	3
2	**Automated and Low-Emissions Intercity Freight System**	Not yet implemented for freight: Passenger transit systems at airports	• Intercity freight corridors • Ports to inland terminals	• Conveyance of containers by specialized transporters • Dedicated guideway systems • Powered by electricity	• Intercity corridors • Between ports and inland terminals	• Right-of-way (ROW) acquisition and site preparation • High capital costs • Community acceptance	4	5
3	**Consolidated Grade Crossing Corridor Safety/Grade Separation Programs**	Many regions including North Carolina, Los Angeles, and Gulf Coast Rail District	• Intercity freight corridors • Urban freight	• Consolidated grade separation projects into a program along the freight corridors	• Freight corridors experiencing safety, mobility, environmental issues due to rail grade crossings (examples include Houston, San Marcos)	• Difficulties securing stable, dependable funding sources • Rail operations modeling is time consuming and expensive	4	5

No.	Strategy/Technology	Extent of Use	Location(s) of Use	Characteristics of Use (Conditions)	Texas Locations	Barriers to Implementation	Time	Dollars
4	**Freight Rail Public-Private Partnerships (P3s)**	Some cases of successful implementation: Tower 55 project in Fort Worth, Alameda Corridor in Southern California, etc.	• Intercity freight corridors	Public-private partnerships for: • Capacity expansion of freight-rail network • Grade-crossing improvements • Grade separations and other improvements	• Freight corridors and metro areas with choke points (e.g., Sabine River bridge in Beaumont)	• Extensive planning to identify relative benefits and justify financial contributions • Maintaining commitment from all partners to the project over the life for the project	5	5
5	**Natural Gas-Fueled, Heavy-Duty Highway Freight Transportation**	Few: Ports of Los Angeles and Long Beach	• Freight corridors • Ports	• Use of natural gas-fueled engine in trucks	• Clean transportation triangle (CTT) corridors • Major ports	• Lack of refueling infrastructure • Fuel tax disparity	4	5
6	**Natural Gas-Fueled Locomotive**	Few: Several demonstration programs	• Long-haul corridors	• Use of natural gas-fueled locomotives for long-haul freight corridors	• Long-haul corridors	• Large capital investment to build LNG plants and fuel stations • Uncertainty of diesel fuel price and long-term availability of natural gas supplies	4	4
7	**Passenger Rail Cargo Delivery**	Moderate: Amtrak offers small-package shipping services between more than 100 cities.	• Intercity or long-distance corridors • Special generators and intermodal exchange area	• Use of passenger rail network for time-sensitive express freight	• High-speed intercity passenger rail network	• Difficulties harmonizing loading/unloading cargos with passenger rail schedules	3	4

No.	Strategy/Technology	Extent of Use	Location(s) of Use	Characteristics of Use (Conditions)	Texas Locations	Barriers to Implementation	Time	Dollars
8	**Railroad Infrastructure Relocation**	Few: Lafayette Railroad Relocation Project, Lafayette, Indiana	• Metro and urban areas • Major freight generators and intermodal exchange areas	• Railroad infrastructure relocation outside urban areas	• Urban areas with extensive railroad infrastructure causing conflicts with other modes	• Major public-sector investment needed for relocation (or rerouting) • Achieving consensus among various stakeholders	5	5
9	**Truck Platooning**	Not yet implemented: Several projects in Europe and California	• Intercity or long-distance freight corridors	• Extension of Cooperative Adaptive Cruise Control (CACC) to keep constant gaps between trucks on the highway	• Major freight corridors	• Slow development of infrastructure to accommodate the strategy • Changing state laws and regulations	3	4

Table B-2. Potential Locations and Barriers for Urban Area Strategies and Technologies.

No.	Strategy/Technology	Extent of Use	Location(s) of Use	Characteristics of Use (Conditions)	Texas Locations	Barriers to Implementation	Time	Dollars
10	**Adaptive and Advanced Signal Control Systems (AASCS)**	Many cases of successful implementation in the U.S.	• Metro and urban areas	• Coordination of traffic flow on arterials by adjusting signal-timing parameters	• Metro and urban areas	• Installation and O&M costs	3	5
11	**Automated and Driverless Trucks**	Not yet implemented: Experimental phase	• Urban freight delivery • Freight corridors	• Automated driverless vehicles to deliver freight within urban environments	• Metro and urban areas	• Regulatory environment • Public acceptance • Liability issues	5	5
12	**Commercial Motor Vehicle (CMV)-Only Lanes**	Few: One successful implementation at New Jersey Turnpike	• Metro and urban highways	• Limited access truck-only lanes on urban highways or between ports and facilities	• Urban highways and intercity freight corridors experiencing congestion and crashes due to high volume of trucks	• High level of investment • ROW acquisitions • Public acceptance when removing existing lanes to create CMV lanes • Technology development	4	4
13	**Compressed Natural Gas and Liquefied Natural Gas for Urban Delivery**	Few: UPS's LNG fueling stations in Las Vegas, Phoenix, California, Ontario, etc.	• Urban freight delivery	• CNG and LNG for medium- and heavy-duty freight transportation	• Metro and urban areas experiencing truck-related environmental issues (e.g., UPS planned to add 700 LNG tractors and a fueling station in Dallas by 2014)	• Availability of refueling infrastructure • Higher vehicle cost	3	4

