Southwest Region University Transportation Center

Megaregion Freight Movements: A Case Study of the Texas Triangle

SWUTC/11/476660-00075-1

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
SWUTC/11/476660-00075-1		

4. Title and Subtitle	5. Report Date
Megaregion Freight Movements: A Case Study of the Texas Triangle	September 2011
	6. Performing Organization Code
7. Author(s) Dan Seedah and Robert Harrison	8. Performing Organization Report No. Report 476660-00075-1
9. Performing Organization Name and Address Center for Transportation Research University of Texas at Austin 1616 Guadalupe Street Austin, TX 78701	10. Work Unit No. (TRAIS) 11. Contract or Grant No. DTRT07-G-0006
12. Sponsoring Agency Name and Address Southwest Region University Transportation Center Texas Transportation Institute Texas A&M University System College Station, Texas 77843-3135	13. Type of Report and Period Covered Technical Report August 2010–September 2011 14. Sponsoring Agency Code

15. Supplementary Notes

Supported by a grant from the U.S. Department of Transportation, University Transportation Centers Program.

16. Abstract

U.S. population growth is predicted to substantially increase over the next 40 years, particularly in areas with large regional economies forecasted to contain over two-thirds of the national economic activity. In Texas, population growth from 2000 to 2040 is predicted to increase around 72% and produce a diverse population of some 36 million. This will comprise 12% rural and 88% urban, much of it in the 26 metropolitan areas. These population and economic estimates stimulated the exploration of appropriate planning strategies to address the needs of serving such growth, including a macro approach encapsulated in the term *megaregions*. Although some planners are skeptical about whether this concept enhances traditional planning, it does merit examination in the freight transportation sector, which tends to get less emphasis in community and regional planning. Texas has at least one megaregion, and the largest—The Texas Triangle, comprising Dallas/Fort Worth-San Antonio-Houston—generates over 60% of the gross state product. The project will consider the Texas Triangle with an emphasis on maintaining efficient future freight movement and will offer multimodal solutions to moving freight to, between, and within the metropolitan economies of the megaregion to 2050.

17. Key Words	18. Distribution Statement
Megaregions, Megaregional Planning, Texas Triangle, Freight Transportation, Freight Bottlenecks	No restrictions. This document is available to the public through NTIS: National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161

19. Security Classif.(of this report)	20. Security Classif.(of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	81	

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

MEGAREGION FREIGHT MOVEMENTS:
A CASE STUDY OF THE TEXAS TRIANGLE

By

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and
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Research Report SWUTC/11/476660-00075-1

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September 2011

Abstract

U.S. population growth is predicted to substantially increase over the next 40 years, particularly within areas with large regional economies, made attractive by forecasts that these areas will contain over two-thirds of state and nation economic activity. In Texas, the population growth from 2000 to 2040 is predicted to increase around 72% and produce a diverse population of some 36 million. Rural population by 2040 will comprise less than 12% and the remainder will be urban, much of it in the 26 metropolitan areas. The population and economic estimates stimulated the exploration of appropriate planning strategies to address the needs of serving such growth, including a macro approach encapsulated in the term *megaregions*. The Regional Planning Association, in its 2009 regional meeting entitled "America 2050—Building the Next Economy," defined the term as "large networks of metropolitan regions linked by environmental systems and geography, infrastructure systems, economic linkages, settlement patterns and shared culture and history." Although some planners are skeptical about whether this concept enhances traditional planning, it does merit examination in the freight transportation sector, which currently receives less emphasis in metropolitan planning. Texas has at least one megaregion, and the largest—The Texas Triangle, comprising Dallas/Fort Worth-San Antonio-Houston—generates over 60% of the gross state product. The project will consider the Texas Triangle with an emphasis on maintaining efficient future freight movement and will offer multimodal solutions to moving freight to, between, and within the metropolitan economies of the megaregion to 2050.

Editorial Note: The term *megaregion* comes in various stylistic forms in the literature—hyphenated, capitalized "M" or "R" (or both). For consistency in this report, its use in both referenced material and findings is in the form of a single, lower case word.

Executive Summary

Introduction

Megaregions, as defined by the Regional Planning Association, are "large networks of metropolitan regions linked by environmental systems and geography, infrastructure systems, economic linkages, settlement patterns and shared culture and history." Although some planners are skeptical as to how this concept might enhance traditional planning, it does merit examination in the freight transportation sector, which tends to get less emphasis in community and regional planning. Currently a dozen megaregions lie within the U.S., Canada, and Mexico, although they lack a federal definition to identify them with any precision. Texas has at least one megaregion, and the largest—The Texas Triangle, comprising Dallas/Fort Worth-San Antonio-Houston— generates over 60% of the gross state product. Dominant activity clusters in the Texas Triangle include energy and natural resources, construction, semiconductors, software, and IT.

Successful megaregions will be utterly dependent on efficient freight movement, which must in the long term mitigate all the social costs presently associated with goods flows in the U.S. This study is a contribution to a Region 6 University Transportation Centers (UTC) integrated initiative examining aspects of megaregional planning and seeking to examine the role of freight in supporting and sustaining economic development in the Texas Triangle megaregion.

This work is the fourth of five inter-related UTC program studies examining key changes in intermodal freight transportation in the United States at both national and state levels. The first study examined changes over the last decade in rail intermodal systems in the United States and the likelihood that a more enhanced role could be played by railroads in moving future volumes of North American continental freight efficiently and competitively. The second examined sustainable supply chains in North America and the role played by rail intermodal operations in lowering ton-mile fuel and emission costs. The third examined the impacts on key U.S. global import and export supply chains of the new, larger locks on the Panama Canal, due to be opened in 2014; these locks will permit larger ships to serve Gulf and North Atlantic ports more competitively from Asian centers of production. The fifth study will evaluate the operation of delivery trucks with reduced or near-zero emissions that will need to be introduced where non-attainment air quality restrictions are in place.

Literature Review

The various definitions of megaregion identified in the literature do not capture the integrating nature of transportation systems. Also not captured is how the private sector is arguably already working at effectively planning freight movement systems that address issues within metropolitan areas, with the focus on integrating all the metropolitan areas and megaregional conglomerations served by their networks. Planners at metropolitan planning organizations (MPOs) in the public sector generally view highways as ways of serving the population. Private sector entities, in contrast, see highways as freight arteries where problems in other metropolitan areas can reduce the effectiveness in their own area. The best example of this systemic view is rail, where companies undertake system-wide maintenance and improvements such as capacity enhancements. In Texas, for example, the improvements to Tower 55 in the Fort Worth area create benefits that are felt beyond state boundaries. The Burlington Northern and Santa Fe (BNSF) railroad actually has studied megaregions and incorporated the ideas into its promotional material—showing, for example, that its central corridor actually links and serves several major metropolitan areas. It would appear that the failure to capture a system-wide perspective of transportation systems is a weakness in current definitions and that the study is merited.

Texas has two megaregions with Houston acting as the point where they overlap. The Texas Triangle was selected as the case study to evaluate aspects of freight transportation flows for two reasons. First, it is the largest and best known economic engine in the state, and second, it lies totally within state jurisdiction and may be simpler to administer as a megaregion as all the planning pieces are in place and available for comment and examination.

Population Growth and Economic Profile of the Texas Triangle

The Texas Triangle Megaregion is spatially delineated by the metropolitan areas of Dallas/Fort Worth, Austin, San Antonio, and Houston—the four most populated metropolitan areas in Texas and all within a 150-mile radius from their centroid. Its total land size is nearly 60,000 square miles and contains approximately 69% of the Texas population in 2010. Of the top 50 fastest growing counties in Texas, 38 are in the Texas Triangle megaregion. Of this 38, 8 are among the top 10 fastest growing counties in Texas. In 2009, the Houston-Sugar Land-Baytown MSA was the fastest growing metropolitan area among economies with real gross domestic product of more than $100 billion. Dallas/Fort Worth has a principal role as a distribution center in such sectors as trucking and warehousing, wholesale trade, aerospace, transportation services, healthcare, finance, and education. The Austin-Round Rock-San Marcos MSA is the fastest growing MSA (by population) in Texas and was the 35th largest metro economy in the U.S. in 2009. The San Antonio-New Braunfels MSA economy is the 34th largest metro economy in the U.S. and provides a strategic location for distribution, transshipment, and international trade processing activities, with key logistical assets that support the delivery of products to both domestic and international customers

Clearly these vibrant economic metropolitan cities comprise a formidable economic and social engine for the state. Recent headlines have featured successful creation of new jobs and much of that growth has occurred within Triangle cities.

This growth has come over time, starting in the mid-1980s. Mexico joined the General Agreement on Tariffs and Trade (GATT)—now the World Trade Organization (WTO)—in 1986 and immediately began lowering a range of tariffs, which stimulated U.S.–Mexico trade. This trade increase ultimately led to the signing of the North American Free Trade Association (NAFTA) in 1992 from which Texas has benefitted significantly because it contains critical transportation corridors for both highways and rail. At least seven NAFTA corridors are used by trucking companies in Texas but the most important is I-35, which links Laredo with Kansas City while picking up I-10 at San Antonio and I-20 at Dallas. The Triangle is defined economically by I-35 and I-45 and the parallel Union Pacific and BNSF rail networks.

Freight Patterns in the Texas Triangle

The Triangle is served by roadways and rail networks that facilitate the movement of goods between the major cities. Also, the presence of a strong air freight industry and intermodal yards and warehouses in each of the cities provides an effective environment for the freight industry, though key problems—rail movement through Houston, for example—have emerged.

In addition, Houston provides the Triangle with a seaborne connection to the rest of the world, and San Antonio has a direct roadway connection to the U.S.–Mexico border city of Laredo.

In the 2007 commodity flow survey, the major cities in the Texas Triangle region accounted for nearly 60% of goods movement by tonnage and 68% by value in Texas. These include commodities moved within, from, and to Texas. For imports and exports, the Triangle cities accounted for 78% of commodities moved by value.

Multimodal freight tonnage moving through the Texas Triangle compared to the entire state is projected to climb from 66 to 72% from 2010 to 2040, while the value increases from 78 to a staggering 85% during the same time period. Transportation performance underlies these forecasts, so it should be remembered that if service levels fall and cost rise, economic activity will shrink and expansion will move elsewhere. So, is the Texas transportation infrastructure ready for the next decade? The railroad industry sponsored a Cambridge Systematics study examining rail network bottlenecks; this study reported in 2007 that $148 billion (in 2007 dollars) was needed for rail infrastructure expansion to accommodate the 88% growth in rail freight out to 2035. The Class I railroads' share of the figure was $135 billion, of which $96 billion would accrue through increased earning and the balance—about $1.4 billion per year—would come from tax incentives and other sources. It now seems likely that rail profitability may meet these targets with additional infusions of money from public-private partnerships and federal, state, or MPO support (as in the case of Tower 55). Highway investment, however, is more uncertain at this time and the unwillingness of Congress to sanction an increase in fuel taxes to meet current and future needs creates doubt that trucking will maintain the predicted growth in market share. Further, while Texas Gulf terminals may be able to cope with substantial growth through internal expansion, the channels that link deep water with those terminals will need to be at least maintained to the design draft and deepened if larger vessels, particularly the new container ships, are to be serviced. Megaregional transportation planning would take into account these needs and perhaps use the considerable political power that comes with economic success to keep the freight systems upgraded and efficient.

Megaregional Planning in the Triangle: Opportunities and Challenges

Megaregional planning theoretically provides benefits better than the traditional planning schemes of MPOs. The current system, wherein states or local governments compete for funds, can be replaced by inter-jurisdictional cooperation. It enables local planning organizations to identify corridors that have an impact on other cities, and provides an effective strategy for researchers, planners, engineers, politicians, and decision-makers to tackle regional issues, economic development planning, and transportation planning.

