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Assessment of Innovative and Automated Freight Strategies and Technologies—Phase II Final Report

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Cooperative Research Program

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16. Abstract

Phase II of TxDOT 0-6837 investigated nine strategy/technology (S/T) areas recommended by the Texas Department of Transportation (TxDOT) at the end of Phase I. Researchers used the National Cooperative Highway Research Program (NCHRP) 750: Volume 3 Systematic Technology Reconnaissance, Evaluation, and Adoption Methodology (STREAM) evaluation method and other appropriate methodologies to assess each S/T area. The nine areas selected for further evaluation were automated/zero emission freight systems, freight rail public-private partnerships, alternative fueled freight vehicles, truck-shipper matching systems, port intelligent transportation systems, separation of trucks from automobiles, truck parking information systems, freight village facility development, and border advanced freight traveler information. The Phase II project expanded the understanding of the nine selected S/T areas using NCHRP-recommended STREAM process evaluation methods, informed the TxDOT project panel how evaluated S/Ts could address TxDOT freight planning goals and objectives, and identified test concepts and applications that could address freight system needs. Phase III will implement activities related to four of the S/Ts advanced by the panel during Phase II.

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

by

Curtis Morgan
Program Manager, Multimodal Freight (Research Supervisor)

Jeffrey D. Borowiec, Ph.D.
Research Scientist, Infrastructure Investment Analysis

C. James Kruse
Director, Center for Ports & Waterways

Mario Monsreal, Ph.D.
Research Scientist

Dennis Perkinson, Ph.D.
Research Scientist

Jolanda Prozzi
Division Head, Environment and Air Quality

Allan Rutter
Division Head, Freight and Investment Analysis

Juan Carlos Villa
Research Scientist

Jeffery Warner
Assistant Research Scientist, Multimodal Freight

Robert Brydia, PMP
Program Manager, Advanced Transportation Operations

Brianne Glover, J.D.
Program Manager, Infrastructure Investment Analysis

John Habermann
Research Engineer

Brett Huntsman
Assistant Transportation Researcher

Dong Hun Kang, Ph.D.
Associate Transportation Researcher

Nicole Blackwell Katsikides
Associate Research Scientist

Jacqueline Kuzio
Graduate Assistant Researcher

Dahye Lee
Graduate Assistant Researcher

Madison Metsker-Galarza
Assistant Transportation Researcher

Matthew Miller
Assistant Research Scientist

Les Olson
Associate Transportation Researcher

Sushant Sharma, Ph.D.
Associate Research Scientist

Maxwell Steadman
Associate Transportation Researcher

Srinivasa Sunkari
Research Engineer

Anthony Voigt
Research Engineer

and

L.D. White
Research Specialist IV

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College Station, Texas 77843-3135

DISCLAIMER

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CHAPTER 1. BACKGROUND AND PROJECT OVERVIEW

INTRODUCTION

Freight activity in Texas plays a major role in the vitality of the state's economy. Current and projected freight levels indicate a vibrant economy and the role that Texas has as a leader in the global economy. The Texas Department of Transportation (TxDOT) recognizes the importance of current and future freight transportation needs and has recently completed an update to the TxDOT Texas Freight Mobility Plan (TFMP) to identify and address many of these goals.

The TFMP projects freight statewide to almost double from 2.2 billion tons currently to 4.0 billion tons by 2045 (*1*) as a result of the state's growing population. Concerns exist as to the ability of the state's transportation network to adequately support this increase without major investment in freight infrastructure; however, questions remain as to how best to make strategic investments and how to select appropriate new technologies that will improve freight system efficiency. Identification of new strategies and technologies (S/T) 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.

BACKGROUND AND OBJECTIVES

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), and
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 considered in drafting the original proposal, which covered only Phase I and initial planning for Phase II of the envisioned, overall project.

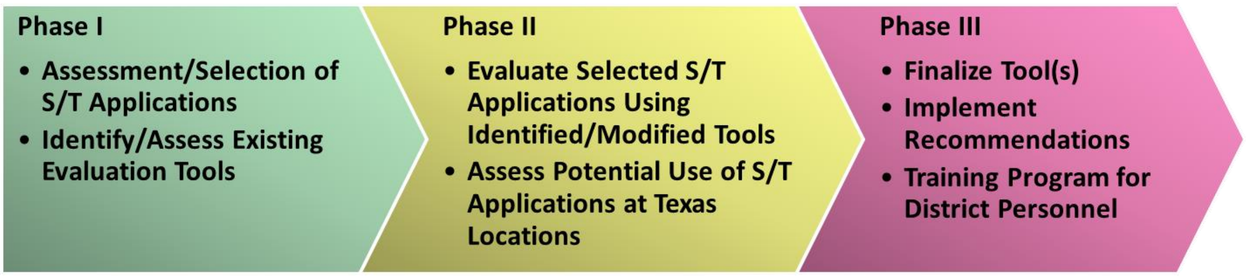

Figure 1. Initial Envisioned Three Phases of the Project.

Phase I Overview

In the Project Agreement for Phase I of TxDOT 0-6837, *Assessment of Innovative and Automated Freight Systems and Development of Evaluation Tools*, which ended on March 31, 2016, researchers undertook a comprehensive review of innovative and automated freight S/T used worldwide. This effort identified approximately 52 potential S/T, which were assessed and grouped by common characteristics. From these groups, nine S/T areas that could impact future freight distribution was recommended for further analysis by the TxDOT project oversight panel in February 2016. The nine areas selected for Phase II research were:

- S/T Area 1: Automated, Zero Emission Freight Systems.
- S/T Area 2: Freight Rail Public-Private Partnerships (P3s).
- S/T Area 3: Natural Gas, Electric/Hybrid, and Other Fueled Freight Vehicles.
- S/T Area 4: Truck-Shipper Matching Systems.
- S/T Area 5: Port Intelligent Transportation Systems (ITS).
- S/T Area 6: Separation of Trucks from Automobiles.
- S/T Area 7: Truck Parking Information Systems.
- S/T Area 8: Freight Village Facility Development.
- S/T Area 9: Border Advanced Freight Traveler Information.

From the various freight project evaluation methods examined during Phase I, the Systematic Technology Reconnaissance, Evaluation, and Adoption Methodology (STREAM) process described in National Cooperative Highway Research Program (NCHRP) Report 750 Volume 3 was identified as the process to use as a base for Phase II S/T evaluations. NCHRP developed STREAM as a process that transportation agencies can use to identify, assess, shape, and adopt new and emerging technologies to help achieve long-term system performance objectives. The process reflects relevant trends in technologies and their applications, and is designed to help transportation agencies anticipate, adapt to, and shape the future. STREAM follows a five-step process:

- Step 1: Frame.
- Step 2: Identify.
- Step 3: Characterize.
- Step 4: Compare.
- Step 5: Decide.

Phase II Objectives

Planned Phase II activities included building upon Phase I work by performing in-depth investigations into the characteristics, costs, and implementation barriers for the nine innovative/automated freight S/T selected to advance into Phase II by the project oversight panel. Each S/T was evaluated for implementation at locations on the Texas freight system and matched to specific needs identified in the most current TFMP. Researchers performed an intensive and detailed analysis of each S/T using STREAM or STREAM-based techniques. From these analyses, data and practices that allow for TFMP-identified problem areas to be addressed more quickly and with innovative approaches were to be identified. Phase II also was designed to finalize an evaluation process and identify specific methodologies for evaluation of future proposed freight transportation S/T for use by TxDOT personnel. Researchers were also to make recommendations on the successful S/T from among those evaluated in Phase II for further implementation in the planned Phase III.

Phase II Research Approach

Phase II project activities closely followed the STREAM process with the framing of freight problems and improvement goals (frame); identifying the information needs (identify); conducting in-depth investigations (characterize); and performing the analysis (compare). Further Phase II STREAM analysis findings and TxDOT project panel review identified four S/T areas that have an emphasis in areas/methods that can be more readily implemented by TxDOT. Through interviews and discussions with freight stakeholders including port individuals, metropolitan planning organization (MPO), and other officials, researchers identified possible locations where S/T could be tested on the state freight system. Researchers then proposed activities within the identified locations for Phase III implementation.

REPORT ORGANIZATION

This report documents the findings of Phase II of TxDOT research project 0-6837. Chapter 1 provides the project background and objectives. Chapter 2 documents the analysis on the S/T with the STREAM process. Chapter 3 summarizes the findings of the STREAM analysis and additional evaluation tools. Chapter 4 discusses potential locations to implement S/T in the state. The report closes in Chapter 5 with a summary of Phase II and an overview of planned Phase III activities. The Appendix is a final write-up for S/T Area 8, Freight Village Facility Development, and is included to fully document the work done to evaluate this alternative strategy.

For more information on Phase II activities, see three of the completed technical memoranda submitted during the project:

- Technical Memorandum #2 identifies the information that was required to conduct the STREAM analysis for each S/T.
- Technical Memorandum #3 contains description of the in-depth investigation and data collection for each S/T that was conducted during the project.
- Technical Memorandum #4 covers each S/T area's performance of the STREAM or STREAM-based analysis.

CHAPTER 2. EVALUATING AND PERFORMING ANALYSIS ON THE STRATEGIES AND TECHNOLOGIES WITH THE STREAM PROCESS

This chapter summarizes STREAM and the analysis of the S/T areas using the STREAM process.

STREAM OVERVIEW

As documented in NCHRP Report 750 Volume 3, researchers at RAND Corporation's Transportation, Space, and Technology Program developed the Systematic Technology Reconnaissance, Evaluation, and Adoption Methodology (STREAM) process. The defined goals of the STREAM process were to help transportation agencies and decision-makers in assessing current and potential technologies according to the highly related characteristics such as the goals of the transportation agency and the present/forecast policy environment. Specific outcomes of the NCHRP work were for STREAM to incorporate more effectively the existing agency functions within an assessment, and expectations that it would improve the quality of evaluation and outcomes, especially when agencies and decision-makers are applying technologies to the transportation area. According to NCHRP, the methodology is designed not only to clearly explain inherent uncertainties (some of which are in distribution, adoption, and implementation), but also to indicate prospective future technologies' impacts. STREAM follows a five-step process: Frame, Identify, Characterize, Compare, and Decide (*2*). For these reasons, STREAM was selected during Phase I of the project as the base evaluation method to be used in Phase II of 0-6837.

METHODOLOGY DESCRIPTION

The STREAM process, shown in Figure 2, starts with defining the problem and goals. The main objective of this Frame step is to clearly explain about 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 result in 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.

Second, the Identify step is about identifying suitable technology applications by review of detailed information on 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.

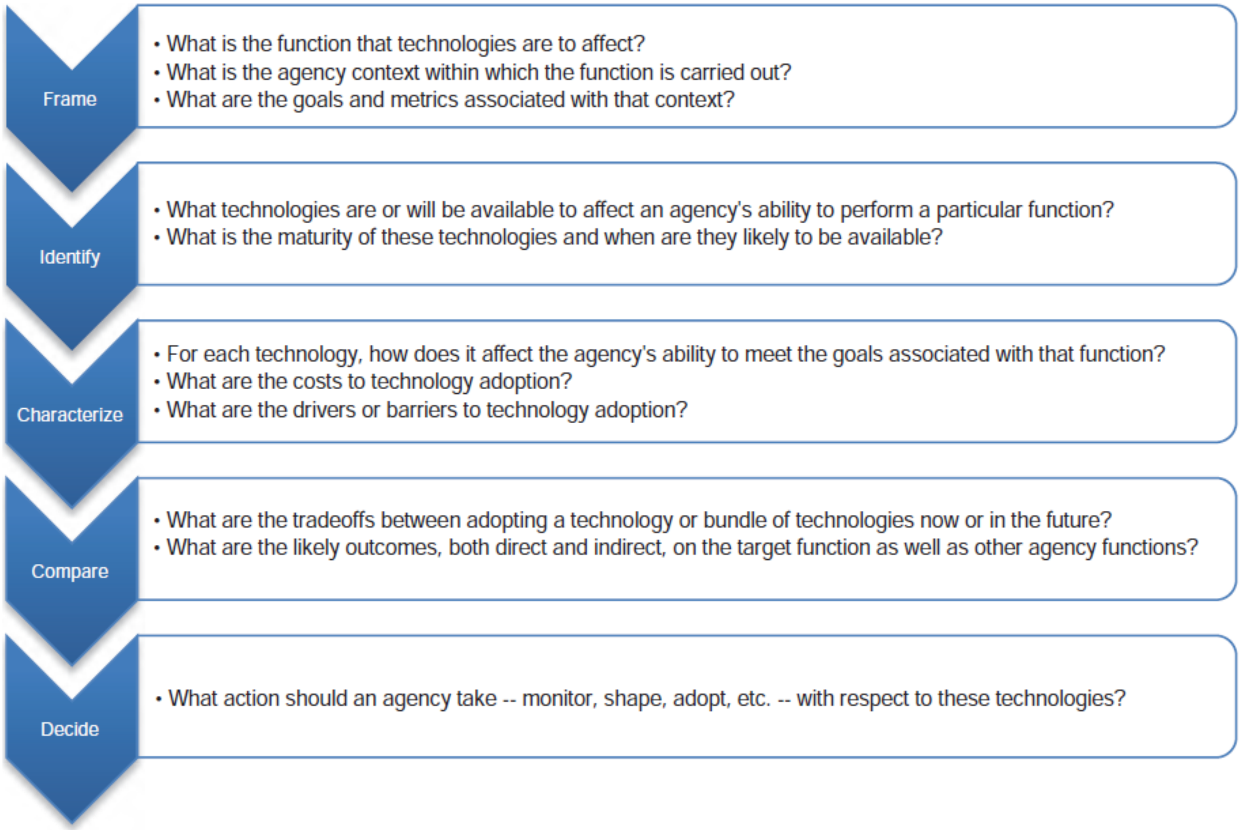

Figure 2. The Major Steps in the STREAM Process (*2*).

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 upon 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, researchers developed a probability of successful implementation (POSI) score and investigated three major impediments: technology, agency process or institutions, and external to agency. Table 1 demonstrates the specific barriers affecting POSI by category of impediment.

In addition, costs need to be characterized in this step. The 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. 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 agency should make on the proposed technologies.

Table 1. Categorized Impediments that Reduce POSI.

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

Source: (2).

STREAM STEP 1: FRAME

The Frame step involves framing the overall functions, goals, and objectives. This section provides background information related to needs and issues that Texas freight system is facing as stated in the TFMP. A review of the most updated TxDOT Strategic Plan (2019–2023) and the TFMP in terms of the potential cross-over and coverage by the selected nine S/T areas is also indicated in this section.

Freight Needs

The TFMP (*1*) identifies and documents 10 significant freight system needs and issues faced by the freight transportation system of the state, ranging from issues such system capacity, multimodal 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 Houston, Dallas, and Fort Worth. 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, multimodal 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.

Safety is one of the identified needs that is largely related to highway and rail systems. Inadequate truck parking impacts safety and mobility of truckers and motorists. Also, public and private at-grade crossings create conflicts between rail and highway users, impacting safety especially in urban areas (*1*).

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 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. The TFMP stressed that improving the connection of the U.S. interstate to Mexico's infrastructure and determining the impact of Mexican infrastructure improvements in the United States should be evaluated (*1*).

TxDOT also notes in the TFMP that improving awareness and understanding of freight operational needs, issues, and roles by the general public has a vital impact on public support of projects and policies on freight. Moreover, improvements to funding levels and inflexible funding programs are needed for the transportation system to keep up with current freight transportation needs (*1*).

Freight Goals

Identification of TxDOT Strategic Plan Goals

The 2019–2023 TxDOT Strategic Plan (*3*) includes TxDOT's seven strategic goals that are primarily focused on improving safety, implementing effective planning, and developing an integrated transportation system for the state. Within the plan, each goal is described along with its objectives, specified action items for achievement, detailed description in supporting each statewide objective, and other considerations.

From among these goals, an initial analysis of the detailed description of each one found that the three goals below are those most closely related to, and likely to be impacted by, the implementation of the S/T in tasks of 0-6837. Under each goal below are listed the specific elements, from the strategic plan, which the S/T analysis in Phase II of 0-6837 addressed:

Goal 1. Promote Safety

- Champion a culture of safety.
- Implement a performance-driven effort to strategically focus safety efforts to mitigate negative safety trends, with initial focus on rising pedestrian fatalities.