No.	Strategy/Technology	Extent of Use	Location(s) of Use	Characteristics of Use (Conditions)	Texas Locations	Barriers to Implementation	Time	Dollars
14	**Electric Delivery Trucks and Dual-Mode, Hybrid Diesel/Electric Trucks**	Few: UPS's electric trucks in Houston and "eHighway" system demonstration at the Ports of Los Angeles/Long Beach	• Urban freight delivery • Major freight generators	• All-electric or diesel-electric hybrid trucks in urban areas to lessen environmental issues	• Ports and urban areas	• High infrastructure cost • Reduced range of all-electric trucks • ROW availability for eHighway system • Industry acceptance	4	4
15	**Electric Truck Designs**	Few: Frito-Lay, FedEx, Coke, and PepsiCo have piloted electric delivery truck fleets in urban markets	• Urban freight delivery • Major freight generators	• All-electric or diesel-electric hybrid trucks in urban areas to lessen environmental issues	• Urban areas with high demand of fixed-route, return-to-base delivery	• Availability of charging infrastructure • High vehicle cost	2	4
16	**Ethanol Fuel Delivery Vehicles**	Few: UPS's ethanol-powered delivery vehicles in Brazil	• Urban freight delivery	• Methanol-diesel fuel or methanol-gasoline mixture for freight vehicles	• Urban areas	• Availability of refueling infrastructure • High cost of producing ethanol	3	4
17	**Fully Automated Vehicles: European Experience**	Not yet implemented for freight: "Flying Carpet" project for passengers in Netherlands	• Urban freight delivery • Major freight generators	• Use of automated vehicles for freight transport	• Urban freight delivery • Major freight generators	• Regulatory environment • Public acceptance • Liability issues • Data security	5	5
18	**Geographically Focused Incentives for Off-Hours Delivery**	Few: Manhattan and other selected test cases	• Urban freight delivery	• Incentives offered for off-hours delivery in urban locations	• Urban areas where regular-hour freight delivery generates traffic congestion	• Business industry support • Difficulties determining the incentive structure	2	3

No.	Strategy/Technology	Extent of Use	Location(s) of Use	Characteristics of Use (Conditions)	Texas Locations	Barriers to Implementation	Time	Dollars
19	**Hazardous Material Vehicle Location Status/Shipment Tracking**	Few to moderate: Multiple systems are available from vendors; USDOT Pipeline and Hazardous Materials Safety Administration is testing a Pilot Program	• Urban freight delivery • Intercity freight corridors	• RFID, GPS/GLS, intelligent video tracking and surveillance systems for tracking HazMat vehicle locations and status	• Urban areas and intercity freight corridors with high volume of HazMat traffic	• Obtaining access to HazMat transport information from private carriers, including subcontractors	varies	varies
20	**Hydrogen Fuel Cell**	Few: FedEx uses hydrogen fuel cell-powered vehicles in Memphis, Tennessee, and in Springfield, Missouri; California has 18 hydrogen fueling stations	• Urban freight delivery • Intercity freight corridors	• Electric vehicles powered by hydrogen fuel cell instead of battery • Can be used for transport refrigeration units	• Urban freight delivery • Intercity freight corridors	• Availability of refueling infrastructure	2	3
21	**Innovative Urban Delivery Modes: Reception Boxes**	Few: BentoBox pilot in Berlin, Germany	• Urban freight delivery	• Unattended collection and delivery points for "last mile" urban delivery	• Densely populated urban areas	• Capital investment for constructing reception box facilities	2	3
22	**Innovative Urban Delivery Modes: Collection and Delivery Points (CDPs)**	Few to moderate: Amazon Lockers in urban areas in the U.S. and DHL's Pack Station Program in Germany	• Urban freight delivery	• Unattended collection and delivery points for "last mile" urban delivery	• Densely populated urban areas	• Capital investment for constructing CDPs	2	3

No.	Strategy/Technology	Extent of Use	Location(s) of Use	Characteristics of Use (Conditions)	Texas Locations	Barriers to Implementation	Time	Dollars
23	**Ramp Metering**	Moderate to extensive: North America and Europe	• Urban freight delivery • Intercity freight corridors	• Controlling traffic onto the freeway by on-ramp signals for harmonized flow	• Metro and urban freeways	• Risk of saturating the surrounding roads • Public acceptance	2	4
24	**Short-Haul Rail Movements within Urban Areas**	Few: A large supermarket chain in Switzerland (Swiss COOP)	• Urban freight delivery	• Short-haul intermodal rail service from exurban distribution centers into urban center	• Metro and urban areas experiencing congestion due to freight delivery from exurban distributions centers to retailers	• Available rail capacity and track conditions • ROW for development of rail-truck transloading facilities • Sufficient demand to divert short-haul shipments from truck to rail	3	3
25	**Truck-Only Roadway**	Few: Some cases such as I-5 in California, Clarence Henry Truckway in Louisiana, I-93 in Massachusetts, and New Jersey turnpike	• Long-distance freight • Intercity freight corridor • Urban freight delivery • Major freight facilities: Seaports and rail terminals	• Dedicated truck-only lanes	• Intercity corridors	• ROW acquisitions • Land space availability • High capital costs • Community acceptance • Trucking industry support	3	5
26	**Truck-Only Toll (TOT) Lanes**	Not yet implemented, no existing TOT lanes	• Urban freight delivery • Major freight facilities: Seaports and rail terminals	• Dedicated TOT lanes	• Intercity corridors	• Toll fees • ROW acquisitions • Land space availability • High capital costs • Community acceptance • Trucking industry support	4	4