The Texas Triangle can take advantage of the megaregional planning perspective to facilitate future transportation planning goals. Preliminary steps that this megaregion can follow include the following:

a) Identifying current and future metropolitan transportation links that impact regional goods movements.

b) Identifying the current bottlenecks and future needs for these links, such as capacity constraints, community impacts, and environmental and permitting regulations.

c) Setting up benchmarks and future planning goals for the links and cities to i) provide an insight into the performance of the current transportation system, (ii) provide a means to establish realistic goals and targets, (iii) allow agencies to determine funding needs, rank capital investments, and evaluate alternative programs, (iv) provide a rationale for allocating scarce resources, and (v) assist in monitoring the progress made towards achieving specific goals and targets.

d) Examining alternative freight systems (hybrid delivery vehicles, long combination vehicles, etc.), transportation improvement strategies (off-peak hours or dynamic tolling, dedicated truck routes, intermodal facilities, etc.), and cost models (CTR-Vcost, CTRail, etc.).

e) Exploring alternative funding sources (to supplement the traditional fixed gas tax).

Despite the benefits of megaregional planning, a number of challenges do exist that require cooperation of the entire megaregion and cannot be solved in isolation. Butler et al. (2009) suggests the critical issues that must be addressed include "reducing suburban sprawl by identifying preferred growth areas, developing a new transportation network, ensuring the region's economic competitiveness, and preserving significant natural resources as well as scenic landscapes."

One great benefit of the Texas Triangle region is that it is entirely contained within the boundaries of a single state. As a result, policy changes necessary to encourage megaregional planning may be easier to implement. However, the role of planning may differ throughout the region, posing a challenge to an overarching megaregion planning perspective.

Another challenge for the megaregion will be how to address the conservation and use of natural resources. As cities grow larger and population growth expands, natural resources such as water will become an issue. In addition, increased population density may lead to increased greenhouse gas emission and environmental pollution. Cities need to work together to determine how best to address such issues before they eventually materialize. A need may raise for memorandums of understanding or compromises by all parties involved. A megaregion approach calls for new ideas, methods, and tools for planning beyond the current toolbox of MPOs because of the geographical scale of the megaregion. Cities will need to work together to develop common standards and policies to ensure uniformity among planning organization. Finally, public funding of new transportation infrastructure is inadequate and therefore feasible and sustainable alternative sources of funding are needed.

Conclusions and Recommendations

Texas is ideally placed to embrace, and benefit from, megaregional planning. Several of the 12 North American areas identified as megaregions are multi-state, which carries both costs and benefits. Multi-state projects, when capable of promoting economic growth, are supported by a large number of politicians, industries, and voters. However, multi-state projects can be more complex and expensive to plan and administer and thus are vulnerable to revenue shortfalls at the state and federal levels. Texas has a foothold in both state and multi-state planning because the Triangle lies within the state and the Gulf megaregion links with Louisiana.

This report finds overwhelming evidence to support some level of megaregional integration into current state transportation planning. The strong growth in state population since

2000, which is predicted to continue to grow to 2030 and beyond becomes a key driver because a majority of the state population will reside within the Triangle. This research benefitted from preliminary results given at the mid-year 2011 Transportation Research Board meeting by a Volpe team working on a study sponsored by the Federal Highway Administration. The Volpe research clearly supports a step-wise, hierarchical approach to megaregional planning that is of particular benefit for those Departments of Transportation—such as Texas's—that work closely with MPOs yet need to have a regional system-wide vision to ensure that freight corridor needs are being addressed.

The overriding conclusion from this work is that megaregional planning has much to recommend and should be pursued at the state, multi-state, and federal levels. Work on highway corridors has been particularly disappointing in terms of new policies and investment packages that benefit corridor improvement. Segments of the interstate highway system face severe congestion that will not be relieved by additional capacity investment in the next decade. Frequently, the planners think of alternative modes and pose questions such as "can rail carry a major part of the freight growth?" Megaregional planning captures all modes and corridors and can be extended to reflect much of the transportation supply chain using basic cost models and transfer costs to evaluate financial impacts.

In summary, the research findings strongly suggest that

1. Megaregional planning, if undertaken, should include freight systems and needs.
2. The Texas Department of Transport (TxDOT) should introduce elements of megaregional planning into its statewide planning, perhaps starting with corridor needs.
3. Planners at MPOs and TxDOT should develop levels of integration, including the private sector, to target bottlenecks to raise corridor efficiencies.
4. The development and use of cost models to evaluate freight transportation multimodal corridors are part of that integration process.

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Disclaimer

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Acknowledgements

This research was financed by a grant from the U.S. Department of Transportation, University Transportation Centers Program to the Southwest Region University Transportation Center. We wish recognize the support of Dock Burke (Director) and Barbara Lorenz (Lead Administrator), who efficiently administer the Southwest Region University Transportation Center (SWUTC) program at the Texas Transportation Institute, Texas A&M University. An SWUTC program objective is to promote study topics that can be readily expanded by other research agencies. In this study, it provided the basis of a successful proposal for larger one year program examining how a megaregional perspective might improve freight planning in Texas. The study, sponsored by the Texas Department of Transportation (TxDOT – Study 0-6627) is entitled "Megaregional Freight Planning in Texas: A Synopsis" and was awarded in 2010.

We gratefully acknowledge the support provided by Dr. Carol Lewis at the Texas Southern University who acted as the project monitor for this study. Dr. Lewis, who led another SWUTC megaregion study, joined the TxDOT 0-6627 team to provide a strong SWUTC component addressing the topic. It would also be remiss not to acknowledge the sterling work of Dr. Katherine Ross of Georgia Tech whose megaregional interests—textbook, papers and teaching—provided the basis for much of the current interest in the subject. This modest study tested whether urban freight issues could be incorporated into megaregional planning and the results suggest a perfect fit. It is a stimulating and rewarding area in which to work as a transportation planner and graduate student. Finally, the authors wish to thank Maureen Kelly for editing the document and Sarah Lind Janak (CTR) for keeping us on track and assembling the manuscript.

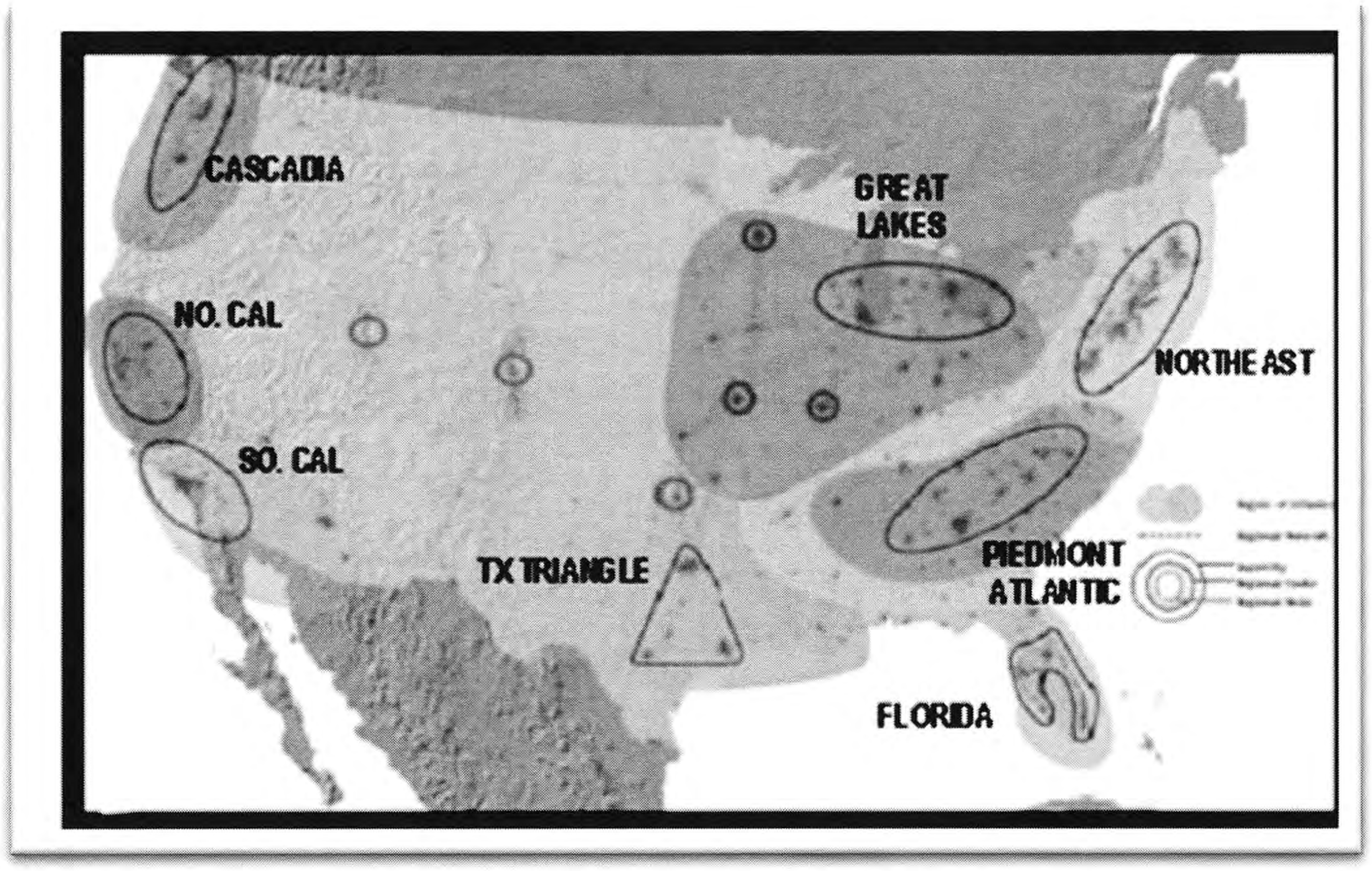
Chapter 1. Introduction

The measurement of current and future national economic performance typically begins with calculating a variety of gross domestic product (GDP) measures. GDP measures are key elements in the current rankings of groups such as the G8[1] and lie behind future moves up the rankings by the economies of Brazil, Russia, India, and China. But should GDP be the key variable in predicting future national growth? Richard Florida, in an April article in the *Wall Street Journal,* reported that of 191 nations in the world, just 40 megaregions power the world economy, accounting for two-thirds of global output and over 85% of all global innovation. The largest is Greater Tokyo with 55 million people and $2.5 trillion in economic activity, followed by the Boston–Washington corridor, with 54 million people and $2.2 trillion in output. He argues that public policy is limiting the success of U.S. megaregions by (a) failing to support efforts to open global trade, (b) diverting financial support to less critical regions, and (c) failing to stimulate higher population densities in existing cities. He makes a compelling case for including megaregions into a variety of policy initiatives and this study examines one of them: freight transportation.

The U.S., Canada, and Mexico currently have approximately 12 megaregions, although they lack a federal definition to identify them with any precision. Carbonell et al. (2005) identified eight U.S. megaregions in 2005 that were, over the next 40 years, predicted to account for half of the nation's population growth and two-thirds of its economic growth, as shown in Figure 1. The megaregions include the Texas Triangle, namely those major cities in Texas forming a large-region triangle that stretches from Dallas/Fort Worth to Houston and San Antonio, including Austin. This region, as shown in Figure 2, accounts for approximately two-thirds of the Texas State Gross Product (GSP). Dominant activity clusters in the Texas Triangle include energy and natural resources, construction, semiconductors, software, and IT. Successful megaregions will be utterly dependent on efficient freight movement that, while competitive, must in the long term mitigate all the social costs presently associated with goods flows in the U.S.