Goal 2. Deliver the Right Projects

- Expand the use of data-driven project prioritization.
- Implement effective planning and forecasting processes that deliver the right projects on-time and on-budget.

Goal 5. Optimize System Performance

- Develop and operate an integrated transportation system that provides reliable and accessible mobility enabling economic growth.
- Establish a statewide integrated traffic management system.
- Improve traffic information for more efficient freight movement by developing connected freight corridors.
- Coordinate with local transportation entities to ensure the efficiency of the overall transportation system to facilitate movement of people and goods.

Identification of Texas Freight Mobility Plan Goals

The 2017 TFMP was enhanced based upon the 2016 Freight Plan with consideration of facilitating the efficient and safe movement of people and freight while meeting new federal requirements. Many of these stakeholders were represented on the Texas Freight Advisory Committee, which approved and outlined specific goals for the future freight system and a list of potential projects needed to implement those goals. The TFMP lays out a bold plan for the coming years. In it, eight key goal areas were identified and enumerated with objectives listed under each area. These eight goal areas were:

Goal 1: Safety – Improve multimodal transportation safety. The safety objectives were to:

- Reduce rates of truck-involved crashes, injuries, and fatalities on the Texas Highway Freight Network.
- Reduce the number of rail-related incidents, including crashes at at-grade highway/rail crossings.
- Increase the resiliency and security of the state's freight transportation system in response to multi-hazard threats, including natural disasters and man-made threats.
- Support the deployment of innovative technologies to enhance the safety and efficiency of the Texas Multimodal Freight Network.

Goal 2: Economic Competitiveness – Improve the contribution of the Texas freight transportation system to economic competitiveness, productivity, and development. Economic competitive objectives were to:

- Strengthen Texas' position as a global trade and logistics hub by improving and maintaining Texas' multimodal freight network infrastructure and connectivity.
- Expand public-private and public-public partnerships to facilitate investments in freight improvements that enhance economic development and global competitiveness.
- Identify critical freight infrastructure improvements necessary to support future supply chain, logistics, and consumer demands.

- Conduct outreach activities and develop educational programs to increase awareness of the importance of freight to the Texas economy.
- Support strategic transportation investments to address the rapid increase in key industries, such as energy, agriculture, and automotive production.

Goal 3: Asset Preservation and Utilization – Maintain and preserve infrastructure assets using a cost-beneficial treatment. The asset management objectives were to:

- Achieve and maintain a state of good repair on the Texas Highway Freight Network.
- Improve the overall ratings of bridges on the Texas Highway Freight Network.
- Increase the percent of pavement lane-miles in good condition on the Texas Highway Freight Network.
- Leverage and utilize the Texas Multimodal Freight Network.
- Utilize technology to provide for the resiliency and security of the state's multimodal freight transportation system in response to multi-hazard threats, including natural disasters and man-made threats.

Goal 4: Mobility and Reliability – Reduce congestion and improve system efficiency and performance. The mobility and reliability objectives were to:

- Reduce the number of Texas Highway Freight Network miles at unacceptable congestion levels (level-of-service D or worse).
- Improve travel time reliability on the Texas Highway Freight Network.
- Apply the most cost-effective methods to improve system capacity and reliability (including technology and operations).
- Partner with U.S. and Mexican federal, state, regional, local, and private sector stakeholders to address Texas-Mexico border crossing challenges.
- Support the development and deployment of integrated Texas-Mexico border crossing management through intelligent transportation system (ITS).
- Leverage technology to improve management and operations of the existing transportation system.

Goal 5: Multimodal Connectivity – Provide transportation choices and improve system connectivity for all freight modes. Multimodal connectivity objectives were to:

- Increase Texas supply chain efficiencies by improving connectivity between modes.
- Improve first/last mile connectivity between freight modes and major generators and gateways.
- Improve connectivity between rural and urban freight centers.
- Improve access into and out of Texas' seaports to facilitate projected future growth.

- Improve ground access to commercial airports to enhance truck access and connectivity.
- Improve highway and rail connectivity to major freight gateways and generators through increased capacity improvements.
- Improve multimodal connectivity to Texas-Mexico border crossings.
- Leverage multi-state organizations to increase multimodal freight connectivity across state lines.

Goal 6: Stewardship – Manage environmental and TxDOT resources responsibly and be accountable in decision-making. Stewardship objectives were to:

- Implement a performance-based prioritization process for freight system investment.
- Reduce adverse environmental and community impacts of the Texas Multimodal Freight Network.
- Lead efforts to foster greater coordination among the agencies responsible for freight network investment.
- Reduce delays in freight project planning, programming, and implementation.
- Coordinate freight project planning and implementation with all planning partners and stakeholders.

Goal 7: Customer Service – Understand and incorporate citizen feedback in decision-making processes and be transparent in all TxDOT communications. Customer service objectives were to:

- Develop and sustain partnerships with private sector industries, communities, agencies, MPOs, and other transportation stakeholders and partners.
- Increase freight expertise in TxDOT districts, across departments, and among elected officials.
- Partner with public and private sector stakeholders to enhance workforce recruitment and retention in the transportation and logistics industry.
- Facilitate statewide dissemination of real-time freight movement information by integrating existing traffic management centers.

Goal 8: Sustainable Funding – Identify sustainable funding sources for all freight transportation modes. Sustainable funding objectives were to:

- Identify funding sources for high priority multimodal freight projects.
- Identify and document the needed transportation investment costs to meet the state’s future freight transportation needs.

- Educate the public and stakeholders on the costs of constructing and preserving the freight transportation system.
- Improve predictive capabilities for revenue forecasting and long-term needs assessments.

Approaches

Upon analysis of these goals, researchers identified the following TFMP recommendations where the nine original S/T under review and evaluation in 0-6837-01 (Phase II), directly or in-directly, carry out or implement both specific and system-wide goals listed of the TFMP (reviewed S/T areas are listed below of each item below):

Freight System Trends

- Energy: alternative transportation fuels.
  - Natural Gas, Electric/Hybrid, and Other Alternative Fueled Freight Vehicles.
- Technology: ITS, autonomous and connected freight vehicles.
  - Automated, Zero Emission Freight Systems.
  - Truck-Shipper Matching Systems.
  - Port ITS.
  - Truck Parking Information Systems.
  - Border Advanced Freight Traveler Information.

Freight Improvement Planning Studies – Program

- Conduct a Statewide Truck Parking and Rest Stop Study to evaluate the current condition of truck parking within the state, analyze the impact of hours-of-service on trucker operations, identify potential community and safety impacts of inadequate truck parking facilities, and develop strategies to meet current trucking needs and future demands.
  - Truck Parking Information Systems.
- Conduct a Truck-Only Lane Feasibility Study to evaluate opportunities to separate trucks and autos on the Texas Highway Freight Network to reduce congestion, and improve safety and mobility for the motoring public and trucks.
  - Separation of Trucks from Automobiles.

Technology and Operations – Program

- Adopt, expand, and deploy ITS technologies to improve mobility and safety for both passenger and freight.
  - Truck-Shipper Matching Systems.
  - Port ITS.

  - Separation of Trucks from Automobiles.
  - Truck Parking Information Systems.
  - Border Advanced Freight Traveler Information.

Border/Ports-of-Entry – Program

- Expand the use of ITS technologies such as electronic screening, advanced traveler information, and other technologies to enhance the fluidity and efficiency of border and to improve safety and mobility, reduces emissions, and improve security at the Texas-Mexico border crossings.
  - Border Advanced Freight Traveler Information.

Rail – Program

- Work with the railroads in preserving and improving rail freight infrastructure and service through increased public-private partnership opportunities.
  - Freight Rail Public-Private Partnerships

STREAM STEP 2: IDENTIFY

The Identify step involves identifying all the relevant S/T. For this step, each of the S/T Area Teams developed a preliminary list of S/T. Additionally, each S/T Area Team identified information sources that could be used to carry out the evaluations required. Also, the early identification of any needed databases or other information needs were stressed. This section includes the S/T Area Team write-ups for this step; see Technical Memorandum #2 for additional content and a detailed matrix that lists information sources by S/T area.

S/T Area 1: Automated/Zero Emission/Fixed Guideway

S/T Area 1's research team identified possible S/T for implementing automated/zero emission freight systems. Researchers assessed the various components that define an automated/zero emission freight system to understand the different technologies proposed or operating within this area. As currently conceptualized, automated freight systems (AFS) include elements of intelligent infrastructure and vehicle control, as well as some effort to remove trucks or rail from the roadway. The aim of an AFS is to reduce emissions, congestion, and logistics costs through the usage of fixed guideways and low to zero emission technologies. Researchers focused on technologies that aimed to carry freight from marine ports or border crossings to urban or distribution centers. Current designs under consideration typically include the use of linear synchronous motors, (e.g., Magplane and Roam Transportation Systems, formerly MegaRail) linear induction motors (e.g., The Freight Shuttle System), electrified rails, or an in-road power supply.

Researchers conducted a thorough literature search that addressed existing technologies and identified developers of such systems and government entities that use AFSs to create clean freight corridors or clean ports (e.g., South Coast Air Quality Management District and Port of Los Angeles and Long Beach). The literature search included the use of the Transportation Research Information Database and Google Scholar. Some key documents were identified that assisted in the identification of other relevant sources including those on-going in the private-sector. This was particularly helpful in the case of identifying private-sector technologies where information can be hard to come by. Researchers also reviewed several of the private sector efforts in this area.

Upon initial review, the TFMP does not appear to directly reference this area in its policies, needs, and issues. The AFS concept does, however, play an ancillary role in helping to reduce congestion, increasing mobility and capacity, reducing community impacts, and improving safety, which are stated goals of the TFMP.

Due to the cost and complexity of these technologies, few real-world examples of automated/zero emission freight systems currently exist. This presented a challenge to collecting observed data and analyzing the impact of these new technologies, as so few systems are in place and many operate on a small scale. In addition, because many of these AFS concept systems are in the private-sector, obtaining the data that do exist proved difficult. This made it challenging for researchers to consider the full cost of implementation and the total impact of such a system when completing the STREAM process in later project tasks.

S/T Area 2: Alternative Fueled Freight Vehicles

Researchers gathered detailed information and examine the use of natural gas, hydrogen, and other alternative fueled vehicles for various uses including intercity trucks, locomotives, barges, cranes, and local delivery vehicles as part of the freight transportation system. Information on benefits and cost tradeoffs of using alternative fuels were gathered and information on newly emerging alternative fuel vehicle technologies. Several prior analyses were identified, but many of the newest technologies and innovations in this area known to the researchers were not included in most of those studies. Researchers found limited detailed information on specific performance characteristics of vehicles in-service as opposed to test cases.

Specific investigation into the Clean Transportation Triangle system within Texas by the Texas Commission on Environmental Quality as an effort to provide natural gas infrastructure along major Texas Interstate routes was performed. Reports and data from the U.S. Department of Energy, U.S. Environmental Protection Agency, and other federal agencies are included among the information sources listed in the matrix for this area in Technical Memorandum #2.

The challenges in evaluating this S/T area are largely limited to two primary issues: operational data/technology information that is considered proprietary by its implementers and how to address new, promising but unproven technology applications in alternative fuel vehicles. For example, much of the literature indicated that electric vehicles are on the cusp of a revolution in battery technologies that will allow broader implementation and adoption; however, evaluating such claims proved difficult and performance in actual freight service may not live up to projected assertions if not adopted widely by private freight operators or in public fleets. Beyond intercity trucks and smaller delivery vehicles, the use of alternative fuels for freight movement remains limited at this time. Benefits and costs of multimodal options are also difficult to assess due to the current experimental, low implementation level for these technologies.

S/T Area 3: Freight Rail Public-Private Partnerships (P3s)

The Office of Innovative Program Delivery (OIPD), a division of the Federal Highway Administration (FHWA), defines P3s as "contractual agreements formed between a public agency and a private sector entity that allow for greater private sector participation in the delivery and financing of transportation projects" (*4*). Recent Texas A&M Transportation (TTI) research categorizes P3s for freight rail as public freight rail projects (PFRPs) that involve, "the public sector in private freight railroad projects…[which] can involve the following four types of projects:

- Passenger rail improvements on the freight rail network.
- Public investment in freight rail network improvements.
- Public investment and facilitation of freight rail improvements involving more than one railroad.
- Public funding and ownership of freight rail facilities" (*5*).

Many of these PFRPs have included discretionary federal funding through the Transportation Investments Generating Economic Recovery (TIGER) grant program administered by the U.S. Department of Transportation (USDOT). In successive iterations of the TIGER grant program, USDOT has become increasingly specific and sophisticated in requiring funding applicants to demonstrate quantitative evidence of positive benefit-cost ratios. TIGER grant applications and supplemental documentation from applicants for PFRPs will have more detailed quantitative information that can be used in applying the STREAM analysis for rail P3s as a strategy. The literature review for this S/T area specifically collected background information on the following recent national rail P3s for analysis during Phase II:

- Tower 55 in Fort Worth, Texas.
- Brownsville West Rail Bypass and International Bridge in Brownsville, Texas.

- Chicago Regional Environmental and Transportation Efficiency Program (CREATE) in the Chicago, IL region.
- Colton Crossing Flyover Project in Colton, California.
- Willmar Rail Connector and Industrial Access in the City of Willmar and Willmar Township, Minnesota.

Additionally, researchers obtained the final environmental assessment for the Neches River Railroad Bridge that TxDOT sought funding for during the 84th Legislature. This document offered data on this additional recent PPP within the state of Texas. Researchers examined TIGER grant application details, financing documents, and environmental documentation on individual CREATE projects and any other information available on the PPPs listed above. Researchers worked directly with the TxDOT Rail Division to obtain more documentation on the Tower 55 project. Project representatives and/or experts on other projects were contacted as necessary to discuss projects further to more fully understand implementation issues that might not be obvious from the available literature.

S/T Area 4: Truck-Shipper Matching Systems

Researchers identified 24 different truck-shipper matching systems that vary in their level of sophistication and services offered. On the one extreme some systems resemble "Uber for trucking," but serving urban and long-distance carriers rather than individual citizens. Other services resemble more traditional load boards (i.e., a web-based platform that shippers and truckers can access to post or access information about shipments). Some identified systems specialized in truckload operations (TL), while others specialized in less-than-truckload (LTL) operations. One studied system focused only in oversize freight movements.

Researchers reviewed the literature to identify criteria and barriers to implementation that might be used during a STREAM evaluation of this type of system. Truck-shipper matching systems hold the potential to reduce the number of trips (specifically "dead head"/empty trips) and empty vehicle miles traveled with associated congestion, vehicle/equipment utilization, fuel efficiency, and emissions benefits. Potential barriers to implementation that were highlighted in the literature were documentation requirements, existing and preferred carrier/driver relationships, data security concerns, performance measurement, and trust. References were also made to operational constraints, such as short average trip lengths, tight scheduling, and variable use of refrigeration. The policy and regulatory requirements for these truck-shipper matching systems seem largely unexplored in the literature. An initial set of data sources (i.e., existing truck-shipper matching systems and contact information as available) were identified and were included in a Preliminary Information Resources Matrix, which is included under the description of this S/T area in Technical Memorandum #2. A major barrier to evaluation for this S/T area was that criteria and data required in a STREAM evaluation were regarded as proprietary by the private sector companies engaged in this work.

S/T Area 5: Port ITS

Researchers for this S/T area identified almost two dozen potential S/T that could fit within the scope of Port ITS. To make evaluation and analysis manageable and meaningful, the list was reduced to S/T that affect TxDOT's operations directly or that could be implemented by TxDOT or with assistance of TxDOT. The following S/T are grouped by TxDOT objectives, with descriptions of each of these concepts below:

- Infrastructure protection—Pre-trip and En-Route Over Height Vehicle Detection and Notification.
- Mobility/Trip Times:
  - Railroad grade crossing monitoring to provide messages for alternate routes.
  - Truck prioritization at isolated traffic signals or during off-peak hours.
  - Truck-influenced dynamic signal timing along signalized freight corridors.
- Reduce negative effects of enforcement activities—On-board truck safety inspection.
- Improve safety of hazardous materials (HAZMAT) transport—Automated route planning information in the permitting process to include inventory of barriers (railroad crossings, low clearance bridges, etc.) of concern for trucks and route clearance with allowable HAZMAT routing and real-time diversion alarms to fleet managers/owners and law enforcement.