No.	Strategy/Technology	Extent of Use	Location(s) of Use	Characteristics of Use (Conditions)	Texas Locations	Barriers to Implementation	Time	Dollars
27	**Unmanned Aircraft Systems (UAS)**	Not yet implemented for commercial freight: Lockheed Martin and Kaman Aerospace Corporation tested an unmanned K-Max lift helicopter for battlefield supply	• Urban freight delivery • Intercity freight corridors	Various UAS technologies for: • Monitoring and patrolling tracks and pipelines • Law enforcement purposes • Emergency deliveries/relief shipments	• Urban areas where frequent delivery-truck trips are expected or where monitoring and patrolling operations are required	• Regulatory environment • Political and social acceptance • Ability to operate under various weather conditions • Airspace	5	3
28	**Urban Delivery Sharing System (Uber-type Dispatching for Freight Trucks)**	Few: UberCARGO, Roadie, Piggyback, Sidecar, etc.	• Urban freight delivery	• Uber-type dispatching service for "last mile" delivery	• Metro and urban areas	• The business model has not been proven profitable yet • Liability issues to insure high-priced times • Legal status of the drivers	1	1
29	**Urban Truck Parking**	Few: New York City implemented flexible metered parking spaces for delivery trucks	• Urban freight delivery	• Time-sharing, designated parking space for delivery vehicles in dense urban areas	• Urban areas experiencing mobility and safety concerns due to the lack of parking spaces for delivery vehicles	• Careful consideration of strategies needed not to create choke points • At some urban roads it may not be feasible to accommodate delivery vehicles	2	1

Table B-3. Potential Locations and Barriers for Special Generator Strategies and Technologies.

No.	Strategy/Technology	Extent of Use	Location(s) of Use	Characteristics of Use (Conditions)	Texas Locations	Barriers to Implementation	Time	Dollars
30	**At-Grade Separation Programs**	Few: Alameda Corridor-East (ACE) program in California	• Intercity freight corridor • Urban freight delivery	• Passenger and freight rail projects • Improving grade-crossing safety and separating roads and railroads	• High-volume corridors that contain multiple at-grade intersections	• High capital costs • Multiple funding sources	4	5
31	**Backscatter X-Ray Imaging**	Extensive: All land ports of entry (POEs) and several road checkpoints	• Border ports of entries (POEs)	X-ray imaging for checking freight containers without unloading	• Border crossings • POE checkpoints	• Incompatible infrastructure with POEs' current facility designs • High capital and operation costs	3	5
32	**Container Movement Software-Connecting Drayage Trucks with Terminals and Shippers**	Few: Pilot tests in Southern California, Dallas–Fort Worth, South Florida, and Port of Los Angeles	• Urban freight delivery • Major freight generators and intermodal exchange areas	• Software to speed movement of cargo among intermodal nodes • Intelligent transportation system (ITS) integration	• Seaport and major rail container terminals • Border cities	• Lack of access to real-time data collected on public infrastructure conditions • Sector freight ITS solutions that offer flexible approaches	3	2
33	**Container Sharing in the Seaport Hinterland**	Few: Los Angeles/Long Beach Virtual Container Yard (VCY)	• Urban freight delivery • Major freight generators and intermodal exchange areas	• Managing empty container moves efficiently • Direct reuse of empty containers without intermediate returns	• Seaport container terminals	• Carriers sharing market information with competitors • High capital costs	5	5

No.	Strategy/Technology	Extent of Use	Location(s) of Use	Characteristics of Use (Conditions)	Texas Locations	Barriers to Implementation	Time	Dollars
34	**Creation of a Freight Village (FV) Facility**	Extensive	• Intercity or long-distance freight corridors • Major freight generators and intermodal exchange areas	• Creating freight facilities and business in the same location for effective/efficient use of assets	• Close to urban areas with the best connections to air, sea, road, and rail	• Stakeholders/tenants of the terminal • Public acceptance • High capital costs • Planning requirements	4	4
35	**Customs-Trade Partnership against Terrorism (C-TPAT)**	Extensive	• Border crossings	• Customs and Border Patrol (CBP) assigns its private partners a tier level based on risk assessment • Tier III partners subject to less likely examinations	• Border crossings	• Consistency of data collected on C-TPAT members • Record management for users	2	3
36	**Dedicated Truck Lanes during Peak Port Freight Flows**	Few: • Clarence Henry Truckway in Louisiana (3.5 miles) • New Jersey Turnpike (32 miles)	• Urban freight delivery • Major freight facilities: Seaports and rail terminals	• Dedicated truck-only lanes during peak freight flows	• Roadway segments near ports with high levels of truck traffic and congestion	• Toll fees • ROW acquisitions • Land space availability • High capital costs • Community acceptance • Trucking industry support	3	3
37	**Free and Secure Trade (FAST) Program for Commercial Vehicles/ Trusted Travelers**	Extensive: Most land ports of entry on the southern and northern U.S. borders	• Border crossings	• Using RFID readers and designated lanes for FAST truck shipments • Truck's windshield sticker tags and driver's ID cards are read by RFID readers	• Border crossings	• Moderate capital costs • Equipment maintenance at land POEs	5	4

No.	Strategy/Technology	Extent of Use	Location(s) of Use	Characteristics of Use (Conditions)	Texas Locations	Barriers to Implementation	Time	Dollars
38	**Hi-Tech Yard Management Systems**	Not yet implemented	• Major freight generators and intermodal exchange areas	• Innovative yard management to track yard activity and asset locations	• Enterprises with large truck yards and/or warehouses	• Minimum of 250 truck parking spaces for warehousing operations is indicated • Truck yards of a certain size or larger	2	3
39	**Innovative Horizontal Transshipment Technique**	Few: Neuweiler Tuchschmid Horizontal Transshipment System (NETHS) in Switzerland and others in Austria and Hungary	• Major freight generators and intermodal exchange areas	• Technology for swapping containers horizontally	• Freight village • Freight generators • Intermodal exchange areas	• High capital costs • Trucking industry support	2	3
40	**Intelligent Truck Control System**	Few: Intelligent Truck Control System at the Port of Aqaba in Jordan	• Urban freight delivery • Major freight generators and intermodal exchange areas	• Data management on trucks, cargos, drivers, roads, and terminals • Manage truck movements in and around the port	• Port terminals	• Political jurisdictions and industries: operating entities • Trucking industry support	3	3
41	**International Border Crossing Electronic Screening of Trucks**	Not yet implemented: Pilot test performed in El Paso, Texas	• Border crossings	• Filing an electronic manifest before entering the land border crossing • e-Manifest data is shared • FMCSA, TxDPS, and BSIF officers use data for targeted vehicle inspections	• Border crossings • POE checkpoints	• Coordinated effort between U.S. state and federal agencies • Truck database has to be up-to-date with carrier information at the truck level • Roadside equipment in Mexico and the U.S. • High capital costs	5	4