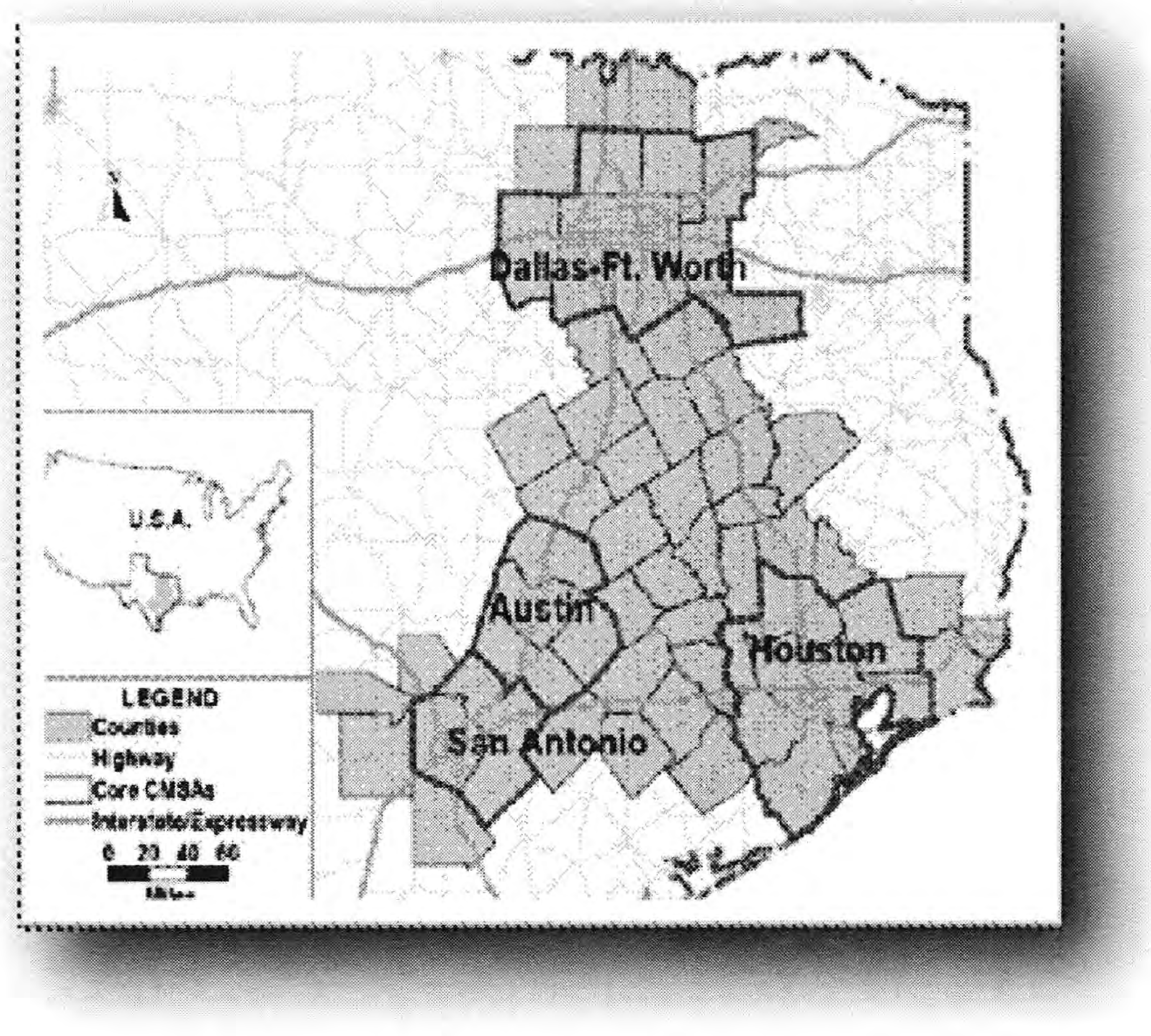
> The Rise of the Megaregion
> "The problem is that much of our public policy not only ignores the rise of the megaregions, but actually works against them. If we want to bolster economic competitiveness and ensure long-run prosperity, we must pursue policies that take megaregions into account."
> Source: R. Florida, WSJ, April 12, 2009.

[1] France called the first meeting of the G6 in 1975 in response to the 1972/3 oil crisis and members included Germany, Italy, Japan, the UK, and the U.S. Canada and Russia joined later and meetings are held regularly—annually for the heads of state and more frequently for economic and foreign policy ministers. In addition, other larger meetings are held, such as the leading 20 nations (G20).



Source: Carbonell et al., 2005

Figure 1. Dominant U.S. Megaregions as reported by Carbonell



Source: Zhang et al., 2007

Figure 2: Major Cities in the Texas Triangle

Substantial economic activity is an essential element of any megaregion and acts as a multiplier for employment, wealth, and services. The Martin Prosperity Institute recently published an analysis showing the heavy concentration of corporate headquarters in U.S. megaregions. The regions (12) identified on the report and shown in Figure 3 were home to 85% of the headquarters of the largest U.S. and Canadian companies—and the same would be true in Mexico where the Monterrey-Mexico City-Guadalajara triangle powers the Mexican economy. There is clearly merit in integrating planning activities in a variety of areas within the boundaries of such economic regions.

Source: Martin Prosperity Institute, 2009

Figure 3: Megaregions Grouped by Business Sectors

The definitions of megaregions are, however, still speculative. For example, America 2050 and Lang and Dhavale (2005) postulate the existence of a Gulf Coast megaregion that stretches from Corpus Christi, through Houston, to New Orleans. However, does combining Houston with New Orleans on the grounds of energy ignore the economic, transportation infrastructure, and cultural linkages between Houston and the major cities of central Texas? Houston serves as the marine gateway to the Texas Triangle and is critical to the maintenance of economic growth in the state. Can Houston be part of both regions? In a systematic sense, it should be able to function in two regions because the reasons for the participating differ greatly and this is not a zero sum issue. If the U.S. is to maintain economic health in the face of increasing metropolitan populations, a variety of changes have to occur at different planning levels and they have to be integrated into a coherent strategy. Transportation offers an example of how this might work and the railroad industry is an excellent case study. In the three decades since the deregulation of the industry, railroads have merged to five U.S. and two Canadian companies that provide both national and NAFTA network coverage serving national markets, together with both imports and, more critically, export flows. Their planning is system-based and serves all current megaregions while remaining competitive with other modes. Yet their operations remain somewhat of a mystery to those in metropolitan planning organizations (MPOs) as the MPO transportation focus is largely on moving people within MPO boundaries. The railroad company focuses on moving freight to, through, and from a specific MPO only within the context of the entire network. Freight is, of necessity as well as example, a key megaregion issue that has to be addressed if U.S. regional economic health is maintained to 2030 and beyond.

Study Objectives and Report Outline

This study is a contribution to a Region 6 University Transportation Centers (UTC) integrated initiative examining aspects of megaregional planning[2]. It seeks to examine the role of freight in supporting and sustaining economic development in megaregions and is part of a multi-year SWUTC initiative to build a multimodal cost approach to evaluate trade flows. Chapter 2 of this report presents the results of a literature review conducted on the various definitions of megaregions. In addition, the benefits and challenges of megaregional planning are discussed. Chapter 3 focuses on the Texas Triangle's population growth and economic profile in comparison with the state of Texas. Chapter 4 provides a detailed description of current freight patterns in the Triangle. It examines the major links between the Triangle's metropolitan areas, and provides freight projections on the various modes. Chapter 5 discusses the opportunities, benefits, and challenges of implementing megaregional planning in the Texas Triangle. It also identifies transportation links within the metropolitan areas that have an impact on goods movement to other areas in the Texas Triangle. It serves as a starting point for transportation planners in each metropolitan area to identify links that are critical connectors, and need careful transportation planning and policies to ensure any improvement or efforts do not negatively impact freight movement to other cities. Suggestions and recommendations for future megaregional planning initiatives are also presented. The findings of this study are summarized in Chapter 6 and form part of a series studies sponsored by Region 6 UTC and the Texas Department of Transportation (TxDOT) to evaluate transportation supply chains from a cost and planning perspective.

[2] Dr. Carol Lewis of the Texas Southern University at Houston is undertaking a companion UTC study.

Chapter 2. Literature Review

The term megaregion is currently defined in a variety of ways, most emphasizing some aspect of economies of scale and success in social and economic relationships, such as a "network of metropolitan centers and their surrounding areas, connected by existing environmental, economic, cultural, and infrastructure relationships" (Ross et al., 2008). Large cities have always challenged planners but arguably the industrial revolution focused attention on how they might be managed and served by a variety of transportation modes. The term megapolitan area was coined by Gottmann, who popularized the idea that modern cities are better reviewed not in isolation but rather as participating in networks evolving to form "city-systems." Over the years, the terminology has changed from megapolis (Gottmann, 1961; Faludi, 2002; Carbonell et al., 2005) to megapolitan areas (Lang and Dhavale, 2005) and now megaregions (Zhang et al., 2007; Ross et al., 2008), but the underlying concept remains the same.

> The name megapolitan plays off of the megalopolis label by using the same prefix—"mega." Interestingly, the name megapolitan was under consideration during the Census Bureau's last review of metropolitan area standards just prior to the 2000 census (Federal Register 1999, PRB 2000). As part of a redefinition proposal to categorize metropolitan areas by size, the catch-all "metropolitan" category was to be scrapped. In its place would be "megapolitan" areas, where the central cities had more than one million residents, and "macropolitan" areas, or regions with central cities ranging from 50,000 to 999,999 residents.[3] *(Lang et al., 2005).*

The concept for megaregional planning is not new as stated by Ross et al. (2008); however, only a limited number of peer-reviewed articles and books are available on the subject. Identified topics relating to megaregional planning include regionalism, globalization, global climate change, governance, economic geography, and spatial planning (Ross et al., 2008). Transportation is not one of the favored topics—hence the reason for this study.

Why Adopt Megaregional Planning?

The challenges of providing adequate basic services in many major global cities are substantial; many urban centers have failed—sometimes spectacularly—to meet the growing demand of their communities. Megacities, as they are popularly known, are said to be "playing catch-up." Megacities in less developed and developing countries (e.g., Lagos, Nigeria; Mexico City; and São Paulo) deal with basic issues of survival, such as access to sanitation and clean drinking water, and those in developed countries (e.g., Los Angeles, New York, and Tokyo) have the task of managing growth to continue advancing the quality of life of their communities (Amekudzi et al., 2007).

Amekudzi et al. (2007) further states that since the 1950s, North America's transportation system has evolved to meet the changing needs of the community, and concerns for the environment, energy use, safety, and equity have greatly influenced transportation planning

[3] This hierarchical system was not approved but the Census Bureau clearly sees that American development patterns vary by scale.

(Amekudzi et al., 2007). It must be added, however, that this planning has favored highway movement—automobiles and trucks—while creating social costs that are not internalized into the pricing of transportation services. The results can hardly be regarded as successful or even capable of serving U.S. cities as they grow and merge with neighbors.

A megaregional planning approach requires that efforts move beyond the metropolitan region to recognize the need to partner with other metropolitan areas, "proactively recognizing and capitalizing on supra-regional opportunities" (Amekudzi et al., 2007). The current planning system, wherein an MPO serves as the lead planning organization for a metropolitan area, fails to encourage greater cooperation among individual MPOs. Zhang et al. (2007) states "the megaregion approach offers provocative and visionary answers to growing problems such as congestion, development disparity, and air pollution that are facing individual metropolitan areas or cities but are unlikely to be solved by each individually" (Zhang et al., 2007). This sweeping claim should be considered carefully, as real answers are yet to be determined in a coherent and compelling way in the U.S.

Succinctly, megaregional freight planning seeks to integrate individual metropolitan transportation plans in a manner that acknowledges the dependence on neighboring cities, particularly in respect to freight movement modal systems. It seeks simultaneous goals that address efficiency, competitiveness, modal choice, and sustainability.