Researchers undertook and completed an initial literature review focused on the use of ITS in and around port environments. Unfortunately, the port-related literature predominantly focuses on use of ITS in terminal operations, with most emphasis on use within container terminals. Since the scope of this project encompasses both on-port property and the roadways outside the gates of a port or terminal, with emphasis on facilities within the public rights-of-way, researchers did not find significant literature dealing with port ITS systems in the interest areas. Researchers also reviewed some publications by ports known to be highly automated and reviewed literature from vendors that are active in the ITS arena to find areas where existing literature/findings might be broadened to encompass the areas of concern for this project.

Researchers determined that the majority of data needed to assess, implement, and/or evaluate the use of these technologies to support port ITS elements would be infrastructure based (from existing or deployed sensors or other existing or deployed controllers) or come from inventory-type support data. For example, in the areas of automated route planning for over-height or HAZMAT trucks, TxDOT bridge clearance, allowable bridge loads, rail crossing locations, and/or HAZMAT route information/data are required. Deploying sensors/infrastructure for evaluation and testing of this type requires coordination with TxDOT or other agencies as needed to install various equipment or install equipment that reads data generated and/or transmitted by existing or installed equipment. Similarly, for implementing any truck signal priority systems, locations of high truck volumes need to be identified and feasibility of the signal systems to accommodate the implementation of a signal priority system needs to be determined. This can be accomplished with TxDOT's support. An implementation of the system to provide information in advance of arrival of a train requires an inventory of the characteristics of the highway-rail crossings, which can be obtained from the rail operators.

With any of the above technologies, there is a risk that current market offerings will not meet the minimum requirements needed and that development must take place per research requirements. Those unknowns would be further identified in the STREAM analysis and documented as the concepts for testing and evaluation are examined further, but researchers do envision assistance needed from TxDOT division and district staff in interagency coordination (with local cities and counties) and deployment assistance in the field to deploy infrastructure for testing, with the time and cost needed varying based on the scope of study and evaluation finalized through the STREAM process.

S/T Area 6: Separation of Trucks from Automobiles

This S/T area examined technologies and strategies for segregation of truck traffic from passenger vehicle traffic through either restricting use of specific lanes by commercial fleet vehicles or by providing special dedicated facilities for fleet vehicle operation. Analysis consisted of several potential types of truck freight separation including: truck only roadways, specialized truck only toll lanes, truck only interchange or intersection bypasses, or as-needed truck-only managed lanes that could be designated to coordinate with high freight traffic time periods such as the arrival of a large containership in a port city.

Researchers conducted a thorough literature review focused on lane-based strategies for segregation of truck traffic, ITS technology deployment needed, and any policy implications. The review included a critical examination of the current state of the practice, experience, and lessons learned both domestically and internationally. Researchers reviewed information from sources such as:

- Transportation Research Information Services bibliographic database.
- International Transport Research Documentation database.
- Research in Progress database.
- TRANSPORT database.
- National Transportation Library database.
- Transportation Research Board's Cooperative Research Program reports.
- FHWA's Electronic Document Library.
- FHWA's ITS Benefit Cost Database and Technology Overview Website.
- Google (and similar) web link databases.
- Association of Metropolitan Planning Organizations website and resources.

- American Association of State Highway and Transportation Officials website and technical resources.
- National Performance Management Research Data Set.
- State MPO associations.

Several recent National Cooperative Freight Research Program reports also were reviewed and case studies of specific freight applications that may not be directly indexed within the databases were identified and examined. Researchers also leveraged the literature review conducted under the ongoing TxDOT project 0-6851 *Strategies for Managing Freight Traffic Through Urban Areas* being conducted by other researchers to avoid duplication of efforts.

Researchers studied the TFMP and tried to identify goals and areas that align with technologies and strategies being studied in this task. Researchers also tried to shortlist identified projects from TFMP that can be considered for implementation of strategies projects for segregation of truck traffic from passenger vehicle traffic. Researchers identified projects from TFMP that can be considered for implementation of strategies for segregation of truck traffic from passenger vehicle traffic. However, the information is not enough to exactly identify the projects. For example, many widening and managed lane projects can be converted to dedicated truck lanes if the corridor experiences major freight bottleneck, but information in the TFMP project list is not exhaustive enough. Researchers are interested in understanding the likelihood/possibility of converting some identified currently as managed lane projects into potential dedicated truck lanes/truck only toll lanes.

S/T Area 7: Truck Parking Information Systems

This area examined potential practices to reduce truck congestion and associated driver fatigue/safety within urban/high-truck traffic areas by assigning designated truck parking areas in terminal locations or alongside intercity routes by providing parking availability information. The main purpose of this effort is to reduce parking-hunting truck trips and loss of productive time in freight movement due to inefficient hunting for parking to ensure compliance with federal hours of service (HOS) rules. Researchers also added a focus on how en route, highway safety rest area truck parking problems may be related to the terminal/urban truck parking issue. Systems and approaches for both terminal/urban and en route truck parking were examined. Land-use/availability and/or parking surface availability is a secondary issue that will need to be examined based upon the actual site where truck parking solutions are considered.

Several USDOT and state-level smart parking pilot studies were reviewed for applicability to Texas. The role of private sector truck parking facilities both at truck stops and in terminal areas was also explored as part of the literature review. Among the items found and listed in the Preliminary Information Sources Matrix in Technical Memorandum #2 is a recent FHWA Request for Comments on changing policy on service availability at public rest stops/parking areas (i.e., food, fuel), which is currently limited under federal law to avoid taking business away from commercial truck stop operators. Reports by federal agencies (e.g., FHWA, Federal Motor Carrier Administration [FMCSA]) and private stakeholders (e.g., National Association of Truck Stop Operators, American Transportation Research Institute) were included in the literature review to identify issues and potential data sources. A recent study and data for a newly opened truck parking system along I-95 on the East Coast was also identified.

Information on equipment and systems that can identify available parking spaces and smartphone applications that allow online reservation of the parking areas can permit truck drivers to avoid unnecessary driving to seek appropriate parking areas near a terminal pick-up/drop-off point. Pre-reservation of parking based on traffic conditions can also prevent truck drivers from exceeding federal safety limits for daily HOS limits and required rest periods related to the HOS limits.

Problems in obtaining data from private sector stakeholders and on truck parking space availability sensors from private sector vendors are the primary barrier/challenge to detailed evaluation in this area. These problems can hopefully be overcome during in-depth investigation through cooperation with TxDOT to seek information sharing. Federal data and data from the Mid America Association of Transportation Officials Regional Truck Parking Information Management System project were identified as potential sources of information available to researchers through public USDOT websites and associated research agencies such as the Volpe Center.

S/T Area 8: Freight Village Facility Development

This S/T area research team explored the use and implementation of a Freight Villages (FVs) strategy to address traffic congestion near major freight traffic generators. Researchers analyzed several definitions of FVs. Two examples include, "a Freight Village is a defined area within which all activities relating to transport, logistics and the distribution of goods, both for national and international transit, are carried out by various operators" (*6*) and "a Freight Village is an area of land that is devoted to a number of transport and logistics facilities, activities and services, which are not just co-located but also coordinated to encourage maximum synergy and efficiency" (*7*). The consensus is that the underlying purpose of an FV is to streamline the freight flow by clustering intermediate freight facilities and services to reduce unnecessary waste of time and fuel, enhance safety, and improve land use.

Through an analysis of the TFMP and the TxDOT Strategic Plan, researchers identified potential freight system needs and issues that could be addressed by or related to FV implementation. Consequently, researchers identified improvement goals and their corresponding information sources per each freight system needs and issues. Based on these relevant needs, issues and goals, researchers considered that the potential information sources are comprised of traffic analysis data (e.g., Texas congestion map), freight data (e.g., Freight

Analysis Framework data from Bureau of Transportation Statistics), and business data from the U.S. Census Bureau economic analysis data (e.g., transportation annual survey).

Researchers reviewed the cases of FVs in Europe and in the United States to establish the evaluation criteria to be used in the STREAM process. Researchers modified the STREAM process steps to fit the FV-specific assessment criteria. The modified STREAM process or FV-specific assessment process (FVAP) considers an estimated cost-benefit comparison among several candidate locations or scenarios for FV implementation. Because of the latter, information related to impacts and investment and operation cost are needed to complete an assessment. Collecting data on these specific concepts presents a challenge given the limited availability of such information and its sensitive nature.

S/T Area 9: Border Advanced Freight Traveler Information

The Border Freight Traveler Information section of the research analyzed the following S/T:

- Strategies – Coordination and data sharing among the various federal, state, local and private sector stakeholders that operate at the border to increase cross-border trade efficiency. As part of the coordination strategies, the potential of implementing inspections by various agencies at one location is being tested with satisfactory results. Sharing information among federal and state vehicle inspection agencies could decrease inspection times and even provide information for a more targeted inspection process.
- Technologies – The use of ITS technologies at international border crossings was analyzed to identify specific applications in Texas. ITS technologies can increase cross border transportation efficiencies. Some of the specific ITS technologies include the deployment of integrated border-crossing management systems that include dynamic messaging, targeted vehicle safety inspection programs, and general public information dissemination. Border crossing and wait time measurement programs using ITS technologies are being implemented to provide valuable user and planning information for federal and state agencies.

STREAM STEP 3: CHARACTERIZE

The Characterize step provides the quantitative and qualitative evaluations on each strategy and technology against criteria. To accomplish this step, researchers performed an extensive investigation of the S/T included in each S/T area. The calculated evaluations are combined in the following Compare step. This intensive investigation was reported in Technical Memorandum #3. Headings within the technical memorandum define the materials covered. Each section/subsection description included the following areas:

- Literature Review Findings and Major Sources.
- Available Information.
- Strategies/Technologies Assessed.
- Remaining Needs.

In several instances, researchers slightly expanded or modified the area focus during execution of the project to ensure that a more robust picture and corresponding increased data available on each S/T area were gathered. In two cases, S/T areas were subdivided further based on specific characteristics:

- S/T Area 2: Natural Gas, Electric/ Hybrid, and Other Alternative Fuel Freight Vehicles was subdivided into on-road (i.e., long haul trucks, local delivery trucks) (Part I) and off-road (i.e., locomotive, barge, cranes, ferry) (Part II) segments.
- S/T Area 7: Truck Parking Information Systems was subdivided into highway rest area/truck stop/en route (Part I) and terminal area parking issues (Part II).

STREAM STEP 4: COMPARE

The Compare step compares the main output characteristics of each strategy and technology. As indicated above, researchers combined the detailed quantitative and qualitative evaluations were performed in combination of the Characterize and Compare steps. Researchers performed the STREAM-based analysis on each of the nine selected S/T area, with S/T Area 5 being subdivided further based on its technological characteristics:

- S/T Area 5: Infrastructure protection and improving safety of HAZMAT transport through pre-trip and en route (Part I) and technology improvements to truck safety and reliability (Part II).

The STREAM process outline in NCHRP 750 Volume 3 was applied in accordance with the principles described in that report and modified as necessary by each S/T area team to achieve a true individual understanding and comparative assessment of the nine selected S/T areas included in this project. Technical Memorandum #4 provides information on the STREAM-based analysis undertaken for each of the nine S/T areas.

STREAM STEP 5: DECIDE

The final step in the STREAM process is Decide. The process is designed to demonstrate the value of S/T against a set of developed criteria. TxDOT and/or other planning entities could use the process for assisting in determining investment priorities.

CHAPTER SUMMARY/CONCLUSIONS

This chapter and the associated technical memoranda summarize the STREAM-based process and document the activities undertaken by researchers to use the STREAM process within each S/T area during Phase II. Using the goals and objectives in the Frame step, researchers were able to develop a set of summary criteria used across each of the S/T areas and subareas. Table 2 overviews those criteria grouped into seven categories. In general, the resulting criteria matrix followed closely with the goals outlined in the TFMP.

Table 2. Criteria Used for the STREAM Analysis.

S/T	Benefits						
	Safety	Mobility / System Operations	Asset Management	Multimodal Connectivity	Environmental / Stewardship	Economic Competitiveness	Sustainable Funding
1	✓	✓	✓	✓	✓	✓	
2		✓			✓		
3	✓	✓			✓	✓	
4		✓			✓	✓	
5A	✓	✓	✓				
5B	✓	✓					
6	✓	✓		✓		✓	✓
7A		✓		✓	✓		✓
7B		✓		✓			✓
8	✓	✓			✓	✓	
9		✓				✓	

CHAPTER 3. EVALUATION TOOLS

One of the primary objectives of Phase II was to assess the use of the NCHRP 750 Volume 3 STREAM process in evaluations of each of the nine original TxDOT-selected S/T areas. TTI was directed to provide a comparison of experiences in using the NCHRP-recommended STREAM analysis for this type of evaluation but expanding the method to include both S/T. The required outcome of the task was an assessment of whether TxDOT should adopt the STREAM process for future freight technology assessment and evaluation, the STREAM plus several other methods (i.e., a toolkit that varies, depending upon the type of project and scope), or whether an entirely new process for such freight technology and strategy assessments must be defined.

FINDINGS OF THE STREAM ANALYSIS

Researchers performed a STREAM-based analysis on each of the nine selected S/T areas selected by the 0-6837 panel at the end of Phase I of the research project. Performing the STREAM-based analysis used the in-depth investigation and data collection as described in the previous chapter. The STREAM process outline in NCHRP 750 Volume 3 was applied in accordance with the principles described in that report and modified as necessary by each S/T Area Team to achieve a true individual understanding and comparative assessment of the nine TxDOT-selected S/T areas.

STREAM USAGE

The following discussion summarizes the use of the STREAM process for each S/T area, whether the STREAM process was used as originally designed or if it was modified to accommodate the distinctive considerations of each S/T area topic. The observations of each S/T Area Team are also included.

S/T Area 1: Automated/Zero Emission Freight Systems

- Comparison between technological systems—All technologies were in the testing and/or prototyping phases.
- Used a modified STREAM process to accommodate the lack of data due to the current status of the technologies, proprietary nature of their development, and the fact that none have been implemented to date—Were able to use NCHRP 750 Volume 3 researcher-provided software and go through the STREAM process comparing technologies.

S/T Area 2: Natural Gas, Electric/Hybrid, and Other Alternative Fueled Vehicles

- STREAM not used directly for this S/T as it was more oriented toward information gathering on various technologies rather than a direct comparison of them.
- Benefits and costs varied too greatly and selection of options to compare across technologies was too great.
- Detailed data were not available for many of the proposed and/or recently introduced alternative fueled vehicle options making STREAM use difficult.

S/T Area 3: Freight Rail Public-Private Partnerships

- Comparison between strategies implemented at different sites, but unique features of each situation made direct comparison more difficult.
- Used STREAM process with the following observations:
    - Has promise in explaining the relative merits of otherwise complicated and obfuscated rail P3 projects.
    - The STREAM tool is limited by the subjective scoring of those participating in the assessment and relatively small band of variance/scores among the criteria used.

S/T Area 4: Truck-Shipper Matching Systems

- Comparison between many, varied technological systems/websites.
- Used both a multi-attribute criteria analysis and the STREAM process—Researchers felt that both evaluation methodologies suffer from lack of detailed information related to the systems type investigated.
- STREAM was able to be used without much modification.

S/T Area 5A: Infrastructure Protection and Improving Safety of HAZMAT Transport through Pre-Trip and En Route (Part 1)

- Comparison between technologies.
- Used the STREAM framework.
    - Did not run any of the tradeoff graphs.
    - Were generally able to develop criteria and scoring for the STREAM framework.

S/T Area 5B: Technology Improvements to Truck Safety and Reliability

- Did not perform STREAM analysis.

S/T Area 6: Separation of Trucks from Automobiles

- Comparison between strategies.
- STREAM adopted as designed.
    - Scoring assessments gathered from five researchers for qualitative analysis.
    - Tradeoff analyses performed, with very little differences found between the strategies.
    - Determined that comparison between these strategies would benefit from a more quantitative analysis tool, or at least the incorporation of more quantitative inputs into the STREAM analysis for this type of strategy.

S/T Area 7A: Corridor/En route Truck Parking

- Comparison between both S/T.
- Used STREAM process.
    - Only included S/T that would increase the availability and/or usability of truck parking.
    - Some of these could be implemented simultaneously.
    - Uses limited quantitative data since most technologies have either not been implemented or have limited implementation.
    - Researchers feel like the STREAM process is rigorous, but a consistent evaluation framework (i.e., quantitative data) is important/needed to fully benefit from it.
    - STREAM analysis viewed as a start to the discussion, but additional analysis would be needed.