No.	Strategy/Technology	Extent of Use	Location(s) of Use	Characteristics of Use (Conditions)	Texas Locations	Barriers to Implementation	Time	Dollars
42	**ITS for Seaports**	Moderate to extensive: North America, Europe container terminals	• Major freight generators and intermodal exchange areas	• ITS installations for proper coordination and control at seaports	• Seaports	• High capital costs • Resources to investigate, test, design, and implement ITS technologies effectively	5	5
43	**License Plate Readers (LPRs)**	Extensive	• Border crossings • POE checkpoints	• LPR technology at land ports of entry (LPOEs) to identify trucks and link the information to e-Manifest	• Border crossings • POE checkpoints	• Privacy • Safeguarding of information • Coordinating the management of information with Mexican authorities	4	5
44	**Natural Gas-Fueled Towboat**	Moderate: Long Island Ferry system, proven practice in locomotives and trucks	• Seaports • Coastal and river waterways	• Converting river towboat engines to dual fuel, diesel/natural gas technology	• Seaports and waterways	• High capital costs for conversion • Lack of willingness to change fuel sources • Lack of natural gas fueling stations at ports	5	5
45	**Off-Peak Incentive Program for Container Terminals/Extended Gate Hours**	Moderate: Los Angeles/Long Beach, Savannah, Port Metro Vancouver, Virginia Port Authority, New Orleans, Charleston	• Urban freight delivery • Major freight generators and intermodal exchange areas	• Incentivizing shippers and receivers to utilize off-peak hours at seaport container terminals	• Container ports	• Customs and terminals availability • Chassis providers, steamship lines, shippers, and consignees must extend their work days to match the new port hours	3	2

No.	Strategy/Technology	Extent of Use	Location(s) of Use	Characteristics of Use (Conditions)	Texas Locations	Barriers to Implementation	Time	Dollars
46	**On-Dock Rail**	Moderate: Significant number of U.S. ports—the biggest is the Alameda Corridor project in the Ports of Los Angeles and Long Beach	• Seaports	• On-dock rail installation for direct transfer of cargo between the vessel and the rail car	• Seaports	• High capital costs	2	5
47	**Photonuclear Gamma Ray Imaging**	Extensive: All land ports of entry	• Border crossings	• High-resolution Photonuclear Gamma Ray Imaging technology for checking freight containers without unloading	• Border crossings	• Infrastructure of border POEs • High capital and operating costs	4	5
48	**Port-to-Rail Intermodal Improvements**	Moderate: Ports of Los Angeles and Long Beach, California; Vancouver and Prince Rupert, British Columbia	• Seaports	• Moving more container freight directly from vessel to rail to reduce truck trips	• Seaports	• Sufficient rail capacity on or near docks needed • Sufficient and regular demand for railcar needed to justify the expansion	3	3
49	**Precision Docking System**	Moderate: Used mainly for transit bus	• Urban freight delivery • Major freight generators and intermodal exchange areas	• Reduce the loading/unloading time by precision docking system	• Freight villages • High-density freight generator area	• High capital costs • Planning and design of the loading/unloading areas	4	4
50	**Radiation Portal Monitors (RPMs)**	Not yet implemented at land POEs	• Border crossings	• Stationary or mobile RPMs for scanning vehicles with radiological materials	• Border crossings • POE checkpoints	• Infrastructure of border POEs • High capital costs • Detect but do not identify sources of radiation (DNDO)	5	5

No.	Strategy/Technology	Extent of Use	Location(s) of Use	Characteristics of Use (Conditions)	Texas Locations	Barriers to Implementation	Time	Dollars
51	**Semi-Automated Intermodal Facility**	Few: CSX Intermodal Terminals at Northwest Ohio Facility	• Major freight generators • Intermodal exchange areas • Container ports	• High-tech design of intermodal facility with reducing human intervention	• Seaports and intermodal yards	• Relatively new technology • Integration of technology • High capital costs	5	4
52	**Traffic Signal Priority System**	Extensive: Countries such as Germany, Italy, the Netherlands, France, and the U.S., mainly for passenger buses	• Intercity or long-distance freight corridors • Urban freight delivery	• Traffic signal priority system for cargo trucks	• Urban areas near major freight generators or freight villages	• High capital costs • Complete instrumentation in a broad number of the trucks	2	3
53	**Truck Appointments at Freight Terminals**	Few: Ports including Los Angeles; Long Beach; New Orleans; Vancouver, British Columbia; Sydney, Australia; and Southampton, UK	• Major freight generators • Central transshipment terminals • Intermodal exchange areas	• Establishing appointment windows prior to truck arrivals • Terminal gates and areas assigned	• Freight terminals	• Trucking industry support • Managing appointment windows and leeway between appointments • Balance system of incentives and penalties for truckers and terminals	1	2
54	**Underground Freight Transportation**	No fully implemented system yet: A pilot project in Germany	• Long-distance freight • Intercity freight corridor • Urban freight delivery	• Moving goods by small, automated vehicles through underground tunnels	• Urban freight delivery • Major freight generators	• High capital costs • Underground geological conditions	3	5