Defining Megaregions

Various authors have defined megaregion areas using integrating forces such as passenger commute patterns or intercity travel, goods movement, business linkages, cultural commonality (e.g., race), physical and geographical environments, population density, population growth, economic outputs, and projected estimates of national GDP (Lang and Dhavale, 2005; Florida et al., 2007). A more complex example of such work is arguably Lang and Dhavale (2005) at the Metropolitan Institute at Virginia Tech[4]. They postulate that megaregions should be defined not only by "space of place" (physical distribution of the built environment) but by "space of flow" (linkages between those physical environments). The authors further state that megaregional areas should possess two qualities—"concentrated populations and the corridor form"—to make them excellent geographic units for transportation system organization, e.g., Amtrak (Lang et al., 2005). Using the above-suggested framework, Lang and Dhavale (2005) suggested that a megaregion could therefore be defined as

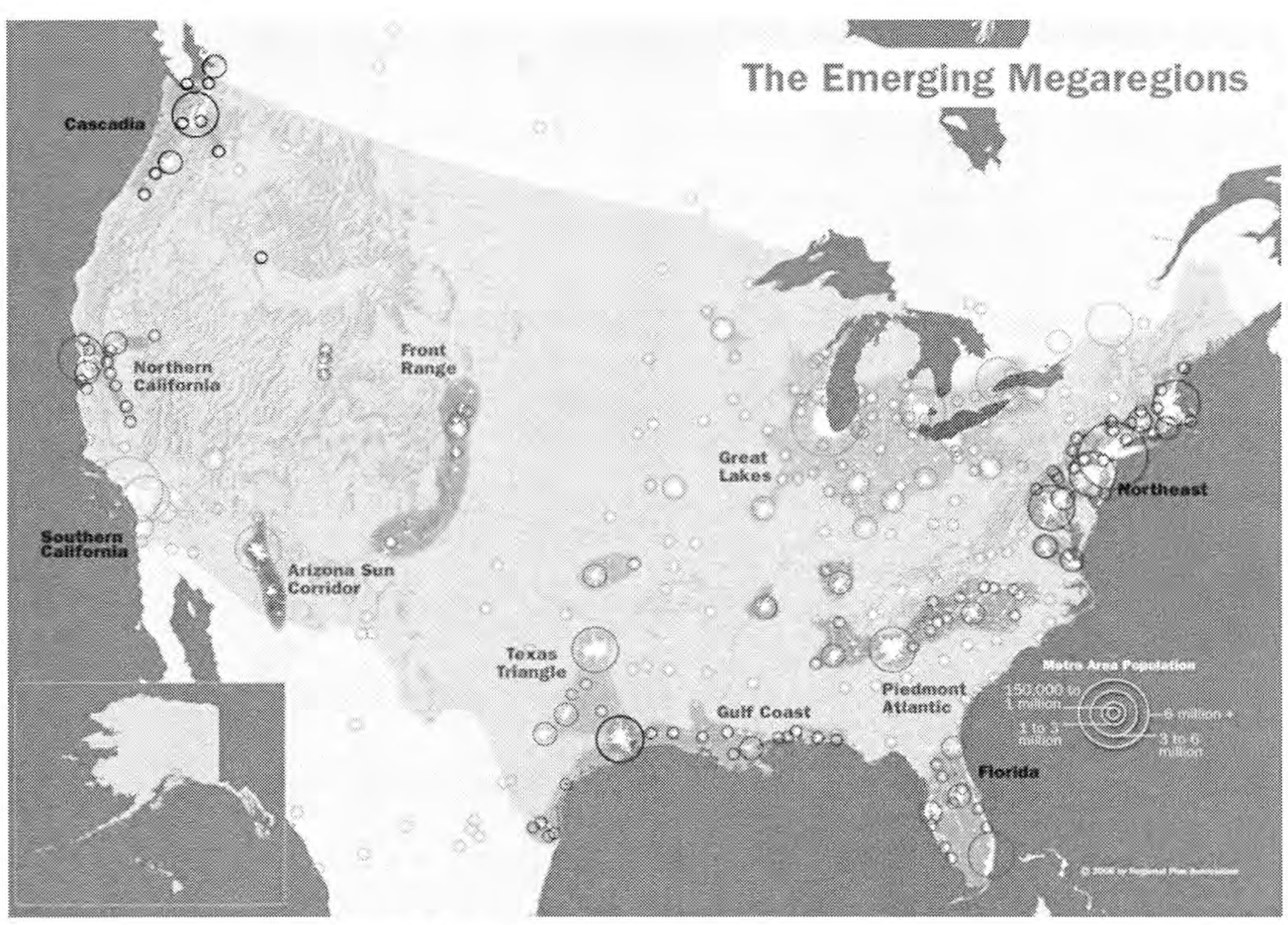
- A combination of at least two existing metropolitan areas.
- Population totaling more than 10 million by 2040.
- Contiguous metropolitan and micropolitan areas.
- A cultural region with a distinct history and identity.
- Occupying a roughly similar physical environment.
- Linking large centers through major transportation infrastructure and systems.
- Forming a functional urban network via goods and service flows.
- Creating a usable geography that is suitable for large-scale regional planning.

[4] Lang and Dhavale (2005) use the terminology "megapolitan" in their paper. Another common terminology used by European researchers is "mega-city region."

- Consisting of counties as the most basic unit (U.S. only) as county data is readily accessible and useful for statistical analysis.
- Including both urbanized and rural areas.

A megaregion does not replace a metropolitan region but rather "adds a larger unit of analysis by rolling the metros and micros into a larger defined space" (Lang et al., 2005). Ross et al. (2008) also identified other researchers who have explored various definitions and delineations of megaregions in the United States, including Metcalf and Terplan, 2007; Zhang et al., 2007; Delgado et al., 2006a; Regional Plan Association (RPA), 2006; University of Pennsylvania, 2006; Contant et al., 2005; and Seltzer et al., 2005.

The RPA's 2006 megaregion delineation is the other most popular delineation (Ross et al., 2008). Criteria used by the RPA include "environmental systems and topography, infrastructure systems, economic linkages, settlement patterns and land use, and shared culture and history" (RPA, 2006). No specific mention of transportation systems, either passenger or freight, is explicitly noted. The RPA assumes that an area that shares many of these criteria will be a cohesive megaregion (Ross et al., 2008). Figures 4 and 5 showcase the major differences between the definitions and delineations suggested by Lang and Dhavale (2005) and the RPA (2006). Both postulate that the U.S. has 10 to 11 megaregions but differ in the delineation of the Texas Triangle cities of Houston, Dallas/Fort Worth, and San Antonio, as well as the Front Range corridor, which runs north-south along the I-25 Corridor from Albuquerque to Denver/Boulder. The Front Range corridor is thought of as the smallest but one of the fast growing megaregions in the country (America 2050).



Source: http://www.america2050.org/maps/

Figure 4: The RPA's Megaregions

Source: Metropolitan Institute

Figure 5: Lang and Dhavale (2005)

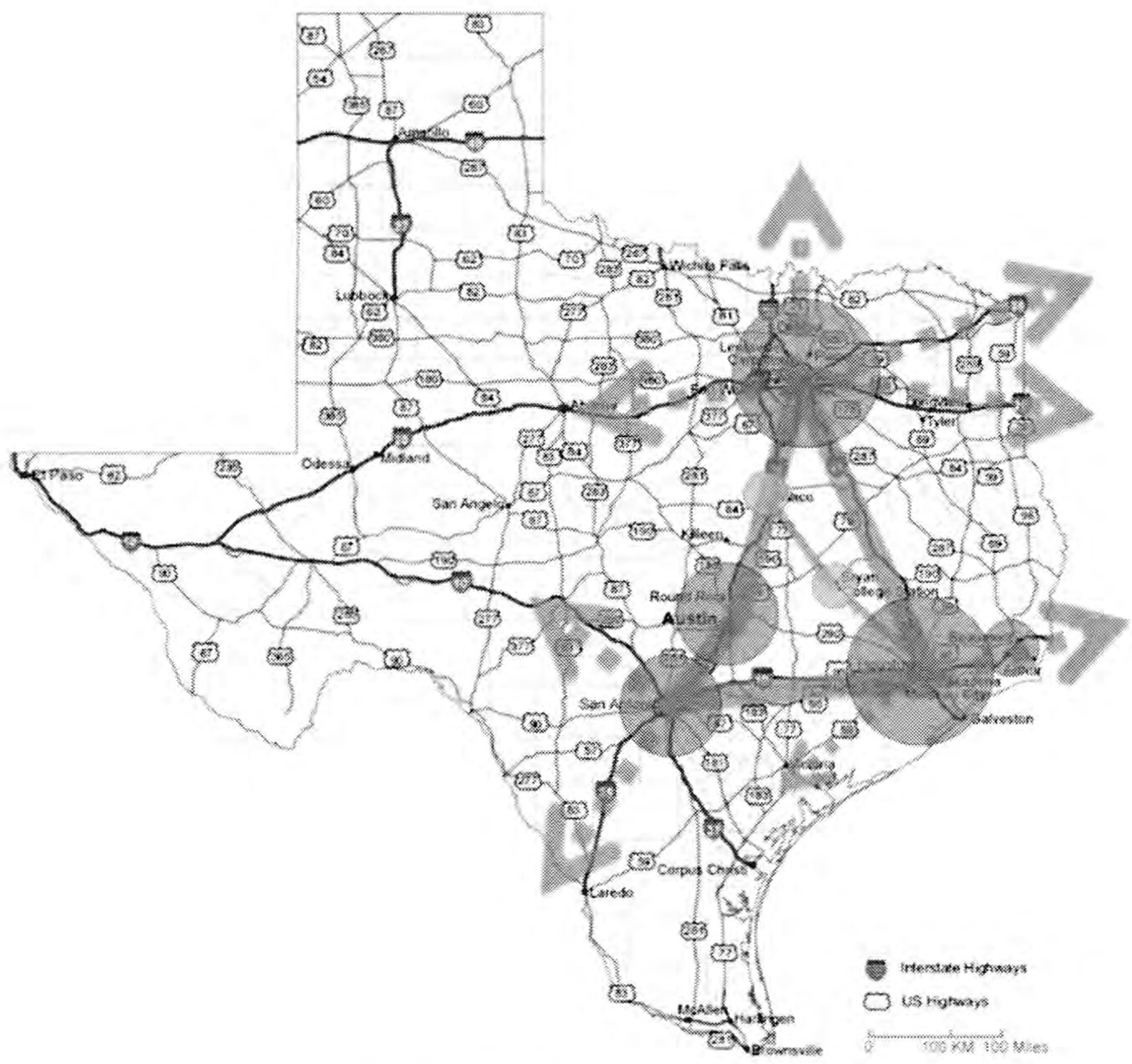
Summary

The various definitions of megaregion identified in the literature do not capture the integrating nature of transportation systems. Also not captured is how the private sector is arguably already working at effectively planning freight movement systems that address issues within metropolitan areas, with the focus on integrating all the metropolitan areas and megaregional conglomerations served by their networks. Planners at metropolitan planning organizations (MPOs) in the public sector generally view highways as ways of serving the population. Private sector entities, in contrast, see highways as freight arteries where problems in other metropolitan areas can reduce the effectiveness in their own area. The best example of this systemic view is rail, where companies undertake system-wide maintenance and improvements such as capacity enhancements. In Texas, for example, the improvements to Tower 55 in the Fort Worth area create benefits that are felt beyond state boundaries. The Burlington Northern and Santa Fe (BNSF) railroad actually has studied megaregions and incorporated the ideas into its promotional material—showing, for example, that its central corridor actually links and serves several major metropolitan areas. It would appear that the failure to capture a system-wide perspective of transportation systems is a weakness in current definitions and that the study is merited.