S/T Area 7B: Truck Parking Information Systems – Urban Area/Terminal Truck Parking (Part II)

- Comparison between both strategies and technologies.
- Used STREAM process—Used qualitative scoring as quantitative data not yet available on a large scale due to recent implementation of many truck parking information systems.

S/T Area 8: Freight Village Facility Development

- This S/T area developed their own evaluation methodology based upon the STREAM process but evaluation was focused on determination of potential best locations for FVs in the state based upon TFMP findings and traffic data.

S/T Area 9: Border Advanced Freight Traveler Information

- Comparison between technologies based largely on qualitative decision making/restricted options available due to regulatory requirements at the federal, state, and departmental levels.
- Did not directly use the STREAM process.

STREAM EVALUATION RESULTS

The following section describes the findings of the analysis using the STREAM process:

- **STREAM provides a consistent framework for evaluation.** The use of a defined process with distinct components like those in STREAM is desirable; however, not all decisions on strategies and technology options can be made to fit into pre-defined categories making such comparisons hard in practice.

  This is especially true for innovative and automated projects that may have no precedent, requiring additional criteria to be added or additional weighting in broad, multicriteria decision analysis matrices.

- **STREAM works best as an aid to decision-making between technology options to address a single issue—not between those options and other strategies.** As designed, STREAM analysis can provide an orderly way to prioritize and compare multiple technologies against one another within a single well-defined area, but cannot as readily evaluate across multiple approaches to a problem.

  To address this shortcoming, specific methods for comparing broader goals must be applied. For example, past evaluation recommendations by TTI to TxDOT on selection of rail projects in TxDOT project 0-6467 (2012) suggested use of a multicriteria analysis focused on compliance with broad policy goals of the agency as set forth in its strategic planning documents. Completion of the TFMP and Texas Border Master Plan documents in recent years have better defined those goals within the freight context and the weighting that each should have in evaluating individual weights that should be applied to each strategy in the future.

- **STREAM does not provide the answer but provides inputs for decision-making.** The evaluation process provides information, but results and interpretation of the results in comparing one analysis with another require high levels of skill and background knowledge not clear when looking only at the STREAM results.

This is a difficulty with all current evaluation tools that seek to make decisions only on the numerical outcome of an evaluation process. Planners and engineers will continue to have need to interpret results and apply professional knowledge/experience in making recommendations to decision-makers or in making their own conclusions on how to proceed. This is inherent and largely independent of which detailed, evaluative method(s) are chosen for conducting a project evaluation.

- **STREAM does allow for tradeoff analyses between metrics**. Use of the process made direct tradeoff analysis (i.e., benefits versus barriers) easier for decision-makers by quantifying or estimating a comparative value within the process.

  This process feature would continue in future evaluative methods chosen for freight projects. Provision of a process for assigning point values and weightings within each evaluation scheme must be determined and applied consistently. Transparency to stakeholders and the public also are paramount in this area.

- **STREAM does not consider cost within the benefits/barriers but does allow to include costs in tradeoff analysis.** Cost and related items were considered as a separate criterion rather than directly within technology/strategy comparisons.

  Delaying the assessment of costs until later in the process or as a separate criterion is advisable in future evaluation methods. In this manner, cost alone does not initially rule out innovative or automated methods that may (in the judgement of officials or decision-makers) provide increased utility or come down in cost at some point in the future.

- **STREAM allows analysis without a great deal of detailed data through subjective scoring.** This is both good and bad. Without data, it is difficult to determine a consistent score across various evaluators.

  Data related to freight demand and movement have always been a challenge. This is especially true when projecting or forecasting freight for a facility or technology application that has not been built or used in the past. In order to address this problem, consistent data and information should be applied in future evaluation methods to all evaluators (if using Subject Matter Expert (SME)-assigned scores) or a consistent numerical method must be developed that is transparent and explainable. Completion of updated TFMP and BMP by TxDOT can aid in providing additional data and knowledge in these areas.

- **STREAM generally uses a limited scale range, which may not create much difference between evaluated strategies and/or technologies.** STREAM used only four levels for many criteria rather than a 1–10 scale for example, leaving a less distinctive option/value for that criterion when compared to other options.

  This weakness could be addressed by broadening the scale; however, with a larger scale—not based on well-defined technology factors such as in STREAM—it becomes more difficult to differentiate between scores. As an example, what is it that would cause a technology or strategy to rate a 6 instead of a 7 or a 2 instead of a 3? For this reason, the use of any broadened scale in future evaluation tools must seek to have more well-defined parameters for each score no matter how many choices on the evaluative scale.

- **STREAM has difficulty in distinguishing between options when data are lacking or unavailable.** Many of the S/T examined are not currently in practice, making it difficult to find data/information and to score. There may be discrepancies between the levels of available inputs between the S/T.

  Lack of data impacts all evaluation methods whether using SME-provided or numerically assessed scores. Data related to freight needs are improving and should be better incorporated into the proposed evaluation tools.

STREAM CONCLUSIONS

The outcome of the STREAM analysis was a mixed result with STREAM proving most useful for assessing direct technology-to-technology decisions for which there is ample quantitative performance data. STREAM proved less capable at comparing options related to strategy implementation—especially conceptual strategies for which little operational data exist—or implementation of one type of strategy or technology across disparate fields. As a result, additional tools and recommendations are necessary.

CHAPTER 4. POTENTIAL LOCATIONS TO IMPLEMENT STRATEGIES AND TECHNOLOGIES

The in-depth analyses performed for each S/T area assisted in narrowing down the most suitable S/T to address existing and future Texas freight barriers. Using the knowledge developed during this evaluation, researchers undertook an exercise to match specific S/T to Texas freight system locations for testing and/or implementation studies during the future Phase III of the project. To accomplish this task, researchers discussed potential solutions through interviews and discussions with stakeholders, including port authorities, MPOs, and other local government and private entity leaders.

REDUCTION OF EXAMINED S/T AREAS BY TXDOT PANEL

Following the STREAM analysis, it was determined by the TxDOT Project Advisory Panel to modify the scope of outreach and S/T areas to be completed under this project. Based on input from the panel review meeting held in Austin on December 14, 2017, and the results of STREAM analysis, further analysis and study efforts were requested to focus upon a smaller set of the original nine S/T areas originally selected for analysis in Phase II. The S/T areas in the original work plan were:

1. Automated/Zero Emission Freight Systems.
2. Natural Gas, Electric/Hybrid, and Other Alternative Fueled Freight Vehicles.
3. Freight Rail Public Private Partnerships (P3s).
4. Truck-Shipper Matching Systems.
5. Port ITS.
6. Separation of Trucks from Automobiles.
7. Truck Parking Information Systems.
8. Freight Village Facility Development.
9. Border Advanced Freight Traveler Information.

Initially, the S/T areas 1, 2, 3, and 4 were considered by the panel as more informational rather than strategies or approaches that could be quickly adopted in implementing the TxDOT Freight Mobility Plan and/or moved forward in the remainder of this project or a potential Phase III. As a result, S/T areas 1, 2, 3, and 4 were eliminated from further analysis and the remaining S/T areas were requested to be pursued under limited, more restrictive parameters than in the original work plan. Additionally, S/T area 8 was not recommended for potential implementation as it could not be implemented by TxDOT. Therefore, the remaining S/T areas include areas 5, 6, 7, and 9. These S/T areas selected to continue by the panel have an emphasis more on areas/methods that can be currently or quickly implemented by TxDOT in a Phase III of this project or through other means.

DETAILED DISCUSSIONS OF POTENTIAL IMPLEMENTATION LOCATIONS

S/T Area 4: Port ITS

The primary objective of project 0-6837 was to establish a process to evaluate innovative strategic freight operational changes and technology applications to ensure continued timely flow of commercial freight through the Texas transportation system. As part of this effort, TTI was tasked with examining and identifying near-port applications of ITS technology that improve traffic flow and that fall primarily within TxDOT implementation authority.

TTI identified five potential implementation activities in three port areas that meet the project objectives. Each of these activities is a stand-alone activity and does not depend on the development of any of the other activities. These activities target situations in which there is freight-related congestion or where freight traffic and passenger traffic are commingled in a less-than-desirable safety scenario. These activities build upon existing ongoing efforts at the local level, where possible.

Task 1: ITS for Port Truck Traffic in Port Arthur

This task investigated and demonstrated the use of advance traffic signal controllers and detection equipment to improve truck mobility. This activity has the potential to have a positive impact on truck traffic into and out of Port of Port Arthur using Gulfway Dr. (16th St.) between Highway 82 and Highway 73 and Houston Avenue, as illustrated in Figure 3. Houston Avenue is the roadway leading into and out of the port area itself. Traffic that uses Houston Avenue will also use Gulfway Dr., primarily east of Houston Avenue, but also west. The corridor has about 15 intersections, and traffic is constantly being forced to stop and start along this route. The corridor also has a flashing red beacon on Houston Avenue close to the port. The ability to detect truck traffic and synchronize these traffic signals to provide a smoother flow of traffic including trucks would be extremely helpful to improve mobility along the corridor.

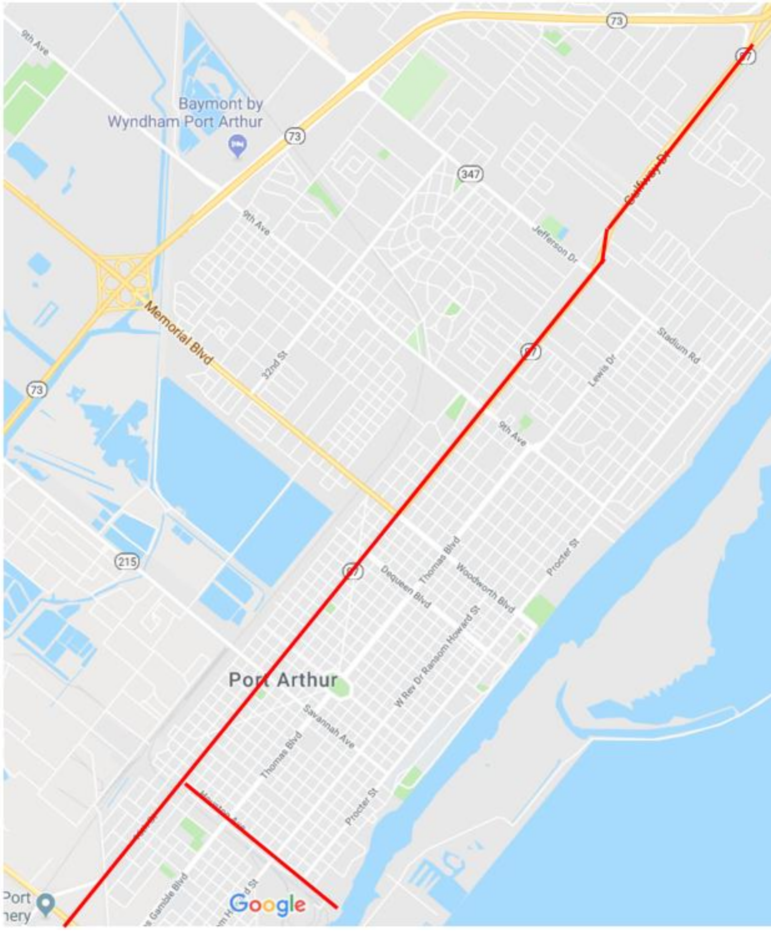

Figure 3. Corridor of Interest in Port Arthur to Improve Truck Mobility.

Task 2: Real Time Train Monitoring at Port of Beaumont

At the Port of Beaumont, trains often block the entrance to the port and the surrounding area when port-related rail activity is taking place. The objective of the proposed activity is to install a train monitoring system near the port entrance and a message sign for trucks approaching the port prior to a truck holding area where they could wait until the blockage has cleared. The ability to monitor trains and alert trucks to the fact that the port is blocked (or is about to be blocked) would help avoid long traffic lines and backups on city streets. It may be advisable to establish a waiting area outside the downtown area where trucks could wait until the blockage caused by a train is removed. The Port of Beaumont has identified a piece of property outside the port (1310 Pennsylvania St.) that could potentially serve as a truck staging area. This site and other possibilities must be evaluated for suitability and effectives. Messaging at the site could provide the needed real-time coordination to release the trucks when the grade crossing is not blocked by trains. The map shown in Figure 4 illustrates the situation.

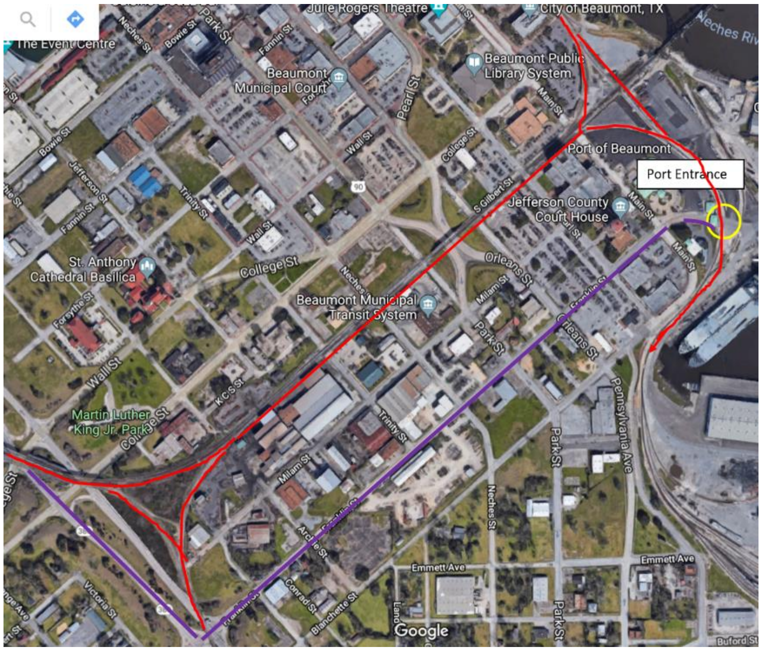

Figure 4. Trucks Routes and Rail Crossing near Port of Beaumont.

There is a project underway to construct Carroll Street Overpass. Port personnel indicate that the project would primarily and almost exclusively benefit dump trucks entering and exiting the Kinder Morgan Terminal. Approximately 90 percent of the port's general cargo arrives via truck through the main gate and would be aided by this proposed activity.

Task 3: Truck Priority along FM 511 in Brownsville

This activity deals with truck traffic approaching the Port of Brownsville from I-69 using Highway 550/FM 511. The overpasses along this highway are tolled. Trucks tend to stay on FM 511 rather than use the tolled overpasses (Highway 550). Therefore, in this situation, FM 511 functions largely as a feeder road. This creates traffic concerns at several intersections. Much of the traffic in this corridor is running between the port and the Los Indios Bridge at Harlingen or the Pharr-Reynosa Bridge. As facilities continue to expand at the port, there is a concern that the truck volumes along FM 511 will increase significantly and seriously impact the mobility and safety along the corridor. The objective of this activity is to improve truck operations along the signalized corridor on FM 511 while providing information on alternative routes along toll road Highway 550 to better service the port area. Figure 5 shows a map of the area.

Figure 5. Study Corridors along Highway 550/FM 511.

Task 4: Truck Priority Corridor for Port of Brownsville Trucks

This activity would address congested highway conditions along State Highway 48/State Highway 4 between the Port of Brownsville and the intersection with I-69. This route is traveled by vehicles of all types. Traffic delays peak in the afternoon when schools let out and at approximately the same time that trucks tend to leave the port headed for Mexico. There is a 4-way stop at FM 511 (Indiana Ave.) and Highway 48 adjacent to the port offices. This stop tends to cause back-ups onto the highway. From there all the way to the intersection with I-69, there is a problem with signal timing and the inability to adjust to traffic volumes and mixes. Figure 6 is a map of the impacted area. The corridor has about 14 intersections, and traffic is constantly being forced to stop and start along this route. The ability to detect truck traffic and synchronize these traffic signals and to progress traffic including trucks would be extremely helpful to improve mobility along the corridor.