No.	Strategy/Technology	Extent of Use	Location(s) of Use	Characteristics of Use (Conditions)	Texas Locations	Barriers to Implementation	Time	Dollars
55	**United States/Mexico Integrated Data Tracking System (IDTS)**	Not yet implemented: Few developing cases	• Border crossings • POE checkpoints	• Binational data tracking system for recording wait times and for flagging additional inspections between Mexican customs and U.S. CBP	• Border crossings • POE checkpoints	• Coordination between Mexico and U.S. agencies • U.S. national security	4	4
56	**United States/Mexico Pre-Clearance Pact**	Not yet implemented	• Border crossings	• Pre-clearance inspections in Mexican territory before shipments reach the border	• Border crossings	• Political challenges • Secure route from the inspection station to the border	5	4
57	**Zero-Emissions Container Mover System (ZECMS)**	Few: Primarily taking place in Southern California	• Urban freight delivery • Seaports • Major freight generators • Central transshipment terminals • Intermodal exchange areas	• Development of a ZECMS between dock and a nearby transfer facility • Possible use of electric guideways, zero-emission trucks, electrified rail, and magnetic levitation	• Special generators and urban areas with short distances, high frequency of transports • Container ports	• ROW acquisitions • Land space availability • High capital costs	5	5

APPENDIX C. CONNECTION BETWEEN CSTS AND THE TFMP POLICY, PROGRAM, AND STRATEGY RECOMMENDATIONS

Table C-1. CSTs and Draft Texas Freight Mobility Plan Policies.

Category	No.	CST Name	Texas Freight Mobility Plan Policies Related to CSTs			
			Title/Description	Objective	Title/Description	Objective
Aviation	A1	Airships/Aerial Transport	11.5.17 Air Cargo Transportation—TxDOT should integrate needs of Texas aviation system into state planning activities, initiatives, and projects	Incorporate air cargo needs, issues, and recommendations in future updates of the TxDOT Texas Airport System Plan		
	A2	Unmanned Aircraft Systems (UAS)				
Non-Highway Systems	NH1	Automated, Zero Emissions Freight Systems				
	NH2	Passenger Rail Cargo Delivery	11.5.15 Rail Freight Transportation—TxDOT should work with private sector rail industry to identify strategies that expand rail capacity, improve rail fluidity, and ease traffic	Foster rail freight as a practical modal alternative that could potentially relieve freight congestion on Texas highways	11.5.5 Multimodal Connectivity—The state should invest in strategies and solutions that link the different freight transportation modes	Ensure the development of a system with adequate and available access points that facilitates the use of alternative modes beyond trucking to alleviate capacity concerns on highways

Category	No.	CST Name	Texas Freight Mobility Plan Policies Related to CSTs			
			Title/Description	Objective	Title/Description	Objective
Freight Rail	FR1	Grade Crossings and Separations	11.5.15 Rail Freight Transportation—TxDOT should work with private sector rail industry to identify strategies that expand rail capacity, improve rail fluidity, and ease traffic	Support strategies that reduce the number of at-grade crossings, improve the efficient movement of freight, and increase the quality of life through reduced congestion and improved safety	11.5.9 Safety, Security, and Resiliency—TxDOT should identify and implement strategies that improve safety and reduce crash rates, fatalities, and injuries associated with freight movement	Prioritize funding for the elimination of freight movement safety hot spots and identify potential crash remediation strategies
	FR2	Freight Rail Public-Private Partnerships (P3s)	11.5.15 Rail Freight Transportation—TxDOT should work with private sector rail industry to identify strategies that expand rail capacity, improve rail fluidity, and ease traffic	Support partnerships for public-private funding and financing opportunities that expand rail capacity and connectivity	11.5.4 System-Based Approach—TxDOT should continue efforts to implement a comprehensive, system-wide freight planning program	Develop public- and private-sector partnerships that target the various modes and users of the freight transportation network

Category	No.	CST Name	Texas Freight Mobility Plan Policies Related to CSTs			
			Title/Description	Objective	Title/Description	Objective
	FR3	Railroad Infrastructure Relocation	11.5.15 Rail Freight Transportation—TxDOT should work with private sector rail industry to identify strategies that expand rail capacity, improve rail fluidity, and ease traffic	Support strategies that reduce the number of at-grade crossings, improve the efficient movement of freight, and increase the quality of life through reduced congestion and improved safety	11.5.5 Multimodal Connectivity—The state should invest in strategies and solutions that link the different freight transportation modes	Prioritize improving connectivity between railroads and seaports, airports and highways, and highway and rail connections to the international border to alleviate congestion at key freight gateways
Alternate Fuels	AF1	Natural Gas Freight Vehicles				
	AF2	Electric/Hybrid Freight Vehicles				
	AF3	Other Fueled Freight Vehicles				
AV/CV Truck	AV1	Truck Platooning				
	AV2	Automated Trucks				
ITS and Operations	IT1	Traffic Signal Coordination Systems				

Category	No.	CST Name	Texas Freight Mobility Plan Policies Related to CSTs			
			Title/Description	Objective	Title/Description	Objective
	IT2	Truck-Shipper Matching Systems	11.5.2 Freight Network Designation and Investment—TxDOT should adopt the Texas Freight Network for statewide transportation investment decisions	Provide an integrated and managed statewide system that links freight gateways to generators, labor forces, and population centers		
	IT3	Port ITS Systems	11.5.2 Freight Network Designation and Investment—TxDOT should adopt the Texas Freight Network for statewide transportation investment decisions	Provide an integrated and managed statewide system that links freight gateways to generators, labor forces, and population centers		
	IT4	Hazardous Material Vehicle Location Status/Shipment Tracking	11.5.9 Safety, Security, and Resiliency—TxDOT should identify and implement strategies that improve safety and reduce crash rates, fatalities, and injuries associated with freight movement	Improve safety along identified priority freight corridors, especially for the movement of hazardous materials	11.5.11 Freight-Based Technology Solutions and Innovation—TxDOT should lead in innovative transportation technologies, techniques, research, and methods	Expand the development of sophisticated real-time information systems and increase the dissemination of dynamic travel information to improve freight movement mobility and reliability