Texas, as already noted, has two megaregions with Houston acting as the point where they overlap. The Texas Triangle was selected as the case study to evaluate aspects of freight transportation flows for two reasons. First, it is the largest and best known economic engine in the state, and second, it lies totally within state jurisdiction and may be simpler to administer as a megaregion because all the planning pieces are in place and available for comment and examination. The next chapter looks at the economic profile of that region.

Chapter 3. Population Growth and Economic Profile of the Texas Triangle

The Texas Triangle Megaregion is spatially delineated by the metropolitan areas of Dallas/Fort Worth, Austin, San Antonio, and Houston—the five most populated metropolitan areas in Texas and all within a 150-mile radius from their centroid (see Figure 6). It has a total land size of nearly 60,000 square miles. The Triangle had approximately 15 million inhabitants in the year 2000 (68% of the Texas population), which grew to 17 million (69% of the Texas population) in 2010 (Census Bureau, 2010). Of the top 50 fastest growing counties in Texas, 38 are in the Texas Triangle megaregion. Of this 38, 9 are among the top 10 fastest growing counties in Texas: Hays, Denton, Williamson, Collin, Bastrop, Montgomery, Rockwall, Fort Bend, and Waller[5] (see Figure 7). Williamson, Hays, Collin, and Denton counties had population changes greater than 34% from 2000 to 2010.

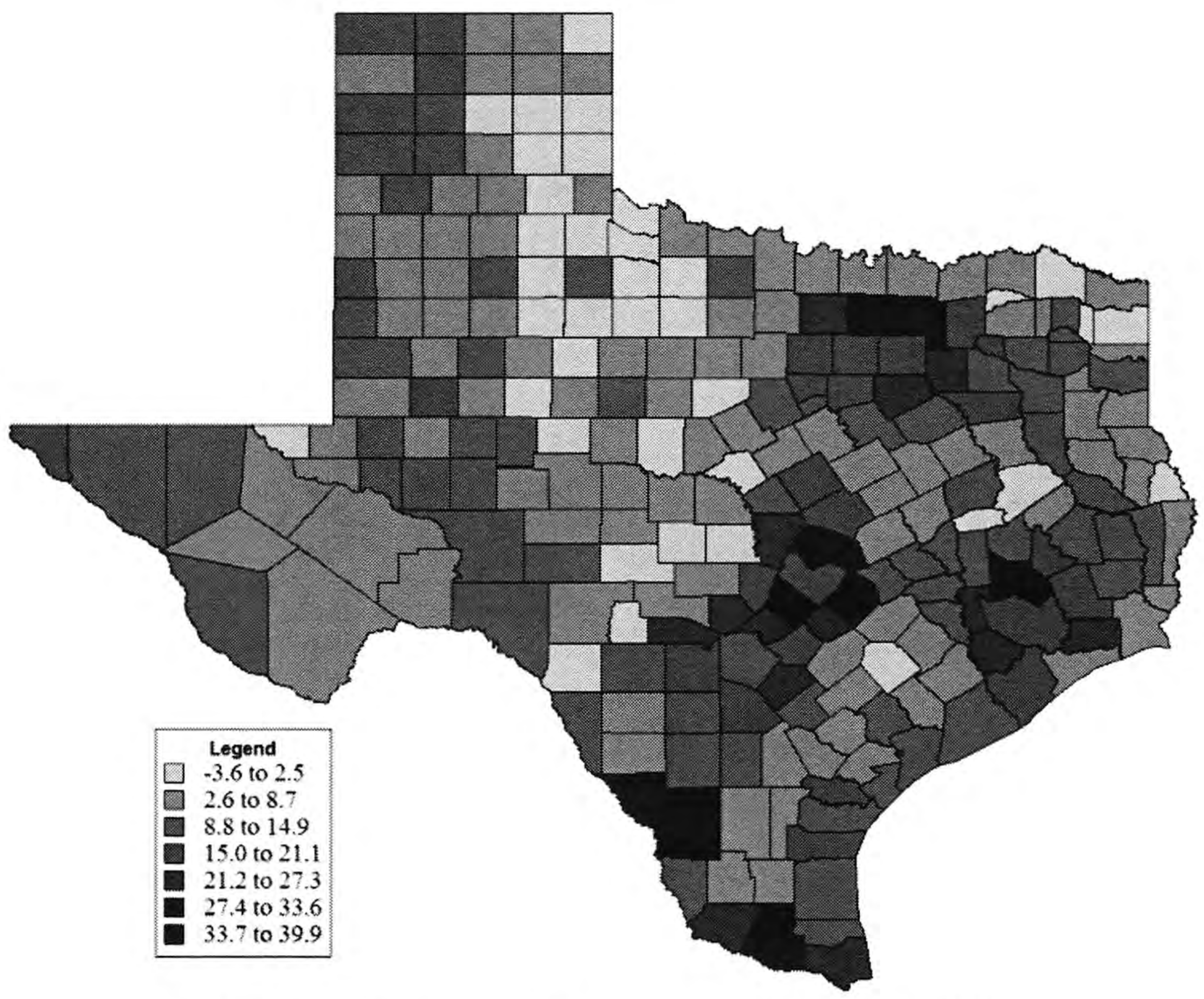


Source: Johnson et al., 2011

Figure 6: The Texas Triangle

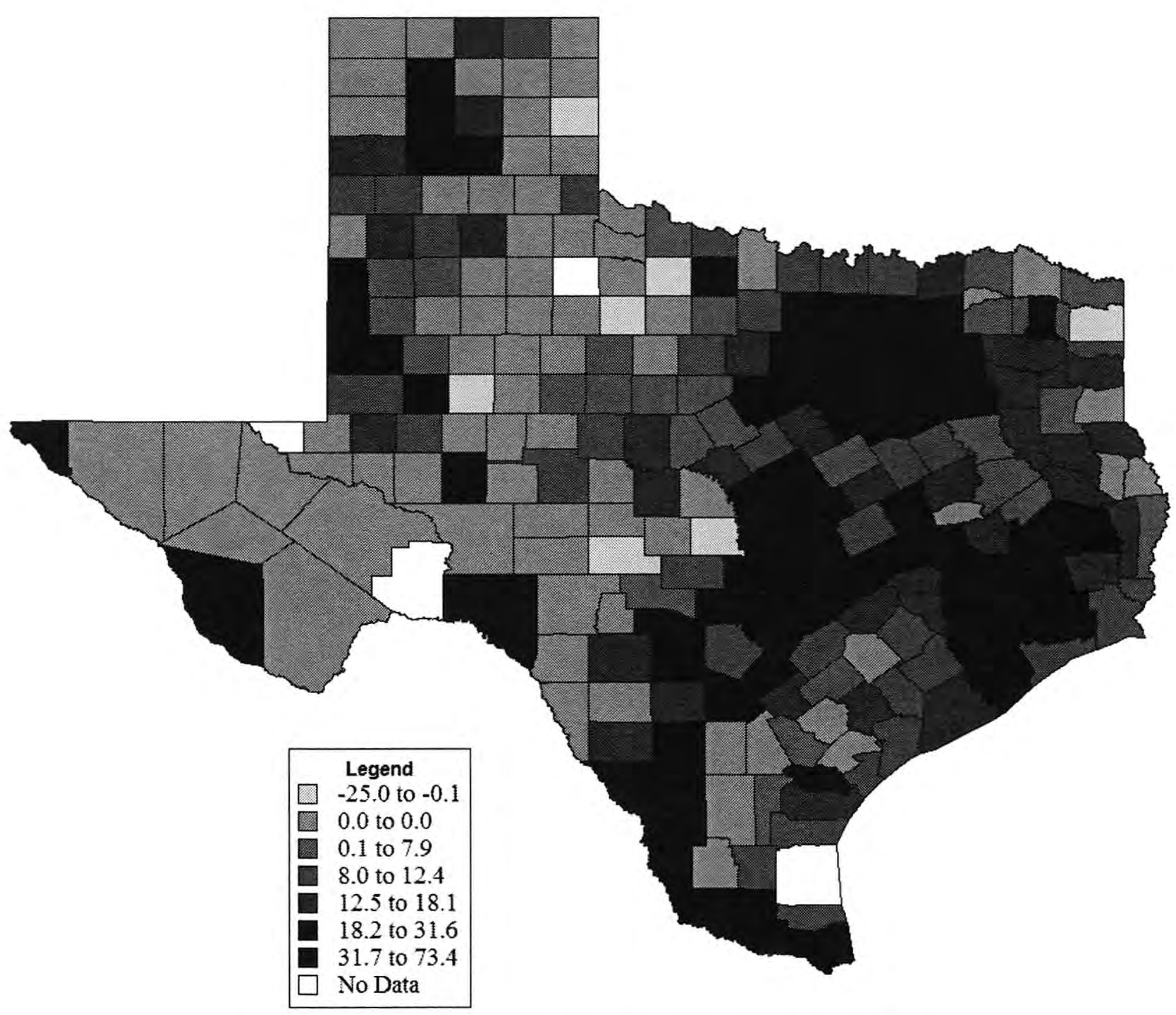
By 2020, the Triangle's total population is projected to rise to 19.7 million or 71% of the total population of Texas. In 2030, the projected total population is 22.3 million or 72% of the total state population. The average population growth of the Triangle counties from 2000 to 2010 was 17%. Population forecasts indicate growth from 2010 to 2020 of 16%, and from 2010 to 2030 of 30% (see Figure 7). Population per land square miles increased on the average of 17% from 2000 to 2010, ranging from -4% (Llano) to 40% (Hays). From 2010 to 2020, population per land square miles is expected to increase on the average by 16%; ranging from -3% (Llano) to 33% (Denton and Williamson). As illustrated in Figure 8, from 2010 to 2030, population per land square miles is expected to increase on the average by 30%, ranging from -6% (Llano) to 73% (Williamson). Denton, Hays, Collin, and Bastrop are projected to have a population increase of 67%, 66%, 64.3% and 64.0% respectively (Texas Comptroller, 2002).

[5] Webb and Hidalgo counties rank fifth and ninth respectively for the whole of Texas.