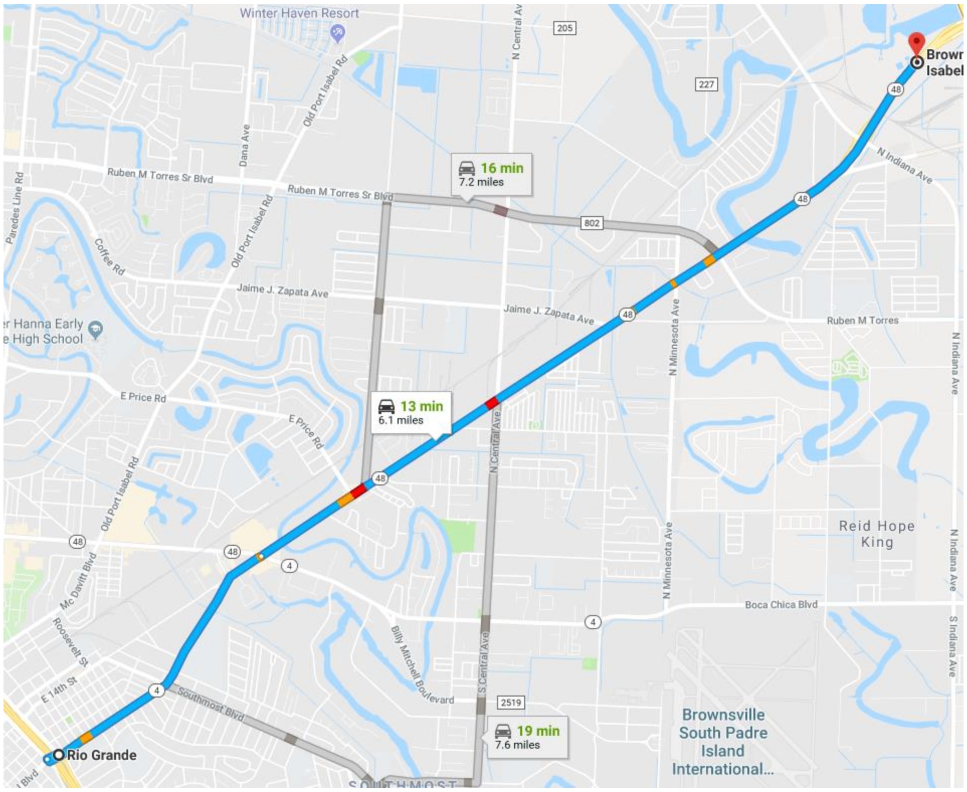

Figure 6. Scope of the Activity along SH 48/SH 4 Corridor.

Task 5: Truck Queuing Along Joe Fulton Corridor

The Joe Fulton International Trade Corridor (JFITC), located in Nueces County along the north bank of the Inner Harbor of the Port of Corpus Christi Authority (POCCA), was developed by the port and TxDOT to link I-37 and US 181. Both highways are part of the state's primary freight network, and the JFITC was designated by Congress as a National High Priority Corridor.

JFITC is an undivided principal arterial roadway with two 12-ft travel lanes (one lane in each travel direction) and 10-ft shoulders. POCCA proposes a series of improvements to roadway infrastructure (detailed below) in conjunction with the integration of ITS and connected vehicle-ready technology to enhance freight access, mobility, and efficiency; minimize air quality impacts from queuing and idling vehicles; and enhance safety. This corridor is characterized by many grain trucks idling to enter the area around the Archer-Daniels Midland (ADM) grain elevator creating a congested area and thus negatively effecting safety and air quality along the corridor.

The objective of this activity task is to develop some staging areas along the corridor where the trucks can be staged until the grain elevator can accommodate the next batch of trucks. The holding area will also have a system to provide the trucks real time status information on the grain elevator accessibility.

S/T Area 6: Separation of Trucks from Automobiles

Separating truck traffic from passenger traffic aims to reduce car-truck interactions in terms of weaving and passing maneuvers. Reducing the interaction between truck traffic and general passenger traffic offers the potential to reduce freight and general congestion, improve overall safety, and enhance economic opportunities related to improved freight movements.

The primary objective is to use Dynamic Traffic Assignment (DTA) and VISSIM simulation of truck-only facilities to identify potential benefits of developing truck-only infrastructure. The DTA model provides performance measures like savings in terms of travel time, emissions, etc., and microsimulation VISSIM provides a safety proxy measure and traffic operations benefits in terms of weaving/merging traffic in the modeled section. This activity would build upon DTA modeling completed by TxDOT project 0-6851, *Strategies for Managing Freight Traffic through Urban Areas,* which assessed freight movement through several key urban areas within the state and produced models for each of them.

Year 1: Proof of Concept at Location #1

Researchers interviewed MPOs to understand potential sites for implementation and before proposing the study locations for modeling strategies for separating trucks from automobiles. As a result of these interviews TTI identified that the Dallas-Fort Worth (DFW) region has highest potential of implementation on TxDOT maintained highways and will benefit from strategies for separation of trucks from automobile. North Texas Council of Governments staff recommended three potential locations within DFW region that might benefit from separation of trucks from automobiles:

- I-45 South of I-30/I-45 interchange to a location a couple of miles south of the I-45/I-20 interchange (10–15 miles in length). This section has heavy truck traffic and high demand.
- I-30 between Dallas and Arlington. Managed lanes in this stretch are a perfect candidate for allowing/modeling truck-only use during off-peak hours.
- I-20 between I-35E/I-20 and I-20/Spur 480 has high truck percentage and grade issues in terms of trucks acceleration and deceleration.

Year 2: Simulation at Location #2

After successfully studying the pilot location, TTI will check with panel to finalize the second study location, which could potentially be located near a port (highway, arterial etc.) in Houston, one of the above-mentioned locations that was not selected for pilot, or another location selected by the panel. Selection would be made to choose a site that would address remaining research questions related to truck-only infrastructure for TxDOT.

S/T Area 7: Truck Parking Information Systems

Truck parking is recognized as a critical issue in the safe and efficient movement of goods along our highways as truck drivers frequently are not able to find adequate, safe parking for rest purposes. States can play a major role in not only providing truck parking spaces but also in communicating space availability in advance of state-owned and/or private parking facilities.

TxDOT is actively addressing truck parking issues in the state with projects focused on I-35 and I-10. The TxDOT 0-6837 project panel directed researchers to advance truck parking research and implementation by examining truck parking at TxDOT rest areas located along corridors not currently under investigation, including I-20, I-30, I-37, and I-45. The proposed activity will have two main objectives:

- Advance truck parking research and implementation within Texas by testing multiple truck parking counting technologies at TxDOT rest areas with truck parking areas located along interstate corridors not currently under investigation.
- Disseminate truck parking space availability information to truck drivers in advance of the test TxDOT rest areas.

In order to meet the activity objectives, the following broad tasks are proposed. Researchers continue to work with the TxDOT Project Manager and project panel members to develop the detailed steps necessary to carry out the activity objectives. The following tasks broadly describe the anticipated steps necessary to address them.

Task 1: Select Activity Location, Initiate Vendor Selection, and Conduct Baseline Surveys

TTI will begin the activity undertaking these three major activities concurrently. Selecting the activity location will involve identifying eligible TxDOT-owned rest areas in the I-20, I-30, I-37, and I-45 corridors; developing a set of selection criteria; performing field evaluations; and seeking panel approval. Initiating contacts with potential vendors at the onset assists with identifying available technologies; assessing operational specifications; and identifying vendor participation requirements. These factors all fold into the activity location decision-making. The final activity involves developing and performing surveys of truck drivers at candidate TxDOT rest areas to determine baseline information, such as their needs and requirements for enhanced truck parking and information sharing at the targeted rest areas.

Task 2: Conduct Field Test

Following the first task TTI will conduct the field test of the truck parking technologies. This broadly involves finalizing the technologies to test, procuring, and installing the technologies and supporting equipment; and testing the equipment with the assistance of the technology vendors. The testing portion of this task involves researchers performing in-field verifications of installation and information sharing of available spaces.

Task 3: Institute Operational Period

Following the testing/verification of the installed technologies, researchers will disseminate truck parking space availability information to truck drivers in advance of the test rest area. This involves determining through the field testing period which technology(ies) will be used to determine the available parking spaces; installation of portable message signs and/or facilitate the use of existing message boards; sending parking availability message to message boards; and monitoring and verification of operations over a period of approximately six months.

Task 4: Analyze Operational Period and Conduct Post Operational Surveys

Following the operational period, TTI will analyze data collected during the operational period and conduct post operational surveys of truck drivers to understand driver perceptions of system performance and overall utility in identification of available parking spaces at the TxDOT rest areas.

Task 5: Prepare Final Documentation

The activity concludes by fully documenting the steps undertaken during the activity, evaluation of the individual technologies and operational activities, and conclusions to include recommendations on which technologies/combinations of technologies met performance expectations.

S/T Area 9: Cross-Border Vehicle Inspection System

This activity will demonstrate an inside-the-border-crossing process solution that will support the TFMP International Border/Ports-of-Entry Policy:

> The state should invest in and facilitate international border coordination strategies to improve freight mobility and eliminate barriers to trade (*1*).

This is part of the strategy that calls for the expansion of ITS technologies such as electronic screening, advanced traveler information, and other technologies to enhance the fluidity and efficiency of border, to improve safety and mobility, reduce emissions, and improve security at the Texas-Mexico border crossings.

The activity leverages investment that TxDOT, FHWA, and U.S. Customs and Border Protection (CBP) have made in the implementation of the border crossing time measurement systems at major border crossings in Texas. The activity has two main objectives:

- Develop and implement a system to coordinate and streamline truck inspections at the border.
- Develop a data exchange system between FMCSA and the Department of Public Safety (DPS) to improve system and eliminate duplicated truck inspections at land border crossings.

In order to meet the activity objectives, the following tasks are proposed.

Task 1: Document and Map Border Crossing Process and Data Exchange

TTI will analyze truck safety inspection procedures and data collection and exchange among the multiple agencies that operate at land border crossings. This task will be performed through the analysis of existing documents that have been prepared by FMCSA, CBP, and the Texas DPS. The TTI team will also perform face-to-face meetings at the El Paso region with the following stakeholders:

- Customs brokers.
- Carriers.
- Shippers.
- CBP.
- FMCSA.
- DPS.

TTI will document the truck inspection process that is currently conducted and the flow of information that is exchanged during the border crossing process.

Task 2: Performance Specifications Recommendation

One of the most important attributes of a successful activity is a clear statement of performance requirements that meet the needs of its stakeholders. The objective of this task to develop a set of performance specifications that will be used to identify the required equipment to conduct the field test.

Prior to development of performance requirements, a brief concept of operations (ConOps) for the system will be developed during this task. The TTI team will use information gathered in Task 1 to prepare the ConOps. The ConOps is a scientific and consensus-based process initially developed by the Department of Defense. Its sole purpose is to capture the high-level needs and requirements of stakeholders of a system under consideration. A ConOps clearly identifies the needs and requirements for a new or revised system, as well as the high-level functional design of a new or upgraded system that meets the needs of the stakeholders.

With the ConOps, the TTI team will develop the system design document and system performance specifications.

Task 3: Develop System and Install Equipment

During this task, TTI will develop the system, coordinating efforts with CBP, FMCSA, and DPS. Information exchange protocols will be developed, and sample data collected to test the system. Any hardware that is needed to collect field data will be purchased and installed during this task.

Task 4: Develop Evaluation and Test Plans

During this task, TTI will develop an evaluation plan that will ultimately document the operational benefits of the proposed system to streamline truck inspections at land border crossings. The evaluation and test plan will include tests and evaluation procedures that would be performed to ensure that the system satisfies the needs of the relevant stakeholders.

The test plan will include measures related to vehicle safety and operational benefits of the system, including number of trucks processed/inspected, number of inspections, time savings to carriers, etc.

The system will also be measured to identify how satisfied the users (FMCSA and DPS in this case) are with the system. This will be done through surveys, interviews, and direct observation.

Task 5: Conduct Field Tests

The TTI team will conduct tests and evaluate the system while it is in operation at the Ysleta-Zaragoza land border crossing. The TTI team will actively coordinate with TxDOT, CBP, DPS, and FMCSA during the field test.

The TTI team will collect the number of vehicles processed, including inspections, inspection time per vehicle, increase in productivity, and queuing conditions, at predefined time intervals before and after the system is in operation.

Task 6: Prepare Final Report

TTI will analyze the data obtained from the field test and document the results. A report will be prepared including recommendations to improve the system and short- and long-term operation and maintenance costs.

CHAPTER 5. PHASE II SUMMARY AND NEXT STEPS

SUMMARY OF PHASE II ACTIVITIES

For project 0-6837 Phase II, researchers investigated nine S/T areas that were recommended by TxDOT at the end of Phase I of the project. Researchers used the NCHRP 750: Volume 3 STREAM–based evaluation method and other appropriate methodologies to assess each S/T area. The nine areas selected were:

- Automated/zero emission freight systems.
- Freight rail public-private partnerships.
- Natural gas, electric/hybrid, and other fueled freight vehicles.
- Truck-shipper matching systems.
- Port ITS systems.
- Separation of trucks from automobiles.
- Truck parking information systems.
- Freight village facility development.
- Border advanced freight traveler information.

SUMMARY OF FINDINGS AND DIRECTIVES

Phase II activities closely followed the NCHRP-recommended STREAM process with the framing of freight problems and improvement goals (frame), identifying the information needs (identify), conducting in-depth investigations (characterize), and performing analysis (compare).

Researchers initially framed Texas freight needs and goals based on the most current version of the TFMP and the TxDOT Strategic Plan. Researchers identified the literature review findings, broad sources of information, databases, S/T assessed, and other remaining needs for each S/T area. Researchers investigated the characteristics, costs, and implementation barriers for the nine innovative and automated freight S/T areas. Each S/T was also evaluated for implementation at locations on the Texas freight system and matched to specific needs identified in the TFMP.

Researchers completed an intensive and detailed analysis of each S/T area using STREAM-based techniques and examined the extensive applicability of STREAM as an evaluation tool.

In some S/T areas, STREAM was not directly applicable and alternative evaluation methods were applied. Researchers determined four specific S/T areas that can be currently or quickly implemented by TxDOT:

- Port ITS.
- Separation of trucks from automobiles.
- Truck parking information systems.
- Border advanced information/cross-border vehicle inspection system.

Researchers then proposed prospective Phase III implementation activities at locations identified from stakeholder outreach and the TFMP where S/T could be tested.

The STREAM method provides a consistent framework for evaluation, works best as a decision-making aid between technology options to address a single issue, and allows tradeoff analyses between metrics. However, the STREAM process cannot as readily evaluate across multiple approaches to a problem—especially when detailed data or other numerical metrics are lacking or unavailable. Each of the four S/T areas selected resulted in one or more independent implementation activities to be employed in Phase III upon TxDOT approval. Activity locations and final details will be finalized and incorporated into the Phase III work plan.

The Phase II project expanded the understanding of the nine selected S/T areas using NCHRP-recommended STREAM process evaluation methods, informed the TxDOT project panel how evaluated S/T could address TxDOT freight planning goals and objectives, and identified test concepts and applications that could address Texas freight system needs.

0-6837-01 Technical Memorandum #2 identifies the information that was required to conduct the STREAM analysis for each S/T. Technical Memorandum #3 describes the in-depth investigation and data collection for each S/T that was conducted during the course of the project. Technical Memorandum #4 covers each S/T area's performance of the STREAM or STREAM-based analysis. The Appendix of this report is a final write-up for S/T Area 8, Freight Village Facility Development, and is included to fully document the work done to evaluate this alternative freight congestion and land-use strategy beyond previous information included within previously submitted Technical Memoranda for the project.

PHASE III OVERVIEW

A Phase III program of activities is planned to implement and test innovative freight S/T related to the four S/T advanced by the panel during Phase II. If advanced, Phase III will further add to the information available on each of the tested S/T areas and provide additional data for analysis in future research.

APPENDIX. ASSESSMENT OF FREIGHT VILLAGE IMPLEMENTATION IN TEXAS: FINAL REPORT

Completed: June 2018

TxDOT Research Project 0-6837-01
S/T Area 8

Mario Monsreal, Madison Metsker-Galarza, Nicole Katsikides, and Don Kang

TTI Mobility Program

PROJECT BACKGROUND

The Texas Department of Transportation (TxDOT) along with researchers from the Texas A&M Transportation Institute (TTI) strive to improve the fluidity of freight movement throughout the state. Freight villages (FVs) are hubs that link the supply chain process to help assist the fluidity of freight movement. The Texas Freight Mobility Plan (TFMP) reports more than 2.6 billion tons of freight moved in 2014 and this number is anticipated to increase to nearly 3.8 billion tons by 2040 (*8*). As freight movement continues to serve a vital role in the connectivity of Texas' transportation system and economy, research must be conducted to ensure efficiency of the freight fluidity system. FVs are one method identified to assist in the freight fluidity system for Texas. The freight industry serves Texans through industries, businesses, and employment; in addition to Texans' needs, it serves the U.S. economy. As Texas is expected to face an increased population of approximately 45 million people by the year 2040, TxDOT must ensure the road network system has the capacity to handle the needs of a population of this size.