Category	No.	CST Name	Texas Freight Mobility Plan Policies Related to CSTs			
			Title/Description	Objective	Title/Description	Objective
	IT5	Intermodal Terminal Efficiency	11.5.2 Freight Network Designation and Investment—TxDOT should adopt the Texas Freight Network as the strategic framework for statewide transportation investment decisions	Provide an integrated and managed statewide system that links freight gateways to generators, labor forces, and population centers	11.5.16 Port and Waterway Freight Transportation—TxDOT should work with Texas ports and the U.S. Army Corps of Engineers to strengthen and improve maritime freight and support port improvement, access, and channel deepening projects	Support public-private partnership opportunities that expand port capacity and connectivity, particularly through the identification of improvements for enhanced rail and truck access to Texas ports
Truck Infrastructure	TI1	Dedicated Truck Roadways	11.5.3 Texas Highway Freight Network Design Guidelines—TxDOT should review and modify design standards of the Texas Highway Freight Network to facilitate safe and efficient movement of people and goods	Assess opportunities to provide greater separation between truck and passenger vehicles on interstate segments of the Texas Highway Freight Network	11.5.14 Energy Sector Development Transportation—TxDOT and the state should address energy freight transportation needs and impacts in the planning and project selection process	Encourage public-private coordination to develop alternative corridors and modes (e.g., roadway, rail, pipeline, and intermodal) to transport oil and energy commodities

Category	No.	CST Name	Texas Freight Mobility Plan Policies Related to CSTs			
			Title/Description	Objective	Title/Description	Objective
	TI2	Truck Lanes in Surge Freight Flows	11.5.3 Texas Highway Freight Network Design Guidelines—TxDOT should review and modify design standards on the Texas Highway Freight Network to facilitate safe and efficient movement of people and goods	Assess opportunities to provide greater separation between truck and passenger vehicles on interstate segments of the Texas Highway Freight Network	11.5.14 Energy Sector Development Transportation—TxDOT and the state should address energy freight transportation needs and impacts in the planning and project selection process	Encourage public-private coordination to develop alternative corridors and modes (e.g., roadway, rail, pipeline and intermodal) to transport oil and energy commodities
Urban Freight	UF1	Short-Haul Rail Movements within Urban Areas	11.5.5 Multimodal Connectivity—The state should invest in strategies and solutions that link the different freight transportation modes	Ensure the development of a system with adequate and available access points that facilitates the use of alternative modes to alleviate capacity concerns on highways	11.5.15 Rail Freight Transportation—TxDOT should work with private sector rail industry to identify strategies that expand rail capacity, improve rail fluidity, and ease traffic	Foster rail freight as a practical modal alternative that could potentially relieve freight congestion on Texas highways

Category	No.	CST Name	Texas Freight Mobility Plan Policies Related to CSTs			
			Title/Description	Objective	Title/Description	Objective
	UF2	Underground Freight Transportation	11.5.3 Texas Highway Freight Network Design Guidelines—TxDOT should review and modify design standards on the Texas Highway Freight Network to facilitate safe and efficient movement of people and goods	Assess opportunities to provide greater separation between truck and passenger vehicles on interstate segments of the Texas Highway Freight Network	11.5.14 Energy Sector Development Transportation—TxDOT and the state should address energy freight transportation needs and impacts in the planning and project selection process	Encourage public-private coordination to develop alternative corridors and modes (e.g., roadway, rail, pipeline, and intermodal) to transport oil and energy commodities
	UF3	Truck Delivery Timing Programs				
	UF4	Package Consolidation Boxes/Lockers				
	UF5	Freight Village Facility Development	11.5.5 Multimodal Connectivity—The state should invest in strategies and solutions that link the different freight transportation modes	Ensure the development of a system with adequate and available access points that facilitates the use of alternative modes to alleviate capacity concerns on highways		

Category	No.	CST Name	Texas Freight Mobility Plan Policies Related to CSTs			
			Title/Description	Objective	Title/Description	Objective
Border	B1	Border Inspection Technology	11.5.13 International Border/Ports-of-Entry—The state should invest in and facilitate international border coordination strategies to improve freight mobility and eliminate barriers to trade	Improve cross-border goods movement, support technology development, and deploy integrated border-crossing management		
	B2	Institutional Arrangements	11.5.13 International Border/Ports-of-Entry—The state should invest in and facilitate international border coordination strategies to improve freight mobility and eliminate barriers to trade	Support integrated cargo security strategies, such as the single-window program that enables inspections to occur prior to the cargo reaching the border, thus reducing congestion at the crossings	11.5.8 Texas as a North American Trade and Logistics Hub and Gateway—The state should invest in strategic transportation solutions that enable Texas' position as a leader in North American trade, a top international trade gateway, and a national logistics hub	Strengthen the state's economy through increased trade with other states, Mexico, Canada, and globally while promoting Texas' strategic location in national and international trade

Category	No.	CST Name	Texas Freight Mobility Plan Policies Related to CSTs			
			Title/Description	Objective	Title/Description	Objective
Seaports	S1	Truck-Terminal Coordination	11.5.2 Freight Network Designation and Investment—TxDOT should adopt the Texas Freight Network as the strategic framework for statewide transportation investment decisions	Provide an integrated and managed statewide system that links freight gateways to generators, labor forces, population centers, available lands, and suppliers		
	S2	Port-Related Rail Improvements	11.5.5 Multimodal Connectivity—The state should invest in strategies and solutions that link the different freight transportation modes	Improve connectivity between railroads and seaports and alleviate congestion at key freight gateways, freight generators, and ports-of-entry	11.5.16 Port and Waterway Freight Transportation—TxDOT should work with the Texas ports and the U.S. Army Corps of Engineers to strengthen and improve maritime freight and support port improvement, access, and channel deepening projects	Support public-private partnership opportunities that expand port capacity and connectivity, particularly through the identification of improvements for enhanced rail and truck access to Texas ports

Table C-2. CSTs and Draft Texas Freight Mobility Plan Programs.