Source: Data from Texas Comptroller, 2002

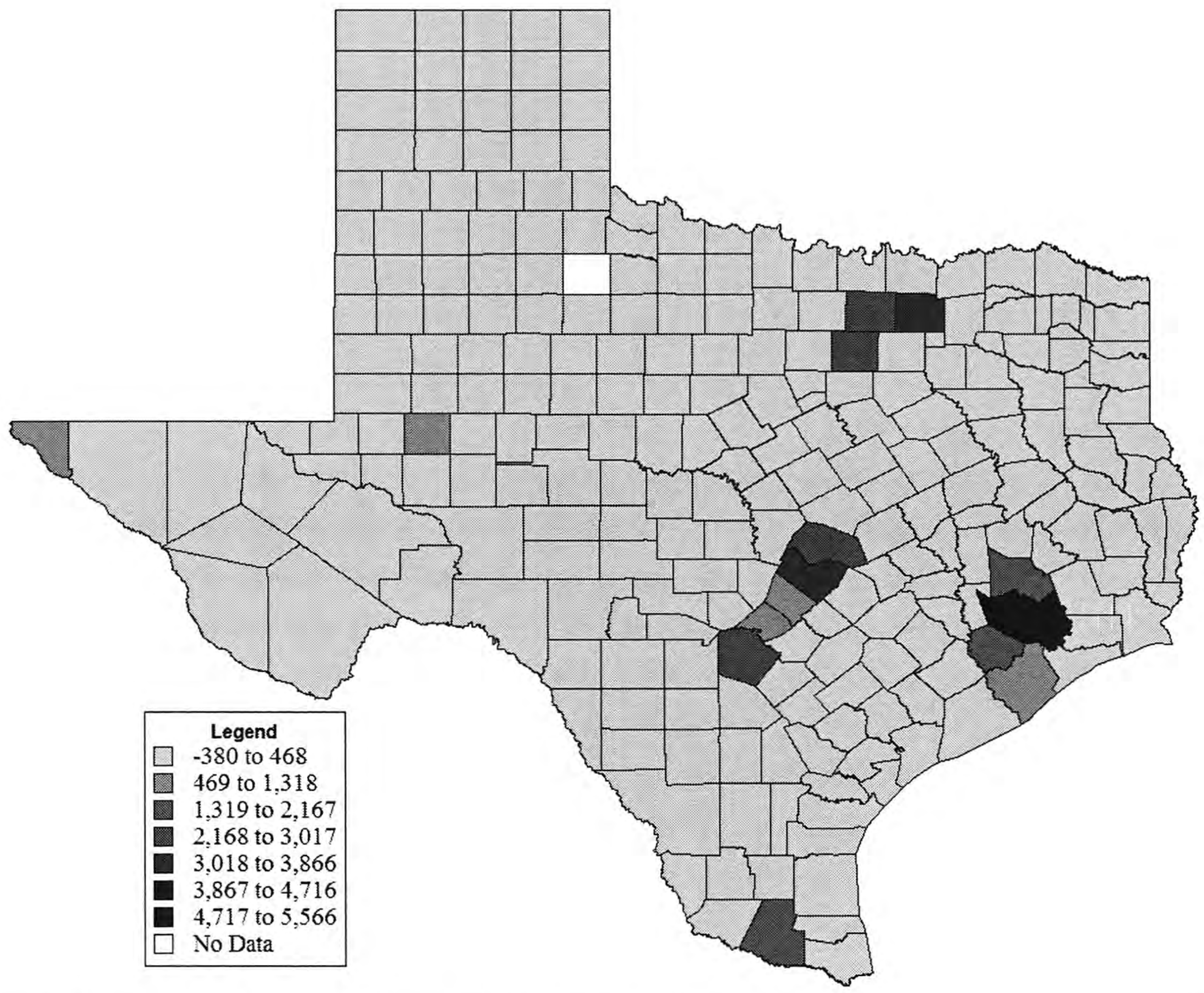
Figure 7: Texas Population Percent Change from 2000 to 2010



Source: Data from Texas Comptroller, 2002

Figure 8: Texas Population per Land Square Mile Percent Change from 2010 to 2030

In addition, the number of business establishments increased dramatically in the Triangle when compared to other parts of Texas. As illustrated in Figure 9, Harris, Collin, and Travis counties established more than 5,500; 3,500; and 3,000 additional businesses from 2003 to 2008, respectively (County Business Patterns, 2008)



Source: Data from U.S. Census Bureau, County Business Patterns, http://www.census.gov/econ/cbp/index.html

Figure 9: Change in Business Establishments from 2003 to 2008

Houston

Houston is the largest city in the Triangle by population and is considered the energy capital of the world with regard to both oil and natural gas. The Houston metropolitan statistical area (MSA), which includes Houston, Sugar Land, and Baytown, recorded a 25.5% population increase from 4715,407 in 2000 to 5,915,715 in 2010 (Texas State Data Center, 2010). The Houston-Sugar Land-Baytown economy is the fourth largest metro economy in the United States by gross metropolitan product (USMayors.org, 2010).

In 2009, the Houston-Sugar Land-Baytown MSA was the fastest growing metropolitan area (2.4%) among economies with real GDP of more than $100 billion (Bureau of Economic Analysis, 2011). According to the Bureau of Labor Statistics, the MSA ranked second nationally in both rate of job growth and number of jobs added in 2010. The Dallas-Fort Worth-Arlington MSA ranked first (Bureau of Labor Statistics, 2011a).

Total nonfarm employment in the Houston-Sugar Land-Baytown MSA stood at 2,559,800 in March 2011, up 51,800 from one year previous (Bureau of Labor Statistics, 2011a). As shown in Figure 10, local nonfarm employment rose 2.1% compared to the national increase of 1.0. The mining and logging sector reported the largest employment gain in the Houston metropolitan area from March 2010 to March 2011 (see Figure 11), up 9.1% (Bureau of Labor Statistics, 2011a). Other sectors that grew during the same time period include the professional and business services sector (4%), education and health services (3.3%), and manufacturing (2.1%). The information sector experienced the sharpest decline of 6.2% followed by the financial activities (-1.4%).

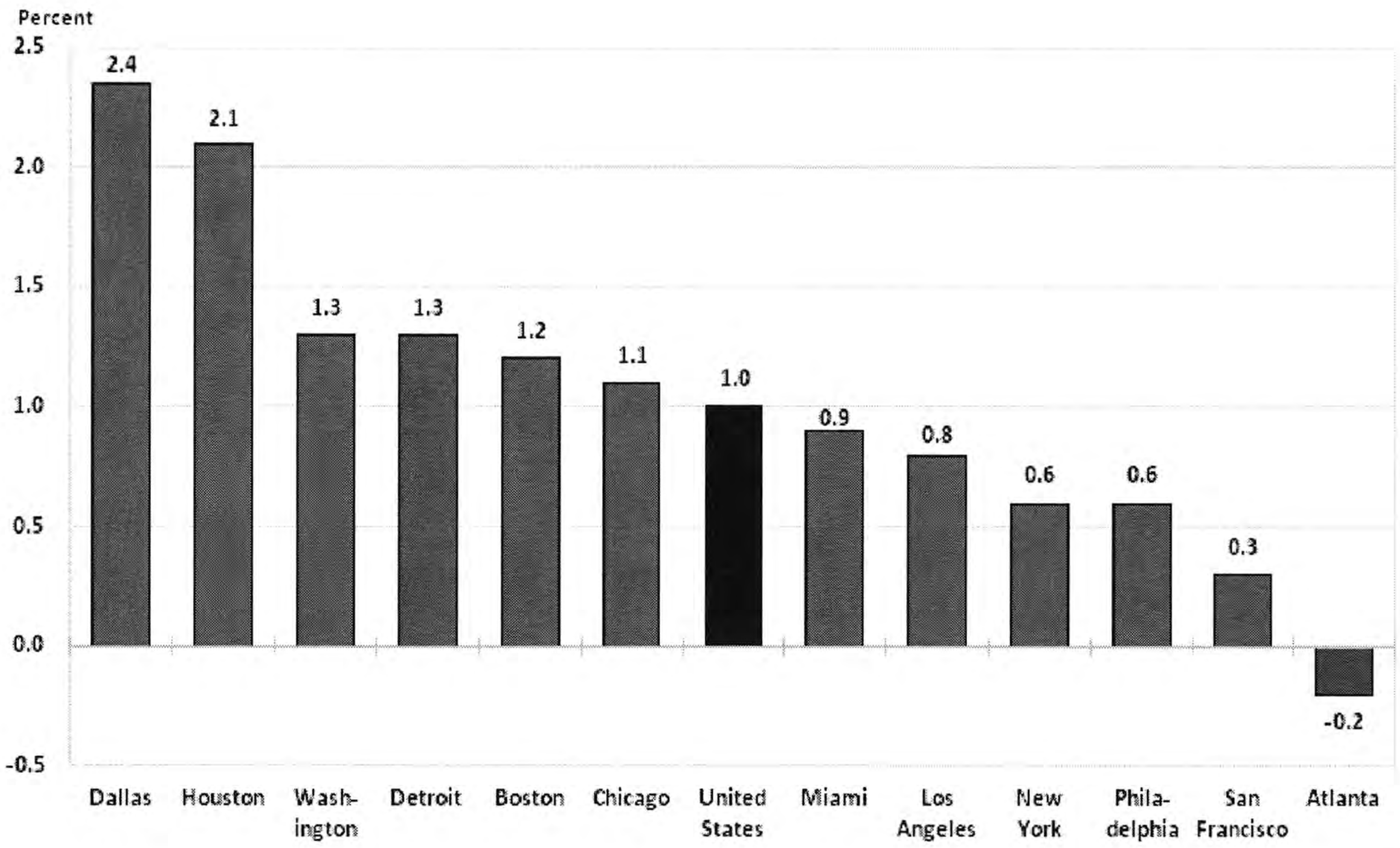
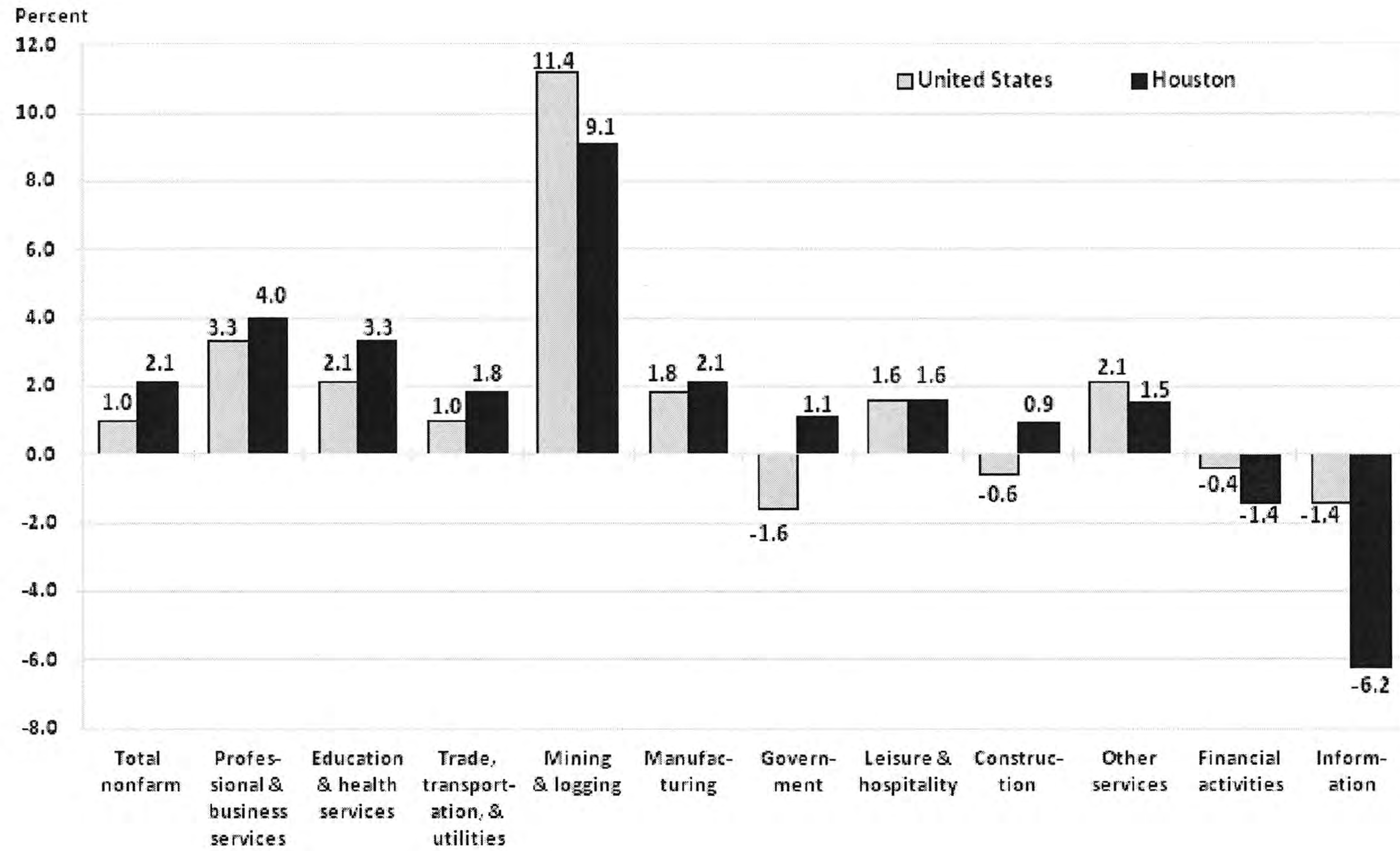


Figure 10: Over-the-year Percent Change in Employment, United States and 12 Largest Metropolitan Areas, March 2011

Houston is home to 22 Fortune 500 companies second largest in the U.S.[6](Fortune 500, 2011). Houston serves as the gateway to the Triangle by sea, and has direct multimodal transportation links to the other three major cities in the Triangle—Austin, San Antonio, and Dallas/Fort Worth.