INTRODUCTION

As part of handling the future freight needs of the state, researchers identified the best strategies to an efficient freight fluidity system. Through the identified needs and issues related to freight through the TFMP, researchers crafted recommendations for the potential development of FV(s), throughout the state.

FVs have been defined as an area within which all activities relating to transport, logistics, and the distribution of goods, both for national and international transit, are carried about by various operations (*9*). The Europlatforms EEIG has defined FVs as the hub of a specific area where all the activities relating to transport, logistics, and goods distribution—both for national and international transit—are carried out, on a commercial basis, by various operators (*10*).

There has been confusion between the term FV and other related terms, such as logistics center. One of the most thorough studies in these concepts positions FVs as a type of Logistics Center, namely a Freight Distribution Cluster. This cluster would include "the range from a basic intermodal facility to a comprehensive development which would also include the wide range of value added services potentially offered by a freight village" (*11*). From these definitions and for the purpose of this study, the project team has defined FVs as follows: an industry intermodal cluster in which activities related to transport logistics and other value-added processes, and ultimately distribution of goods is carried out.

STREAM PROCESS

To determine locations for FVs in the state, researchers used a modified version of the five-step Systematic Technology Reconnaissance, Evaluation and Adoption Methodology, (STREAM) process, to guide the selection of FV locations in Texas. The STREAM process is a methodology used to expedite technology assessment and adoption by transportation agencies (*12*). Transportation agencies use this process to identify, assess, shape, and adopt new and emerging technologies to achieve long-term system performance objectives (*12*). The STREAM process provides a better way to evaluate the applicability of emerging technologies for specific agencies to ensure the best decision is made for implementation. The STREAM process is based on seven key principles (*2*):

1. Assess and compare technologies in relation to agency goals.
2. Derive transportation agency technology needs based on specific functions that require support.
3. Use multiple metrics to assess and compare technologies with respect to the full range of agency goals.
4. Identify and compare existing and prospective technologies by effect on functional performance, rather than by technology type.
5. Include current knowledge about existing and prospective technologies within a common framework for assessment, tracking, and decision.
6. Make the assessment process less disruptive and more integral to regular agency functions.
7. Provide sufficient information to understand the degree of uncertainty and enable flexible operation under evolving circumstances.

The principles defined in the STREAM process consider the agency goals to be the foundation of the need for an implemented emerging technology. To determine the need for an implemented technology, a five-step process is used as an assessment by agencies (*12*,*2*):

1. Frame the problem and specify goals.
2. Identify potentially appropriate technology applications.
3. Characterize alternative technology applications by:
    a. Characterizing effects on agency missions.
    b. Characterizing barriers to successful implementation.
    c. Characterizing costs.
4. Compare technology alternatives and tradeoffs.
5. Decide, adopt, shape, monitor, research.

The STREAM process focuses in technology comparison. However, the current study focuses on assessing FV's implementation. Therefore, researchers adopted some components of the STREAM process while modifying others to guide the assessment of FVs in the state. The specific FV-oriented STREAM process will be discussed in the next section. Recommendations based on the needs identified in the TFMP, along with selection criteria developed from a thorough literature review will help researchers identify potential FV locations in Texas.

METHOD OF ASSESSMENT: STREAM PROCESS

Through an analysis of the TFMP and the TxDOT Strategic Plan, researchers identified the needs and issues related to freight within the state. Based on the original STREAM process, researchers altered the method of assessment STREAM process, specifically for FVs and created a nine-step process. The modified nine-step STREAM process was used to evaluate where and if in Texas, the implementation of FVs will best meet the needs identified in the TFMP. The nine-step process is described, in Table 3, in terms of what researchers have completed and steps that still need to be completed.

Table 3. Nine-Step STREAM Process for FV Implementation in the State.

Step	Name of Step in the STREAM Process	Date of Completion
1	Researchers framed the problem and specified freight objectives based on the goals in the TFMP.	November 15, 2016
2	Researchers developed a set of criteria to evaluate FV implementation feasibility.	April 7, 2017
3	Researchers defined, classified, and identified stakeholders.	March 27, 2017
4	Researchers characterized key economic elements for the implementation of FVs in the state.	July 28, 2017
5	Researchers identified specific candidate locations for FV implementation in Texas based on the selected criteria and an economic analysis.	August 3, 2017
6	Researchers estimated the impact baseline calculation of FVs based on specific measure set.	June 7, 2018
7	Researchers will estimate the cost and investment needs for FV implementation.	TBD
8	Researchers will compare cost-benefit ratio among all candidate locations.	TBD
9	Researchers decide final proposed FV locations.	TBD

LITERATURE REVIEW

Researchers conducted a literature review of implemented FVs both nationally and internationally. Analyses of FVs were found through scholarly articles and publications. While FVs implemented internationally will be researched, two FVs in the United States were selected as points of reference as they have relevance to the Texas economy.

FREIGHT VILLAGES

The supply chain process has had a considerable impact on freight movement globally at all levels of the transportation process. Goods in all parts of the supply chain process (manufacturing, transportation, and warehousing) must flow efficiently to ensure a stable economy. During the transportation of freight, it is natural for clusters of freight-related activities to spatially concentrate, which are often referred to as logistics centers and are associated with various names and contexts (*11*). Logistics centers is a loose name, which is often used to describe distribution centers, dry ports, inland ports, load centers, logistics nodes, gateways, FVs, and others. There is often confusion about what name to use, because of the loose definition. Additionally, there is a lack of standardized terminology because intermodal logistics is a relatively new field and logistics has evolved rapidly with fast-changing technology. In addition, regional effects remain fundamental; and issues such as modal availability, market function and intensity, regulation, and governance create unique circumstances by jurisdiction (*11*). A level of hierarchy has been established within the supply chain process to better identify which type of center should be used in a certain part of the process, this was based on what type of activity occurs during the supply chain process.

The lowest level (the first level) is the warehousing and distribution cluster, which includes facilities such as warehouses, container yards, and distribution centers, and is primarily truck-oriented and unimodal (*11*). The second level, namely the Freight Distribution Cluster, usually consists of goods changing modes, and usually includes intermodal terminals, inland ports, and FVs (*11*). FVs often service this level as it primarily consists of a cluster that ranges from a basic intermodal facility to a comprehensive development (*11*). The third level is considered a gateway cluster and is typically reserved for international main port terminals and in rare cases, the freight operations of major international airports (*11*).

FVs serve the role of the second hierarchy of the supply chain process as they contain four key aspects (*11*):

1. A localized cluster of transport and logistics facilities that are co-located and coordinated for synergies.
2. Among the facilities is an intermodal terminal located near container storage, handling areas and warehouses linked to rail to reduce cargo handling costs, time, and the use of roads for containers.

3. Access to shared facilities, equipment, and services (e.g., customs services, truck cleaning, post office, conference and training facilities, and other services and amenities).
4. Centralized management and ownership structure for long-term planning, investment, governance, environmental management, and other issues.

Shared access is a key factor in the ability of FVs to serve the needs of this portion of the supply chain process. FVs not only serve needs of the supply chain process, but also the residential population, which allows a diverse group of industries to be employed in a clustered area. This means that retail shops, restaurants, and residential areas can all share the same space as a freight distribution center. This cluster of industries requires FVs to be in strategic areas where they have good access to transportation nodes. Typically FVs will be located at or near the cross-roads of two or more major highways and rail connections, normally near major metropolitan areas that also serve as a market or supplier of much of the goods that pass through (*11*).

With a shared distribution center with several types of industries, FVs offer multiple benefits to the economy with most focusing on the synergy, efficiency, and improved economics of scale and sharing (*11*). The synergistic logistics process includes haulage, storage, and packing and in infrastructure provides connections to networks, transshipment equipment, and railway sidings, which promotes an overall reduction in wasted movements with the potential to internalize intermediate moves (*11*). In addition to the synergistic efficiency, FVs promote a large amount of transport knowledge in one location, which can be leveraged in the management company to benefit smaller tenants and through the marketing side. This consolidation can lead to the reduction of transportation links in the supply chain and a higher quality of those who remain. FVs through the consolidation of knowledge and resources can attract perspective tenants through their warehousing capacity and availability of modern equipment, boosting the overall competitiveness of inland regions (*11*).

With positives of FVs alternatively comes negatives as well, as most of its shortcoming stem from the coordination between stakeholders. In the case of the public sector, coordination is difficult, as varying levels of government come with varying political interests, which is often limiting. In relation to the private sector, modern day supply chains are vertically oriented, whereas the FV concept is horizontal in its ideal form, and is less dependent on various firms cooperating among one another (*11*). The observation has typically been that many firms operate independently from others in terms of development restricting the ability of proper FV development. In addition, concerns about cooperating for competitive reasons and dependence on government subsidies has led to difficulties in urban consolidation/distribution of potential FVs (*11*).

There are two types of FVs: integrated and non-integrated. An *integrated freight village,* accomplishes modal changes on-site, in addition to providing a range of services in which transportation is only a single element of global logistics performance. This is the ideal-type of

FV. A *non-integrated freight village* does not have modal changes within the FV. Freight can change vehicle (i.e., truck-to-truck or rail-to-rail transshipment) but not transport mode (i.e., rail-to-truck). Modal changes occur at an intermodal terminal nearby. These usually exist in the peripheries of large urban areas and perform as consolidation/deconsolidation centers for urban distribution

The literature review found numerous studies on FVs in Europe and less literature on FVs in the United States. In addition to FVs being more prominent in Europe, there are also key differences between the United States and Europe. In Europe, FVs are typically framed through the lens of public sector intervention in the marketplace. This provides incentives and disincentives to the FV, such as subsidies for intermodal transportation. The goals of FVs in Europe include: promotion of intermodal transportation, employment, and economic development, increasing the sustainability of freight transport and urban development, mitigating congestion, and reducing emissions.

In United States, the market (private sector) has driven the development of FVs and other logistics centers. For example, intermodal transportation has flourished in North America without the use of major governmental subsidies. In the United States, FVs have developed without the level of public involvement seen in Europe. Revenue generation rather than any overarching public benefit is a primary goal for FVs in the United States. Additionally, overall FVs are fewer in number but larger in size in comparison to their larger European counterparts.

Fort Worth-Alliance, Texas, and the Raritan Center in New Jersey were two FVs located in North America to be analyzed for the study. Both examples provide a strong emphasis on road and rail and greenfield development.[1]

PORT OF ENTRY: FORT WORTH-ALLIANCE TEXAS

Due to the diversity, location, and geography of Texas and its economy, there are many trade opportunities. Through a collection of seaports, inland ports, and border crossings several types of imports and exports are possible, leading to the strong presence of Texas' economy. With the state of Texas responsible for nearly $650 billion in international trade in 2015 and over 11 percent attributed to cargo arriving and/or departing by air through the state's air/multimodal ports (*13*).

AllianceTexas was first developed in 1990, when Hillwood Development Company (Hillwood) partnered with the Federal Aviation Administration and the city of Fort Worth to open the Fort Worth Alliance Airport as the first industrial airport. AllianceTexas has evolved into mixed-use community that includes "nearly every real estate asset class, including office, industrial, medical, aviation, retail and residential components as well as the Alliance Global

[1] Greenfield Development: sites that have not been built before and are often rural/countryside areas.

Logistics Hub," and is managed by private-sector firm (*13*). With investors still investing into the region, additional growth opportunity is still to come. The Alliance Global Logistics Hub connects the three major sources of transportation (air, road, and rail) in one central location, allowing this area to thrive in trade and distribution. The hub includes (*13*):

- 9,600 acres (part of a larger 18,000-acre master-planned, mixed-use development).
- Direct access to I-35/State Highway 170/State Highway 114.
- An approximately 500 acre multifaceted rail facility (owned and operated by BNSF) with direct access to West Coast ports.
- Two runways, currently at 9,600 ft and 8,200 ft and both expanding to 11,000 ft by 2017, capable of handling large aircraft such as the DC10, B747, B787, and AN124.
- A general-purpose Foreign Trade Zone (FTZ #196) covering the entire port.
- An integrated infrastructure system (air, rail, and ground).

AllianceTexas has contributed to the development of more than 45,000 jobs, including 31,000 jobs directly related to the Alliance Global Logistics Hub (*13*). Although, the transportation and logistics services play a prominent role in the hub, many of the employees have little to do with this sector. AllianceTexas is home to sectors such as: distribution, retail, manufacturing, office, support, manufacturing and distribution, transportation, and sales.

Comptroller staff estimated that the Hub and AllianceTexas together contributed $10.9 billion to the Texas economy and supported 67,000 jobs in 2015. The Texas Comptroller of Public Accounts also affect the state economy in other positive ways. These may be hard to measure, but the Comptroller acknowledges that there is potential that these developments have had additional positive economic impacts. The Alliance Airport continues to grow as they saw a record year in 2015 for air cargo. BNSF Alliance Intermodal facility saw an increase in cargo units coming in from Asia through the U.S. West Coast.

RARITAN CENTER

The Raritan Center began its operations in New Jersey in 1964 and was originally purchased to become an industrial park, but instead flourished with the addition of hotels and conference centers. After 2000, the Raritan Central Railway was purchased and improvements were made to the 18 miles of the rail lines within the center, which attracted more tenants to the site. These improvements along with marketing strategies resulted in the shift from the traditional industrial park into a FV that includes the 695,000-square foot Trammell Crow food distribution center. There were also plans in place to create a more prominent short sea shipping yard that would facilitate the start of a rail shuttle that would go between Port Newark.

The Raritan Center is located at the intersection of several major highways including the New Jersey Turnpike, I-287, the Garden State Parkway, along with a few local major roads around the area. The Center is also near, around 20-minutes away, the Port of Newark and the

Liberty International Airport (*11*). The proximity of the Raritan Center to major transportation and shipping areas aids in making it profitable. With the Raritan Center once being an army arsenal, there is plenty of space and is currently made up of a 2,350-acre brownfield site with many large warehouses and facilities used by tenants (*11*). It is also comprised of a new rail yard, a 95,000-square foot rail-to-truck intermodal dock, and a 90,000-square foot food-grade rail-to-truck warehouse. The Raritan Central Railway short line has connectors to CSAO, NS, and CSX rail systems. Five hotels, office buildings, and the New Jersey Exposition Center also make up the Raritan Center. Despite the amount of office buildings, the majority of the Raritan Center is for industrial use with 13 million square feet of the center used for industrial space and buildings.

The Raritan Center is privately owned with a bottom-up development plan, making it flexible with room to make changes according to the trends. At one point, suburban office parks were increasingly becoming the latest trend, and with the center being able to capitalize through existing open land.

ANALYSIS

Researchers used the modified STREAM process to conduct the analysis of possible FV locations.

STEP 1: RESEARCHERS FRAMED THE PROBLEM AND SPECIFIED FREIGHT OBJECTIVES BASED ON THE GOALS IN THE TFMP

Researchers first framed the problems and specific freight goals based on the goals in the TFMP related to FVs. Improvement goals, which FVs facilitate, were developed. Table 4 presents the needs and issues for FVs.

Table 4. Texas Freight Mobility Plan Needs and Issues in Relation to FVs.