Category	No.	CST Name	Texas Freight Mobility Plan Programs Related to CSTs		
			Title/Description	Title/Description	Title/Description
Aviation	A1	Airships/Aerial Transport	11.6.8 Aviation: Air Cargo Development and Improvement—identify strategies that expand air cargo capacity and improve air cargo transportation infrastructure		
	A2	Unmanned Aircraft Systems (UAS)			
Non-Highway Systems	NH1	Automated, Zero Emissions Freight Systems			
	NH2	Passenger Rail Cargo Delivery	11.6.1 TxDOT Multimodal Freight Planning—developing strategies, policies, and methodologies to improve the freight transportation system	11.6.6 Rail Development and Improvement—expand rail freight capacity and improve rail freight mobility	
Freight Rail	FR1	Grade Crossings and Separations	11.6.6 Rail Development and Improvement—expand rail freight capacity and improve rail freight mobility		

Category	No.	CST Name	Texas Freight Mobility Plan Programs Related to CSTs		
			Title/Description	Title/Description	Title/Description
	FR2	Freight Rail Public-Private Partnerships (P3s)	11.6.6 Rail Development and Improvement—cooperate with the freight industry in a comprehensive Rail Freight Development and Improvement Program		
	FR3	Railroad Infrastructure Relocation	11.6.6 Rail Development and Improvement—expand rail freight capacity and improve rail freight mobility		
Alternate Fuels	AF1	Natural Gas Freight Vehicles			
	AF2	Electric/Hybrid Freight Vehicles			
	AF3	Other Fueled Freight Vehicles			
AV/CV Truck	AV1	Truck Platooning	11.6.1 TxDOT Multimodal Freight Planning—developing strategies, policies, and methodologies to improve the freight transportation system		
	AV2	Automated Trucks			

Category	No.	CST Name	Texas Freight Mobility Plan Programs Related to CSTs		
			Title/Description	Title/Description	Title/Description
ITS and Operations	IT1	Traffic Signal Coordination Systems	11.6.1 TxDOT Multimodal Freight Planning—developing strategies, policies, and methodologies to improve the freight transportation system	11.6.3 Freight-Based Technology and Operations—enhancing freight transportation system safety, management, operations, and asset management	
	IT2	Truck-Shipper Matching Systems	11.6.1 TxDOT Multimodal Freight Planning—developing strategies, policies, and methodologies to improve the freight transportation system	11.6.3 Freight-Based Technology and Operations—enhancing freight transportation system safety, management, operations, and asset management	
	IT3	Port ITS Systems	11.6.1 TxDOT Multimodal Freight Planning—developing strategies, policies, and methodologies to improve the freight transportation system	11.6.3 Freight-Based Technology and Operations—enhancing freight transportation system safety, management, operations, and asset management	11.6.7 Port and Waterway Development and Improvement—identify strategies that expand port and waterway capacity and improve waterway infrastructure
	IT4	Hazardous Material Vehicle Location Status/Shipment Tracking	11.6.1 TxDOT Multimodal Freight Planning—developing strategies, policies, and methodologies to improve the freight transportation system	11.6.3 Freight-Based Technology and Operations—enhancing freight transportation system safety, management, operations, and asset management	

Category	No.	CST Name	Texas Freight Mobility Plan Programs Related to CSTs		
			Title/Description	Title/Description	Title/Description
	IT5	Intermodal Terminal Efficiency	11.6.1 TxDOT Multimodal Freight Planning—developing strategies, policies, and methodologies to improve the freight transportation system	11.6.3 Freight-Based Technology and Operations—enhancing freight transportation system safety, management, operations, and asset management	11.6.7 Port and Waterway Development and Improvement—identify strategies that expand port and waterway capacity and improve waterway infrastructure
Truck Infrastructure	TI1	Dedicated Truck Roadways	11.6.1 TxDOT Multimodal Freight Planning—developing strategies, policies, and methodologies to improve the freight transportation system	11.6.5 Highway Safety, Design, Construction, Bridge, Interchange Improvement—minimizing conflicts between trucks and passenger vehicles on the network	
	TI2	Truck Lanes in Surge Freight Flows	11.6.1 TxDOT Multimodal Freight Planning—developing strategies, policies, and methodologies to improve the freight transportation system	11.6.5 Highway Safety, Design, Construction, Bridge, Interchange Improvement—minimizing conflicts between trucks and passenger vehicles on the network	
Urban Freight	UF1	Short-Haul Rail Movements within Urban Areas	11.6.1 TxDOT Multimodal Freight Planning—developing strategies, policies, and methodologies to improve the freight transportation system		

Category	No.	CST Name	Texas Freight Mobility Plan Programs Related to CSTs		
			Title/Description	Title/Description	Title/Description
	UF2	Underground Freight Transportation	11.6.5 Highway Safety, Design, Construction, Bridge, Interchange Improvement—minimizing conflicts between trucks and passenger vehicles on the network	11.6.1 TxDOT Multimodal Freight Planning—developing strategies, policies, and methodologies to improve the freight transportation system	
	UF3	Truck Delivery Timing Programs			
	UF4	Package Consolidation Boxes/Lockers			
	UF5	Freight Village Facility Development	11.6.1 TxDOT Multimodal Freight Planning—developing strategies, policies, and methodologies to improve the freight transportation system		
Border	B1	Border Inspection Technology	11.6.4 Texas Border/Ports-of-Entry Transportation and Trade—enhance international border coordination strategies to facilitate trade and travel without compromising security		