Nearly one-third of all jobs in oil- and gas-related fields are located in Houston, and each day, the Texas Gulf Coast is capable of producing 3.853 million barrels of refined petroleum products, accounting for 23% of the U.S. daily total (Rice University, 2004). Houston is home to multi-national oil companies ExxonMobil, ConocoPhillips, Shell, Reliant, ChevronTexaco, and 5,000 other energy firms. The area's economy used to be based almost primarily on oil and refining; however, changes over the last few decades have resulted in a much more diversified economy.

[6] As of 2011, New York was home to 45 Fortune 500 companies (Fortune 500, 2011).



Source: Bureau of Labor Statistics, 2011[7]

Figure 11: Total Nonfarm Employment, Over-the-year Percent Change in the United States and the Houston Metropolitan Area, March 2004–March 2011

In addition to its dominance in the energy sector, the petrochemical facility located at the Houston ship channel is the largest in the country and among the largest in the world (Port of Houston, 2009). The Houston area contains more than 400 chemical plants—nearly every major chemical company has a plant in the city—employing more than 35,000 people (Houston Economy, 2009).

Another major industry in the Houston area is the aerospace sector, which hosts facilities like the Johnson Space Center (JSC) of the National Aeronautics and Space Administration (NASA) and the United Space Alliance (USA). USA provides space operations, services, and technologies to its customers—primarily NASA. Other aerospace and defense firms in Houston include Raytheon, Boeing, and Lockheed Martin (Prozzi et al., 2011).

The Texas Medical Center (TMC), located in Houston, accounts for another substantial part of the regional economy. TMC consists of 47 non-profit institutions, which include 13 hospitals, two specialty institutions, two medical schools, four nursing schools, and schools of dentistry, public health, and pharmacy; altogether, this group makes up the largest medical center in the world (Federal Reserve Bank of Dallas, 2001).

Dallas/Fort Worth

The Dallas-Fort Worth-Arlington MSA is the largest of its kind in Texas. From a population of 5,161,544 in 2000, the MSA's population grew by 24.2% to 6,480,858 in 2010 (Texas Data Center, 2010). Dallas/Fort Worth has a principal role as a distribution center in such sectors as

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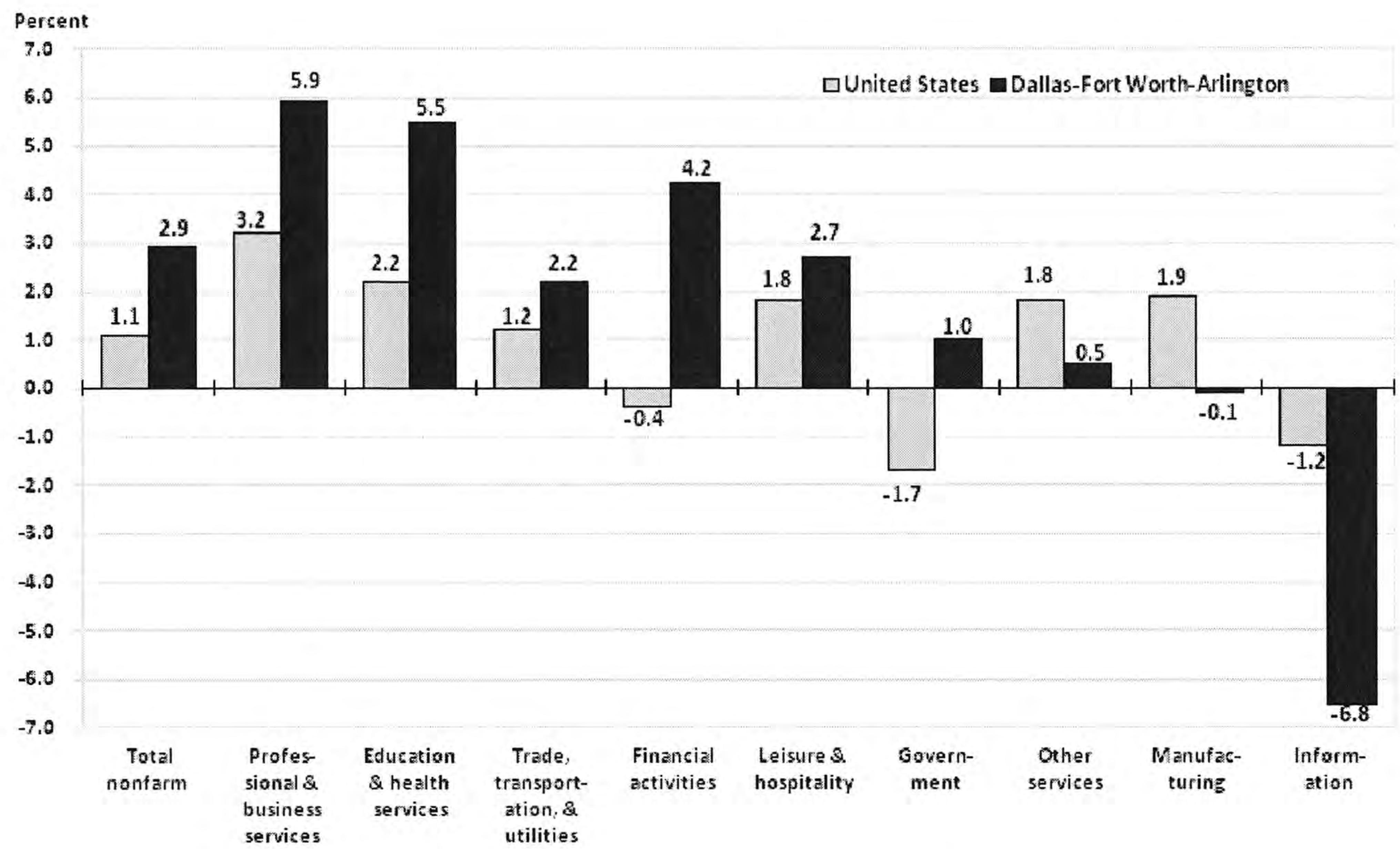
[7] http://bls.gov/ro6/fax/houston_ces.pdf

trucking and warehousing, wholesale trade, aerospace, transportation services, healthcare, finance, and education (Butler et al., 2009).

The economic output of the Dallas-Fort Worth-Arlington MSA was $356,615 million in 2009, based on current dollars (Bureau of Economic Analysis, 2011). The Dallas-Fort Worth-Arlington economy is the sixth largest metro economy in the United States. Financial activities led all sectors. Financial activities contributed $74,585 million in 2009—19.6% of the total economic output of Dallas-Fort Worth-Arlington. Other major sectors in the MSA's economy are trade, $45,125 million, and professional and business services, $44,996 million. In 2008, manufacturing was the largest among all industries in the Dallas-Fort Worth-Arlington economy; contributing $46,072 million or 12.8%. Other major industries include real estate, $43,390 million, finance and insurance, $29,365 million, and wholesale trade, $27,624 million (Bureau of Economic Analysis, 2011; EconPost, 2010). In 2008, the economy of Dallas-Fort Worth-Arlington posted a real GDP growth rate of 1.5%. Economic growth in nominal terms from 2007 to 2008 was 4.9%, while in real terms the growth was 1.5%. During the years of 2001–2008, the Dallas-Fort Worth-Arlington GDP grew at an annual rate of 5.9% in nominal terms and in real terms the economy grew by 3.1% (EconPost, 2010).

Total nonfarm employment in the Dallas-Fort Worth-Arlington MSA stood at 2,929,700 in April 2011, up 83,100 during the year (Bureau of Labor Statistics, 2011b). During the previous 12 months, nonfarm employment rose 2.9% in the local area compared to 1.1% nationwide. Of the 12 largest metropolitan areas in the country, Dallas-Fort Worth-Arlington ranked first in both the rate of job growth and the number of jobs added during the past year (Bureau of Labor Statistics, 2011b). The Dallas-Fort Worth-Arlington MSA is composed of two metropolitan divisions—separately identifiable employment centers within the larger metropolitan area. The Dallas-Plano-Irving Metropolitan Division accounted for 71% of the area's workforce, but 76% of its job growth, as employment rose by 62,900, or 3.1%, from April 2010. The Fort Worth-Arlington Metropolitan Division added 20,200 jobs during the 12-month period, a 2.4% increase.



Source: Bureau of Labor Statistics, 2011b

Figure 12: Over-the-year Percent Change in Employment by Industry Supersector, United States and the Dallas-Fort Worth-Arlington Metropolitan Area, April 2011

The largest job growth from April 2010 to April 2011 was in the professional and business services supersector (24,700 jobs) and the education and health services supersector (19,600 jobs)—the largest 12-month gain since the inception of the series in January 1990 (Bureau of Labor Statistics, 2011b). Job growth in this industry was strong in the two metropolitan divisions as Fort Worth-Arlington registered a 6.4% increase and Dallas-Plano-Irving, a 5.2% increase, both more than twice the national rate of 2.2% (Bureau of Labor Statistics, 2011b). The metropolitan's largest supersector—trade, transportation, and utilities—added 12,600 jobs over the year, an increase of 2.2%. Nationwide, employment in this industry advanced 1.2% (Bureau of Labor Statistics, 2011b). The local mining, logging, and construction supersector gained 10,300 jobs over the year, increasing at a rate of 6.6% (Bureau of Labor Statistics, 2011b).

Other local supersectors recording employment advances from April a year ago were financial activities (9,600), leisure and hospitality (7,500), and government (4,000). The nation also experienced job gains in leisure and hospitality, but declines in the financial activities and government supersectors over the 12-month period. The largest over-the-year job loss in the Dallas-Fort Worth-Arlington metropolitan area was registered in the information supersector. Employment fell 5,400 from the previous April, a decline of 6.8% (Bureau of Labor Statistics, 2011b).

Twenty Fortune 500 companies are headquartered in Dallas/Fort Worth, the third largest host city in the U.S. These include Exxon-Mobil Corporation, AT&T, AMR, Fluor, Kimberly-Clark, J.C. Penney, Texas Instruments, Dean Foods, and Southwest Airlines (Dallas Chamber of Commerce, 2010; Fortune 500, 2011). Top employers in the area include Wal-Mart Stores, AMR, Bank of America, Baylor Health Care System, Texas Health Resources, AT&T, Carlson Restaurants Worldwide, and Lockheed Martin Aeronautics. Important freight stakeholders in the region include the Alliance Global Logistics Hub, a 17,000-acre facility that offers strategic multi-modal transportation access. This includes the BNSF Alliance Intermodal Facility, two Class I rail lines (BNSF and UP), Fort Worth Alliance Airport (a 100% industrial cargo facility), IH 35W from Mexico to Canada, Texas Highways 114 and 170, and the FedEx Southwest Regional Sort Hub (Alliance Texas, 2010). General Electric (GE) Transportation also plans on opening a new locomotive plant in the Fort Worth area. GE Transportation is the world's leading maker of rail and transportation products. According to Congressman Michael C. Burgess, the manufacturing "plant will produce rail and transportation-related equipment, including locomotives, and will include a financial investment of GE of up to $96 million ... [and] create more than 500 jobs by 2012" (GE Transportation, 2011). The facility also includes a range of subdivisions providing housing and services to those employed at the site.

Austin

The Austin-Round Rock-San Marcos MSA is the fastest growing MSA (by population) in Texas. Two counties in this MSA, Williamson and Hays, recorded a population growth of more than 60% from 2000 to 2010 (Texas State Data Center, 2010). The MSA's population grew from 1,249,763 in 2000 to 1,712,461 in 2010, a 37% increase (Texas State Data Center, 2010).