Freight System Needs	Freight System Issues	FV Relation to Needs	Degree of Relation	Improvement Goals
System Capacity	Congestion and bottlenecks on key freight corridors	Consolidation and strategic location of freight facilities More efficient cargo management and allocation	Direct Contribution	FVs will contribute to reduce cargo movements in the freight transportation network including key freight corridors. FVs will decrease the number of transportation vehicles needed.
System Operations	Developing a statewide freight network	Planning phase of a FV should consider the state freight network Developing a statewide freight network comprises planning for FVs	Direct Contribution	Texas FVs plan will aid in the planning and design of the state freight network by providing estimated freight flows, markets, cargo type, and other important base factors.
Safety	Reducing the number of at-grade highway rail crossings	More efficient rail movements between ports and intermodal terminals Consolidation of depots and urban rail operations outside urban conflicting areas	Indirect Contribution	FVs will decrease traffic conflicts between rail and highway.
Intermodal Connectivity	Improving port-rail connections Increasing the number of intermodal connection points	Consolidate and substitute scattered logistics facilities	Direct Contribution	FVs will mitigate the traffic conflicts and will allow each transportation mode to better perform based on its characteristics (long-haul vs. last mile), by providing adequate linking nodes, and thus improve the connectivity between the modes.
Rural Connectivity	Improving north/south connectivity to the border Increasing rural access to the freight network	FV services such as crossdocking function as coupling activities between different types of modes and even within the same mode of transportation but with different vehicles capacities and purposes	Direct Contribution	By consolidating and strategically locating freight facilities and services, FVs will enhance rural access and connectivity to freight network. FV also enable streamlined transshipment activities within and between modes for rural deliveries. The latter is also applicable for border crossing operations.
NAFTA and Border/Ports-of-Entry	Congestion at the border Customs processing time	FVs may include on-site customs services, inspection facilities including warehouses and intermodal connection facilities for cross-border freight movements	Direct Contribution	By providing adequate facilities and needed services in secure and logistical areas, FVs will improve flows and connections between U.S. and Mexico freight network.
Public/ Private-Sector Coordination	Enhance connections with neighboring states' infrastructure	FV locations provide functionality as inventory buffers and manufacturing/assembling services	Direct Contribution	FVs planned location based on trading states infrastructure will increase reliability of the continuous flow to and from neighboring and trading states.

Source (8)

STEP 2: RESEARCHERS DEVELOPED A SET OF CRITERIA TO EVALUATE FV IMPLEMENTATION FEASIBILITY

Researchers investigated measures to evaluate the feasibility of FV implementation into specific areas in Texas. This was completed by identifying criteria for successful implementation, which was found through the literature review. Table 5 shows the criteria and its impact.

Table 5. Criteria Methodology for FV Implementation.

Dimension	Criteria	Impacts by FV Implementation and Operation (for Public)	Impacts by FV Implementation and Operation (for Private)	Measures	Specific Measures
System Design	System Capacity	Improved roadway level of service (LOS) by reducing freight volume in urban areas. LOS is volume to capacity ratio		Traffic volume Commodity flow volume	- Daily volume (# vehicles/day) - Hourly volume (# vehicles/hour) - Peak-hour volume (# vehicles/hour) - Commodity tons per year
	Fluidity	Less delay and bottlenecks with more reliable travel times by reducing truck traffic in urban area	Less delay and bottlenecks with more reliable travel times by reducing truck traffic in urban area	- Annual hours of truck delay - Travel time reliability	- Average peak-hour delay (hours) - Percentage of congested travel - TTTR (truck travel time reliability) - Time between mode A arrival and mode B departure
	Land Use	Higher land utilization/More balanced land use		- Land use distribution	
	Modal Utilization	Changes in utilization level of each mode	Changes in dependency for certain transportation mode	Utilization ratio by mode	Percentage of commodity flow by mode
	Connectivity		More streamlined commodity flow among transportation modes (highway, rail, air, and waterway)	Number of connections	Average number of connections from origin to destination per commodity
System Operations	Efficiency		Increased service rate of supply chain by achieving economy of scale. Increased efficiency for supply chain	Supply chain cost reduction On-time delivery rate	Percent (or dollar amount) changes of SCM cost Number of units delivered on time over operation cost
	Effectiveness		Increased effectiveness for supply chain	Fill Rate	Percentage
Safety	Roadway Safety	Increased roadway safety by reducing freight traffic from the urban area	Increased drivers' safety by reducing number of trips within urban area	Annual freight-related traffic accidents	Number of truck injury and fatal crashes (per thousand truck miles, per thousand trucks, etc.) Number of highway/rail fatal crashes
Environmental	Air pollution	Improved air quality by reducing freight traffic in urban area		Emissions from freight traffic	O3, CO, NOx (ppb), PM2.5 & PM10 (µg/m3) Greenhouse gas emissions (metric tons)
	Noise Level	Reduced noise		Noise level from traffic (roadway)	Decibels (dB)
Economy	Employment	Changes of employment rate		Total employment	Number of employees
	Revenue	Possible tax revenue changes for agencies in the region	Possible tax rate change	Tax revenue (public) Tax rate (private)	Dollar amount (public) Tax rate change in % (private)
	Cost	Infrastructure construction and maintenance cost required	FV facility construction and maintenance cost required	Total construction cost Percent of budget change of construction/ maintenance	Dollar per square feet (or acre) Percent changes of annual budget

STEP 3: RESEARCHERS DEFINED, CLASSIFIED, AND IDENTIFIED STAKEHOLDERS

Researchers developed a formal definition for stakeholders in relation to FVs for the impact analysis and information source identification to be followed in the next section. A stakeholder of FVs are "an entity(ies) that have an interest, use, or influence in a freight village and is impacted or impacts its operation. This includes but is not limited to:

- The project owner or manager of the freight village that has a direct and vested interest in the economic vitality of the logistic center.
- Transport companies (e.g., railways, port authorities, and air ways).
- Freight Forwarders.
- Logistics providers, and shippers that will use the service of the freight village or have altered behaviors because of the service.
- Local authorities (e.g., cities, counties, MPOs, and state agencies) that will be economically impacted by the service of the freight village."

Based on the above definition, researchers identified stakeholders from multiple FV cases in the United States and Europe. The identified stakeholders then categorized by five stakeholder groups to analyze the influence and the impact between each stakeholder group and FV, as shown in Table 6.

Table 6. FV Stakeholders Identification and Impact Analysis.

Stakeholder Group	Stakeholder Example	Influence on FV (Stakeholder → FV)	FV Impact to Stakeholder (FV → Stakeholder)
Project Owner (Public)	State Agency	- Initiating FV plan - Preparing infrastructure - Providing policy support	- Congestion mitigation - Safety improvement - Environmental improvement - Intermodal connectivity improvement - Cost to build or improve infrastructure
Authorities	Federal & Local Agencies	- Providing on-site service at FV - Providing policy support for FV	- Improved service rate at the land/sea/air ports of entry - Congestion mitigation - Safety improvement - Economic benefit - Job creation - Population growth - Cost to build or improve infrastructure - Cost to operate and maintain facility and personnel - Possible conflicts with local land use
Project Owner (Private)	Development (management) Company	- Developing and executing overall FV plan	- Cost to build a FV - Burden of unsuccessful implementation
Potential Users	Transport/ Forwarder company, Logistics providers, Shippers	- Utilizing FV functions	- Streamlined flows of supply chain - Improved access to market - Facility construction and operation cost
Special Interest Group	Local stakeholders	- Local opinion on FV development	- Economic benefit - Job creation - Environmental concerns

STEP 4: RESEARCHERS CHARACTERIZED KEY ELEMENTS FOR THE IMPLEMENTATION OF FVS IN THE STATE

Before specific candidate locations for FVs were identified in Texas, researchers used the TFMP to understand commodity flows and clusters of industries in the state, through the identification of major warehousing facilities by commodity group, shown in Table 7.

Table 7. Major Warehousing Facilities by Commodity Group.

City	Commodity
Amarillo	Not available
Lubbock	Forest/Ceramic, Stone, Mineral Products
Fort/Worth	Not available; Forest/Ceramic Shone, Mineral Products; Food/Grains
Dallas	Not available; Food/Grains; Petroleum/Coal; Forest/Ceramic, Stone, Mineral Products
Austin	Not available; Food/Grains; Forest/Ceramic, Stone, Mineral Products
Port Arthur	Not available; Food/Grains; Petroleum/Coal
Houston	Not available; Food/Grains; Petroleum/Coal; Forest/Ceramic, Stone, Mineral Products
Galveston	Food/Grains; Petroleum/Coal; Forest/Ceramic, Stone, Mineral Products
Austin	Not available; Food/Grains
San Antonio	Not available; Food/Grains; Petroleum/Coal; Forest/Ceramic, Stone, Mineral Products
Corpus Christi	Not available; Forest/Ceramic, Stone, Mineral Products
Brownsville	Not available; Food/Grains
Laredo	Not available; Food/Grains
El Paso	Not available; Food/Grains
Abilene	Not available

Source (8)

While this table was not used directly for identifying potential areas for FVs, it was used as a proxy or indicators of what cities experience the most in warehousing, distribution, and industry. From here, researchers used data from the Freight Analysis Framework (FAF) and the Bureau of Economy Analysis Gross Domestic Product Data (BEA) to identify which cities experience the most economic value (in terms of GDP), seen in the next section.

STEP 5: RESEARCHERS IDENTIFIED SPECIFIC CANDIDATE LOCATIONS FOR FV IMPLEMENTATION IN TEXAS BASED ON THE SELECTED CRITERIA AND AN ECONOMIC ANALYSIS

Researchers identified specific candidate locations for FV implementation in Texas based on the selected criteria and an economic analysis using the TFMP, BEA, and FAF. Table 8 ranks major metropolitan cities' 2015 GDP by wholesale and transportation industries.

Table 8. Rank of Cities' 2015 GDP by Wholesale and Transportation Industries.

Rank	City	Wholesale (GDP)	Transportation (GDP)
1	Dallas	28,470,982	11,720,808
2	Houston	24,955,227	10,273,458
3	San Antonio	16,344,944	6,728,814
4	Austin	7,535,656	3,102,246
5	Corpus Christi	3,714,760	1,529,276
6	Beaumont	2,640,133	1,086,878
7	El Paso	1,618,574	666,327.4
8	Laredo	1,472,637	606,248.7
	Total	**133,000,000**	**54,617,000**

Source. Bureau of Economic Analysis

To ensure the rankings were consistent among various data sources, FAF 2015 data were used during the analysis, shown in Table 9.

Table 9. Rank of Cities' Total Tonnage.

Rank	City	Total Tonnage per City	Percent of Total Tonnage
1	Dallas	200,208.6	21.5%
2	Houston	175,514.3	18.8%
3	San Antonio	114,934.1	12.3%
4	Austin	52,996.71	5.7%
5	Corpus Christi	26,153.56	2.8%
6	Beaumont	18,529.11	2%
7	El Paso	11,388	1.2%
8	Laredo	10,310.96	1.1%
	Total	**932,850.2**	**100%**

Source: U.S. Department of Transportation FHWA: Freight Analysis Framework

The economic data suggest that Dallas/Fort Worth (DFW), Houston, and San Antonio would be suited best for FV implementation based on their highest feasibility in terms of GDP and total tonnage per city. This assumption is based solely on economic data and does not consider the other criteria mentioned in previous sections. The application of additional criteria is considered in Step 6 below.

STEP 6: RESEARCHERS EVALUATED THE TOP FV CANDIDATES BY APPLYING QUANTITATIVE AND SEMI-QUALITATIVE ASSESSMENT

With three locations identified based on economic data, researchers sought to apply additional dimensions and appropriate criteria as identified in Step 2. Per Table 5, the dimensions included:

- System Design.
- System Operations.
- Safety.
- Environmental Dimensions.
- Economic Dimensions.

Researchers carefully considered the data necessary to evaluate the criteria and developed a resource matrix (See Appendix D) to catalogue all the measures and data and to determine what was considered preferable in terms of a result. For example, for the dimension of System Design and its criteria of fluidity, the measure of a lower Planning Time Index score is preferable over a higher score. The lower score indicates a more reliable route for freight traffic, which is an important factor for the success of a FV. After the measures and preferred results were assessed, researchers collected data for each measure and determined a value for each location based on a run of the measures.

For ranking, the most preferable city for each measure received the rank value of one and the least preferable city gets the rank value of three. However, for most measures, the second city does not automatically get the rank value of two. Instead, it is scaled by the relative location between the first and third city values. There were a few measures where an ordinal scale was applied or where the values were all the same.

For example, annual excess CO_2 value of the second rank city (DFW with 298,362,195) is very close to the first city (Houston with 294,029,801) when compared to the third rank city (San Antonio with 66,255,659). So DFW's rank value is calculated as 1.04 (not 2). In another example of truck daily vehicle miles of travel, Houston (9,843,943) is located almost middle of DFW's value (14,011,286) and San Antonio's value (6,273,598). Houston's rank value of 2.08 is close to number 2.

After all the rank values were calculated per each measure, they were weighted by the pre-defined weight parameters. Currently, they are all set to the same number of one, but they can be changed according to the relative importance of the measures based on the importance TxDOT wishes to place on a given criteria.

In Table 10, the right three columns show the weighted rank values of the cities. They are then summed to get the final score. Based on the dimensions and criteria measured in this step and the resulting quantitative values, DFW is most preferable city followed closely by Houston in terms of the total scores.

Table 10. Rank Order of Quantitative Assessment.

Rank Order Table of the Three Cities for Freight Village Locations

Measure Number	Specific Measures (units)	DFW	Houston	San Antonio	Rank Value of the 3 cities (1.00 is highest importance and 3.00 is lowest importance) DFW	Houston	San Antonio	Weight of the Measures (1 is the highest importance. Larger number means lower importance of the measure)	Weight Adjusted Rank Values DFW	Houston	San Antonio
1	Truck DVMT (Daily Vehicle Miles of Travel)	14,011,286	9,843,943	6,273,598	1.00	2.08	3.00	1.00	1.00	2.08	3.00
2	Total tonnage (Ktons)	627,041	1,886,300	286,353	2.57	1.00	3.00	1.00	2.57	1.00	3.00
3	Annual Hours of Truck Delay (person-hrs)	8,140,525	8,801,515	2,009,574	1.19	1.00	3.00	1.00	1.19	1.00	3.00
4	Average of PTIs (Planning Time Index) of the Congested Roads	1.44	1.60	1.49	3.00	1.00	2.38	1.00	3.00	1.00	2.38
5	Percentage of commodity flow by Truck	63% (100,141 million ton-mile)	22% (80,105 million ton-mile)	58% (30,487 million ton-mile)	1.00	3.00	1.24	1.00	1.00	3.00	1.24
6	Annual Excess CO2 Produced Due to Truck Congestion (pounds)	289,362,195	294,029,801	66,255,659	1.04	1.00	3.00	1.00	1.04	1.00	3.00
7	Median Construction Cost for Warehouse	$46.38 per sq. ft.	$48.03 per sq. ft.	$44.89 per sq. ft.	1.95	3.00	1.00	1.00	1.95	3.00	1.00
								Sum of the Rank Values	**11.76**	**12.08**	**16.62**

Researchers felt that this analysis needed more detail and that too much of the criteria measures were missing data and analysis. A supplemental assessment was sought to improve the assessment. This is described in the next section.

Supplemental Data Assessment

Initially, to supplement the measures and data, researchers developed a survey that intended for system users to answer. Quantitative data on elements of their operations such as the amount of buffer time built in to their operations, number of connections or trip legs within a specific region, and information on cost of doing business were desired.

The survey (See Appendix A) was developed based on gaps identified in the quantitative assessment and stakeholders among the private sector were identified for the team to survey. Researchers reached out initially to 20 logistics managers in the three project locations. Researchers quickly found that many of these initial contacts had either moved on or were not in a capacity to respond on behalf of their company. Researchers then reached out to the metropolitan planning organization (MPO) freight contacts and sought assistance from private sector stakeholders involved in MPO freight planning groups. The survey was sent to numerous stakeholders for the three locations.

Feedback from these stakeholders was that the information desired was too proprietary or difficult for them to discern, even if the results were to be aggregated and anonymized. In San Antonio, for example, even the Bureau of Labor Statistics declines to report some business data because there are too few entities and the data are too proprietary or easy to identify the company. Additional feedback was that their choice of location had much to do with their history of operations in the region and the commodity they transport.

Researchers decided that since the surveys were not yielding the quality of information desired, another option would be to consult the MPO freight plans where some performance information had already been captured. Additionally, researchers collected determined alternative options for measuring the criteria and derived data related to the survey questions and criteria needs such as numbers of jobs, tax rates, sales, and travel times. Researchers found data that related to or could be substituted to improve on the analysis and provide more detail on the locations.

The additional measures and analysis in conjunction with information on needs and issues from MPO freight plans helped to bolster the assessment. Researchers also consulted economic development resources from each location such as marketing materials, economic incentive programs, and real estate assessments from the Texas A&M Transportation Institute Real Estate Center. This information yielded excellent data and insight that helped to improve the assessment. Table 11 shows the additional quantitative data derived from this supplemental assessment.

Table 11. Supplemental Assessment and Ranking.