Category	No.	CST Name	Texas Freight Mobility Plan Programs Related to CSTs		
			Title/Description	Title/Description	Title/Description
	B2	Institutional Arrangements	11.6.4 Texas Border/Ports-of-Entry Transportation and Trade—enhance international border coordination strategies to facilitate trade and travel without compromising security		
Seaports	S1	Truck-Terminal Coordination	11.6.1 TxDOT Multimodal Freight Planning—developing strategies, policies, and methodologies to improve the freight transportation system	11.6.7 Port and Waterway Development and Improvement—identify strategies that expand port and waterway capacity and improve waterway infrastructure	
	S2	Port-Related Rail Improvements	11.6.1 TxDOT Multimodal Freight Planning—developing strategies, policies, and methodologies to improve the freight transportation system	11.6.6 Rail Development and Improvement—expand rail freight capacity and improve rail freight mobility	11.6.7 Port and Waterway Development and Improvement—identify strategies that expand port and waterway capacity and improve waterway infrastructure

Table C-3. CSTs and Draft Texas Freight Mobility Plan Strategies.

Category	No.	CST Name	Texas Freight Mobility Plan Strategies Related to CSTs	
			Title/Description	Title/Description
Aviation	A1	Airships/Aerial Transport		
	A2	Unmanned Aircraft Systems (UAS)		
Non-Highway Systems	NH1	Automated, Zero Emissions Freight Systems		
	NH2	Passenger Rail Cargo Delivery	12.3.3 Strategic/Future Rail Improvements—enhance/expand the role of short line railroads	
Freight Rail	FR1	Grade Crossings and Separations	12.3.3 Strategic/Future Rail Improvements—reduce the number of at-grade crossings statewide	12.3.1 Highway Projects: Primary Freight Network–Non-Interstate Corridors—remove freight bottlenecks and upgrade and improve interchanges
	FR2	Freight Rail Public–Private Partnerships (P3s)	12.3.3 Strategic/Future Rail Improvements—continue to work with the railroads through public-private partnership opportunities	
	FR3	Railroad Infrastructure Relocation	12.3.3 Strategic/Future Rail Improvements—Improve multimodal connectivity to industrial facilities, including ports, industrial parks, and transloading facilities	
Alternate Fuels	AF1	Natural Gas Freight Vehicles		
	AF2	Electric/Hybrid Freight Vehicles		

Category	No.	CST Name	Texas Freight Mobility Plan Strategies Related to CSTs	
			Title/Description	Title/Description
	AF3	Other Fueled Freight Vehicles		
AV/CV Truck	AV1	Truck Platooning		
	AV2	Automated Trucks		
ITS and Operations	IT1	Traffic Signal Coordination Systems	12.3.2 Strategic/Future Operational and Technology Improvements—improved freight movement signal timing/coordination to reduce congestion and improve safety	
	IT2	Truck-Shipper Matching Systems	12.3.2 Strategic/Future Operational and Technology Improvements—expand and deploy ITS technologies to make better use of the network, reduce congestion, and increase mobility	
	IT3	Port ITS Systems	12.3.2 Strategic/Future Operational and Technology Improvements—expand and deploy ITS technologies to make better use of the network, reduce congestion, and increase mobility	
	IT4	Hazardous Material Vehicle Location Status/Shipment Tracking		
	IT5	Intermodal Terminal Efficiency		

Category	No.	CST Name	Texas Freight Mobility Plan Strategies Related to CSTs	
			Title/Description	Title/Description
Truck Infrastructure	TI1	Dedicated Truck Roadways	12.3.1 Highway Projects: Primary Freight Network–Interstate Corridors—develop and complete new corridors and additional freight conduits	
	TI2	Truck Lanes in Surge Freight Flows	12.3.1 Highway Projects: Primary Freight Network–Interstate Corridors—develop and complete new corridors and additional freight conduits	
Urban Freight	UF1	Short-Haul Rail Movements within Urban Areas	12.3.3 Strategic/Future Rail Improvements—enhance/expand the role of short line railroads	
	UF2	Underground Freight Transportation	12.3.1 Highway Projects: Primary Freight Network-Interstate Corridors—develop and complete new corridors and additional freight conduits	
	UF3	Truck Delivery Timing Programs		
	UF4	Package Consolidation Boxes/Lockers		
	UF5	Freight Village Facility Development		

Category	No.	CST Name	Texas Freight Mobility Plan Strategies Related to CSTs	
			Title/Description	Title/Description
Border	B1	Border Inspection Technology	12.3.6 Strategic/Future Border and Port-of-Entry Improvements—increase the application of ITS and other technology improvements through electronic screening, cargo inspection, and advanced traveler and trucker information	
	B2	Institutional Arrangements	12.3.6 Strategic/Future Border and Port-of-Entry Improvements—develop a comprehensive and coordinated Texas-Mexico border strategy and increase the development and deployment of integrated border-crossing management	
Seaports	S1	Truck-Terminal Coordination	12.3.4 Strategic/Future Port and Waterway Improvements—expand port capacity and connectivity, improve truck access, and maintain landside access to ports and facilities	12.3.2 Strategic/Future Operational and Technology Improvements—expand and deploy ITS technologies to make better use of the network, reduce congestion, and increase mobility
	S2	Port-Related Rail Improvements	12.3.4 Strategic/Future Port and Waterway Improvements—expand port capacity and connectivity and provide direct rail connections to ports	12.3.3 Strategic/Future Rail Improvements—improve multimodal connectivity to industrial facilities, including ports, industrial parks, and transloading facilities