					Rank Value of the 3 cities (1.00 is highest importance and 3.00 is lowest importance)			Weight of the Measures (1 is the highest importance. Larger number means lower importance of the measure)	Weight Adjusted Rank Values		
Measure Number	**Specific Measures (units)**	**DFW**	**Houston**	**San Antonio**	**DFW**	**Houston**	**San Antonio**		**DFW**	**Houston**	**San Antonio**
8	Industrial Rental Rate	$4.48	$6.39	$5.29	1.00	3.00	2.15	1.00	1.00	3.00	2.15
9	Square Footage of Available industrial Space	764,942,214	226,464,329	46,443,095	1.00	2.50	3.00	1.00	1.00	2.50	3.00
10	Square Footage of Vacant Space	44,497,529	37,838,267	6,641,363	1.00	1.35	3.00	1.00	1.00	1.35	3.00
11	Employment ($1000)	3,904	3,408	1,188	1.00	1.37	3.00	1.00	1.00	1.37	3.00
12	Unemployment Rate	3.4	4.2	3.1	1.55	3.00	1.00	1.00	1.55	3.00	1.00
13	City Sales and Use Tax % Change Last Year	3.9	7.54	5.15	3.00	1.00	2.31	1.00	3.00	1.00	2.31
14	Tax Rate	8.25	8.25	8.25				1.00	0.00	0.00	0.00
15	Total Manufacturers Shipments, 2012 ($1000)	17,731,342	53,787,073	14,068,085	1.18	1.00	3.00	1.00	1.18	1.00	3.00
16	Total Merchant Wholesaler Sales, 2012 ($1000)	22,578,009	322,772,620	N/A	2.00	1.00	3.00	1.00	2.00	1.00	3.00
17	Total Retail Sales, 2012 ($1000)	16,889,012	41,589,435	23,870,168	3.00	1.00	2.43	1.00	3.00	1.00	2.43
18	Total Retail Sales per Capita, 2012	13,607	19,247	17,260	3.00	1.00	1.70	1.00	3.00	1.00	1.70
19	Mean Travel Time to Work	26.3	26.8	23.9	2.66	2.00	1.00	1.00	2.66	2.00	1.00
20	Trad Transporation and Utilities Employment ($1000)	774.4	624.9	182.3	1.00	1.50	3.00	1.00	1.00	1.50	3.00
21	Credit Worthiness	Aa2	Aa3	AAA	2.00	3.00	1.00	1.00	2.00	3.00	1.00
22	Intermodal Access, # of modes available	4	5	4	2.00	1.00	3.00	1.00	2.00	1.00	3.00
								Sum of Supplemental Rank Values	**25.39**	**23.72**	**32.60**

The Sum of the Rank Values was done for all criteria measured for the supplemental values so that the difference could be seen between the initial quantitative assessment and this supplemental assessment. When the supplemental assessment was added, the values changed and Houston emerged as the most preferable. Researchers removed measure 22 of intermodal access as a test since Houston is the only location with maritime access, but Houston still emerged as the preferred location with the supplemental assessment.

Results

The results of the quantitative and supplemental assessment demonstrate that DFW and Houston have significant freight activity, system, environmental, and economic elements that would make these locations most suitable for FV implementation. DFW already has a FV, for example, and it is reasonable that these two locations with their high level of freight importance and modal access would be strong options. However, the criteria demonstrate that all three locations have merit as FV candidates. In addition, economic development information derived for the locations demonstrates readiness, incentives, workforce, space, and connections that will continue to require freight movement over time.

CONCLUSION

This research assessed options for FV implementation in Texas. The STREAM process was modified to determine the optimal locations and to evaluate these locations further. Additionally, stakeholders were identified that could support FV implementation. The top locations determined with potential for FVs were DFW, Houston, and San Antonio. In-depth analysis of these locations demonstrate that Houston emerges as a preferred location with DFW a close second. However, all three candidate locations were found to be at the ready to support FV implementation, especially due to their multimodal infrastructure and geographic position, projected economic growth, and future demand.

APPENDIX A: DRAFT FREIGHT VILLAGES SURVEY

Freight Villages Survey

Hi, my name is [insert name of researcher] and I am a researcher for the Texas A&M Transportation Institute. We are developing a general study of Freight Villages and their benefits to companies and the regional economies. We have identified your company as a valuable source to show the benefits of a freight village and would appreciate the opportunity to ask you a couple of questions. This will only take a couple of minutes of your time and we guarantee anonymity and access to the results of the study.

1) What percentage of your budget is dedicated to annual maintenance costs?
2) If company has always been located there: What is the current tax rate you pay in terms of land-use or location.
    a. If company hasn't always been there ask: How has this changed since the building was constructed?
3) How many employees are employed by your company?
4) Are you a multimodal company?
    a. If yes, then:
        i. On average how many connections do you have per shipment route?
        ii. How much time does it take in between switching modes for arrival and departure?
        iii. Of total shipments, what percentage were delivered on time? What percentage of stock out per period of time?
        iv. Of those commodities delivered, how many were fulfilled by stock in the warehouse, and how many had to be fulfilled by outsourcing stock?
5) What is your estimated change in cost percentage from not being in a freight village to being in one?
    a. If always in one, what is your percentage of supply chain cost?

APPENDIX B: LIST OF TOP 50 U.S. 3PLS

2016 Rank	Third-party Logistics Provider (3PL)	2016 Gross Logistics Revenue (USD Millions)	2016 Global Rank
1	C.H. Robinson	13,144	5
2	XPO Logistics	8,638	7
3	UPS Supply Chain Solutions	6,793	10
4	J.B. Hunt (JBI, DCS & ICS)	6,181	14
5	Expeditors	6,098	15
6	Kuehne + Nagel (The Americas)	4,909	2
7	DHL Supply Chain North America	4,200	1
8	Burris Logistics	3,629	23
9	Hub Group	3,573	25
10	FedEx Trade Networks/SupplyChain Systems/GENCO	2,916	29
11	Ryder Supply Chain Solutions	2,659	30
12	DB Schenker (The Americas)	2,630	4
13	Coyote Logistics	2,360	32
14	Total Quality Logistics	2,321	33
15	CEVA Logistics (The Americas)	2,310	11
16	Panalpina (The Americas)	2,209	17
17	GEODIS (The Americas)	2,200	9
18	Schneider Logistics & Dedicated	2,125	35
19	DSV (The Americas)	1,798	6
20	Echo Global Logistics	1,716	37
21	Transportation Insight	1,710	38
22	Landstar	1,632	42
23	Transplace	1,620	43
24	Americold	1,555	45
25	Penske Logistics	1,500	47
26	Swift Transportation	1,431	48
27	NFI	1,250	50
28	Werner Enterprises Dedicated & Logistics	1,156	N/A
29	OIA Global	1,150	N/A
30	BDP International	1,090	N/A
31	APL Logistics Americas	1,055	39
32	Yusen Logistics (Americas)	1,044	21
33	Cardinal Logistics Management	1,006	N/A
34	Mode Transportation	949	N/A
35	SunteckTTS	900	N/A
36	Syncreon	900	N/A

2016 Rank	Third-party Logistics Provider (3PL)	2016 Gross Logistics Revenue (USD Millions)	2016 Global Rank
37	Lineage Logistics	900	N/A
38	Radial	800	N/A
39	TransGroup Global Logistics	800	N/A
40	Ruan	796	N/A
41	Nippon Express (The Americas)	790	3
42	Radiant Logistics	783	N/A
43	Damco (The Americas)	773	31
44	Neovia Logistics Services	763	N/A
45	Worldwide Express	750	N/A
46	ArcBest	677	N/A
47	Odyssey Logistics & Technology	650	N/A
48	Hellmann Worldwide Logistics (The Americas)	640	26
49	Kenco Logistic Services	626	N/A
50	Crane Worldwide Logistics	616	N/A

APPENDIX C: LIST OF TOP 50 GLOBAL 3PLS

2016 Rank	Third-party Logistics Provider (3PL)	2016 Gross Logistics Revenue (USD Millions)
1	DHL Supply Chain & Global Forwarding	26,105
2	Kuehne + Nagel	20,294
3	Nippon Express	16,976
4	DB Schenker	16,746
5	C.H. Robinson	13,144
6	DSV	10,073
7	XPO Logistics	8,638
8	Sinotrans	7,046
9	GEODIS	6,830
10	UPS Supply Chain Solutions	6,793
11	CEVA Logistics	6,646
12	DACHSER	6,320
13	Hitachi Transport System	6,273
14	J.B. Hunt (JBI, DCS & ICS)	6,181
15	Expeditors	6,098
16	Toll Group	5,822
17	Panalpina	5,276
18	GEFCO	4,800
19	Bolloré Logistics	4,670
20	Kintetsu World Express	4,415
21	Yusen Logistics	4,169
22	CJ Logistics	3,662
23	Burris Logistics	3,629
24	Agility	3,576
25	Hub Group	3,573
26	Hellmann Worldwide Logistics	3,443
27	IMPERIAL Logistics	3,352
28	Kerry Logistics	3,097
29	FedEx Trade Networks/SupplyChain Systems/GENCO	2,916
30	Ryder Supply Chain Solutions	2,659
31	Damco	2,500
32	Coyote Logistics	2,360
33	Total Quality Logistics	2,321
34	Sankyu	2,275
35	Schneider Logistics & Dedicated	2,125
36	Wincanton	1,720

2016 Rank	Third-party Logistics Provider (3PL)	2016 Gross Logistics Revenue (USD Millions)
37	Echo Global Logistics	1,716
38	Transportation Insight	1,710
39	APL Logistics	1,700
40	NNR Global Logistics	1,676
41	Mainfreight	1,640
42	Landstar	1,632
43	Transplace	1,620
44	Arvato	1,615
45	Americold	1,555
46	Fiege	1,550
47	Penske Logistics	1,500
48	Swift Transportation	1,431
49	Groupe CAT	1,328
50	NFI	1,250

APPENDIX D: TABLE OF QUANTITATIVE MEASURES OF THE THREE CITIES FOR FREIGHT VILLAGE LOCATIONS

Table of Quantitative Measures of the Three Cities for Freight Village Locations

Dimension	Criteria	Measures	Specific Measures (units)	DFW	Houston	San Antonio	Comment	Data Source
System Design	System Capacity	• traffic volume	Truck DVMT (Daily Vehicle Miles of Travel)	14,011,286	9,843,943	6,273,598	• Year 2016 data. • DFW value is the sum of Dallas district and Fort Worth district	Source: TxDOT Roadway Inventory (https://www.txdot.gov/inside-txdot/division/transportation-planning/roadway-inventory.html)
			Total DVMT (Daily Vehicle Miles of Travel)	184,744,171	157,633,915	63,469,391	• Year 2016 data. • DFW value is the sum of Dallas district and Fort Worth district	Source: TxDOT Roadway Inventory (https://www.txdot.gov/inside-txdot/division/transportation-planning/roadway-inventory.html)
		• commodity flow volume	Total Export* from the region (Ktons)	317,535	924,528	141,378	• 2015 data • sum of domestic and foreign exports	FAF4
			Total Import* to the region (Ktons)	309,506	961,772	144,975	• 2015 data • sum of domestic and foreign imports	FAF4
			Total tonnage (Ktons)	627,041	1,886,300	286,353	• 2015 data • sum of domestic and foreign tonnage	FAF4
	Fluidity	• Delay Measures	Annual Hours of Truck Delay (person-hrs)	8,140,525	8,801,515	2,009,574	sum of the peak period, offpeak period, and weekend delay from trucks	source: Texas' Most Congested Roadways 2016 (https://mobility.tamu.edu/texas-most-congested-roadways/)
			Annual Hours of All Vehicle Delay (person-hrs)	130,079,202	160,166,878	33,467,225	sum of the peak period, offpeak period, and weekend delay from all vehicles	source: Texas' Most Congested Roadways 2016 (https://mobility.tamu.edu/texas-most-congested-roadways/)
		• travel time reliability	Average of PTIs (Planning Time Index) of the Congested Roads	1.44	1.60	1.49	Planning Time Index - (a reliability measure) ratio of the 95th percent peak period travel time to the freeflow travel time.	source: Texas' Most Congested Roadways 2016 (https://mobility.tamu.edu/texas-most-congested-roadways/)
		• transshipment time	Time between mode A arrival and mode B departure				N/A	Not available
	Land Use	•Real Estate	Industrial Rental Rate	4.48	6.39	5.29		https://www.recenter.tamu.edu/research/market-research
			Square Footage of Available Industrial Space	764,942,214	226,464,329	46443095		
			Square Footage of Vacant Space	44497529	37838267	6641362.585		

	Modal Utilization	• utilization ratio by mode	percentage of commodity flow by Truck	63% (100,141 million ton-mile)	22% (80,105 million ton-mile)	58% (30,487 million ton-mile)	truck % of the total flow moved in 2015	FAF4
			percentage of commodity flow by Rail	14% (22,838 million ton-mile)	28% (103,718 million ton-mile)	34% (17,655 million ton-mile)	rail % of the total flow moved in 2015	FAF4
			percentage of commodity flow by Water	0% (13 million ton-mile)	11% (41,900 million ton-mile)	0% (1.6 million ton-mile)	water % of the total flow moved in 2015	FAF4
			percentage of commodity flow by Air	0% (313 million ton-mile)	0% (182 million ton-mile)	0% (36.8 million ton-mile)	air % of the total flow moved in 2015	FAF4
	Connectivity	• number of connections	average number of connections from origin to destination per commodity				N/A	
System Operations	Efficiency	• supply chain cost reduction	percent (or dollar amount) changes of SCM cost				N/A	
		• on-time delivery rate	number of units delivered on time over operation cost				Need to be collected from the field survey	
	Effectiveness	• fill rate	percentage				Need to be collected from the field survey	
Safety	Roadway safety	• annual freight-related traffic accidents	number of truck injury and fatal crashes (per thousand truck miles, per thousand trucks etc.)				possible to get the data from TxDOT CRIS database later	
			number of highway/rail fatal crashes				possible to get the data from TxDOT CRIS database later	

Environmental	Air pollution	• emissions from freight traffic	Annual Excess CO2 Produced Due to Truck Congestion (pounds)	289,362,195	294,029,801	66,255,659	additional CO2 produced due to truck congestion - pounds of additional Carbon Dioxide produced because of truck congestion	source: Texas' Most Congested Roadways 2016 (https://mobility.tamu.edu/texas-most-congested-roadways/)
			Annual Excess CO2 Produced Due to All Vehicles Congestion (pounds)	1,182,139,425	1,396,902,251	294,647,897	additional CO2 produced due to congestion - pounds of additional Carbon Dioxide produced because of congestion	source: Texas' Most Congested Roadways 2016 (https://mobility.tamu.edu/texas-most-congested-roadways/)
	Noise level	• noise level from traffic (roadway)	decibels (dB)				N/A	
Economy	Employment	•unemployement		3.4	4.2	3.1		'www.bls.gov/regions/southwest
	Employment	• total employment	number of employees in thousands	3903.5	3407.7	1188.3		www.bls.gov/regions/southwest
	Revenue	• tax revenue (public)	dollar amount (public)				Available data but city sales and use tax comparison is a better economic indicator.	
		•CITY SALES AND USE TAX COMPARISON SUMMARY	% change	3.9	7.54	5.15	Net payments allow you to compare current-year sales and use tax payments with those of the previous year. When used with other local indicators, they may help indicate present and future economic trends.	https://comptroller.texas.gov/transparency/local/allocations/sales-tax/cities.php
		• tax rate (private)	tax rate	8.25	8.25	8.25		https://comptroller.texas.gov/taxes/sales/city.php
	Cost	• Construction cost	Median Construction Cost for Warehouse	$46.38 per sq. ft.	$48.03 per sq. ft.	$44.89 per sq. ft.	estimaion based on the size of 10,000 square feet	source: Building Journal (http://buildingjournal.com/commercial-estimating.html)
		• % of budget changes about construction and maintenance	% changes of annual budget				N/A	
	Business	•Total Manufacturers Shipments, 2012		17731342	53787073	14068085		'www.bls.gov/regions/southwest
		•Total Merchant Wholesaler Sales, 2012		22578009	322772620	N/A		
		•Total Retail Sales, 2012 ($1000)		16889012	41589435	23870168		
		•Total Retail Sales per Capita, 2012		13607	19247	17260		
		•Mean Travel Time to Work		26.3	26.8	23.9		
		•Trade Transporation and Utilities		774.4	624.9	182.3		
		•Credit Worthiness	Rating level	Aa2	Aa3	AAA		https://infogram.com/major-city-bond-

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