The Austin-Round Rock MSA's economy was the 35th largest metro economy in the United States in 2009 (USMayors.org, 2010). It recorded a GDP of $78,426 million in 2009, a decrease of 1.25% compared to 2008. Top industries in the MSA in 2008 include manufacturing (14% of GDP), real estate, rental, and leasing (10% of GDP), wholesale trade (9%), and information and retail trade (6%). Companies such as Dell, National Instruments, and IBM, among others, are either headquartered in Austin, or have an office there. By sector, trade and financial activities accounted for 15% of GDP followed by information, communication and technology (14% of GDP), and education and health services (6% of GDP). Other sections include transportation and utilities (2%) and leisure and hospitality (4%).

Top employers in the MSA include the Austin School District, City of Austin, Dell, IBM, Seton Healthcare Network, St. David's Healthcare Partnership, the State of Texas, and the University of Texas at Austin (SOCRATES, 2011).

Other major cities and economic generators close to Austin and within the Texas Triangle are Waco and Temple to the north and Bastrop to the southwest.

San Antonio

The San Antonio-New Braunfels MSA economy is the 34th largest metro economy in the United States (USMayors.org, 2010). The MSA's population grew from 1,711,703 in 2000 to 2,090,692 in January 2010, a 22.1% change (Texas State Data Center, 2010). According to the San Antonio-Bexar County Metropolitan Planning Organization, San Antonio provides a strategic location for distribution, transshipment, and international trade processing activities, and has key logistical assets that support the delivery of products to both domestic and international customers (San Antonio MPO, 2010). It is well known for its manufacturing, trade, and transportation services, with a rapidly growing biomedical and biotechnology sector, and a diversified manufacturing sector, producing everything from aircraft and semiconductors to rolled aluminum sheet.

The City of San Antonio (2007 city population 1,328,984; 2008 metropolitan population 2,031,445) is located in south central Texas. San Antonio's strength is still in the federal and military sectors along with a large tourist industry.

It has a strong military presence made up of Fort Sam Houston, Lackland Air Force Base, Randolph Air Force Base, and Brooks City-Base, with Camp Bullis and Camp Stanley outside the city. San Antonio is also home to five Fortune 500 companies—Valero Energy Corporation, Tesoro Petroleum, USAA, Clear Channel Communications, and NuStar Energy (CNN Money, 2010). Toyota also has a truck manufacturing plant in the area. The South Texas Medical Center, a conglomerate of various hospitals, clinics, and research units, is the only medical research and care provider in the South IH 35 corridor region. As of 2008, San Antonio's largest private employers included USAA, a worldwide insurance and diversified financial services association; and H-E-B Grocery Company, the largest private grocery company with stores in Texas and Mexico, and the 19th largest private company in the United States (Forbes.com, 2009).

Other companies with a major presence in San Antonio include Frost National Bank, Texas Southwest Research Institute, and Boeing San Antonio (InformationSanAntonio.com, 2010), Kinetic Concepts, Harte-Hanks, Eye Care Centers of America, Bill Miller Bar-B-Q Enterprises, Taco Cabana, Whataburger, Builders Square, and Rackspace, as well as the aforementioned Tesoro and Valero.

San Antonio also boasts of a strong tourism industry with over 20 million visitors in 2008 and an annual economic impact of over $11 billion (San Antonio Area Tourism Council, 2008).

Summary

These vibrant economic metropolitan cities clearly comprise a formidable economic and social engine for the state. Recent headlines have featured the successful creation of new jobs and much of that growth has occurred within the Triangle. This growth has come over time, starting in the mid-1980s. Mexico joined the General Agreement on Tariffs and Trade (GATT)—now the World Trade Organization (WTO)—in 1986 and immediately began lowering a range of tariffs which stimulated U.S.–Mexico trade. This trade increase ultimately led to the signing of the North American Free Trade Association (NAFTA) in 1992 from which Texas has benefitted significantly because it contains critical transportation corridors for both highways and rail. At least seven NAFTA corridors are used by trucking companies in Texas but the most important is I-35, which links Laredo with Kansas City while picking up I-10 at San Antonio and I-20 at Dallas. The Triangle is defined economically by I-35 and I-45 and the parallel Union Pacific (UP) and BNSF rail networks. Finally, it is worth noting that High Speed Rail (HSR) is being currently touted politically and studied by planners, some in the context of megaregional planning. Texas had an HSR planning organization in place in 1987 with legislative support to link first Houston with DFW and then DFW with San Antonio. A French system was chosen and the Triangle offered the perfect city distances to run HSR efficiently. However, the project could not be fully funded privately and was finally abandoned in the early 1990s[8].

Freight flows in the Triangle play a key role in encouraging planners to adopt a system-wide approach to transportation both within and between MPOs; freight flows thus represent another reason to support megaregional planning. The next chapter examines these flows in more detail.

[8] It must be added that Southwest Airlines played a critical role in convincing legislators to not support subsidies. At the time, the airline offered 17 flights a day from Dallas to Houston so its opposition was expected.

Chapter 4. Freight Patterns in the Texas Triangle

The Triangle is served by roadways and rail networks that facilitate the movement of goods between the major cities. Also, the presence of a strong air freight industry and intermodal yards and warehouses in each of the cities provides an effective environment for the freight industry, though key problems—rail movement through Houston for example—have emerged. In addition, Houston provides the Triangle with a seaborne connection to the rest of the world, and San Antonio has a direct roadway connection to the U.S./Mexico border city of Laredo.

In the 2007 commodity flow survey, the major cities in the Texas Triangle region—Dallas/Fort Worth, Houston, Austin, and San Antonio—accounted for nearly 60% of goods movement by tonnage and 68% by value in Texas (see Figure 13a and 13b). These include commodities moved within, from and to Texas. For imports and exports, the Triangle cities accounted for 78% of commodities moved by value (see Figures 13c).

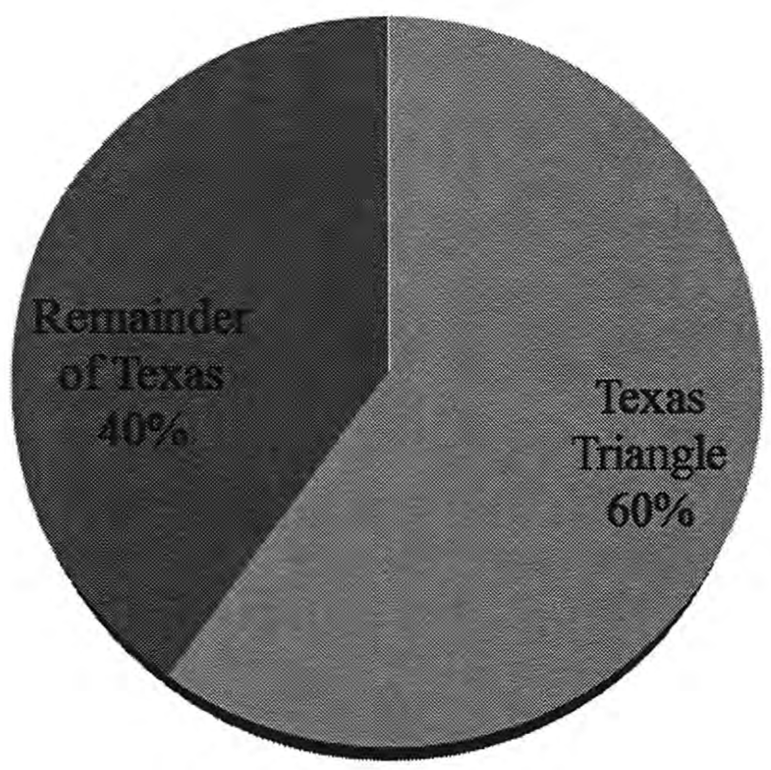


Figure 13a: 2007 Texas Domestic Flows by Tonnage

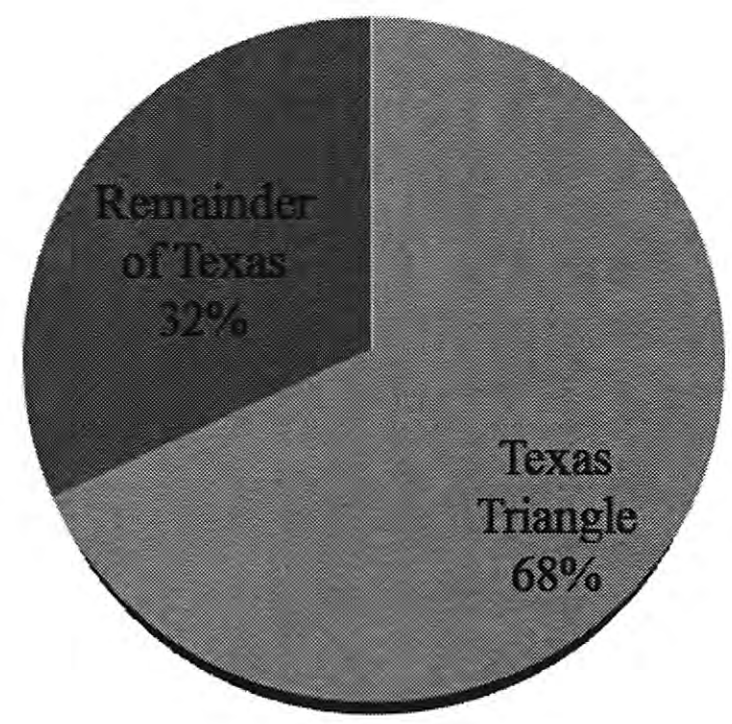


Figure 13b: 2007 Texas Domestic Flows by Value

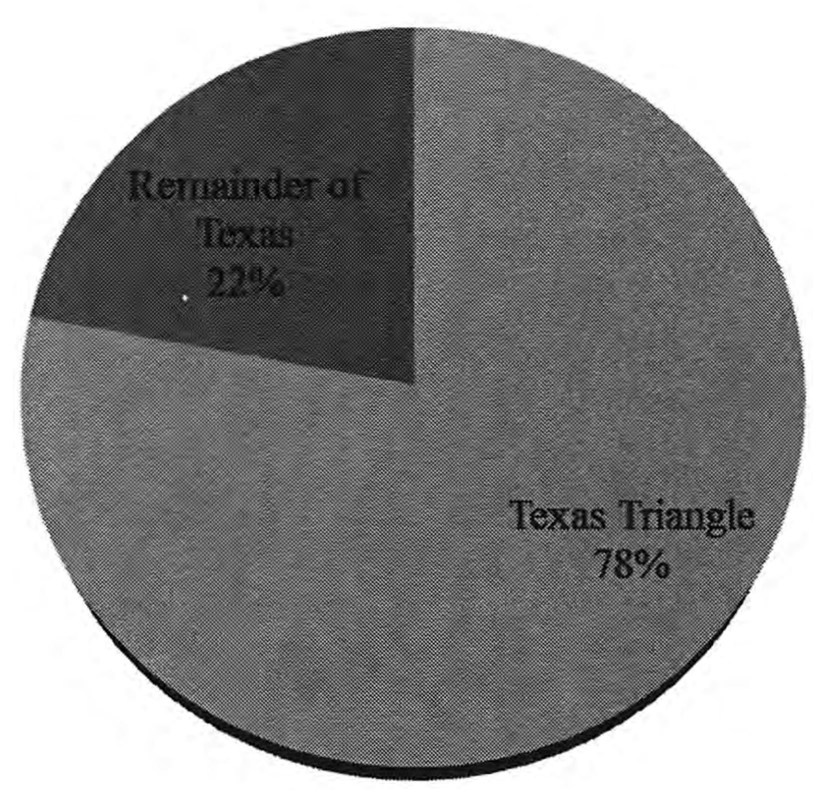
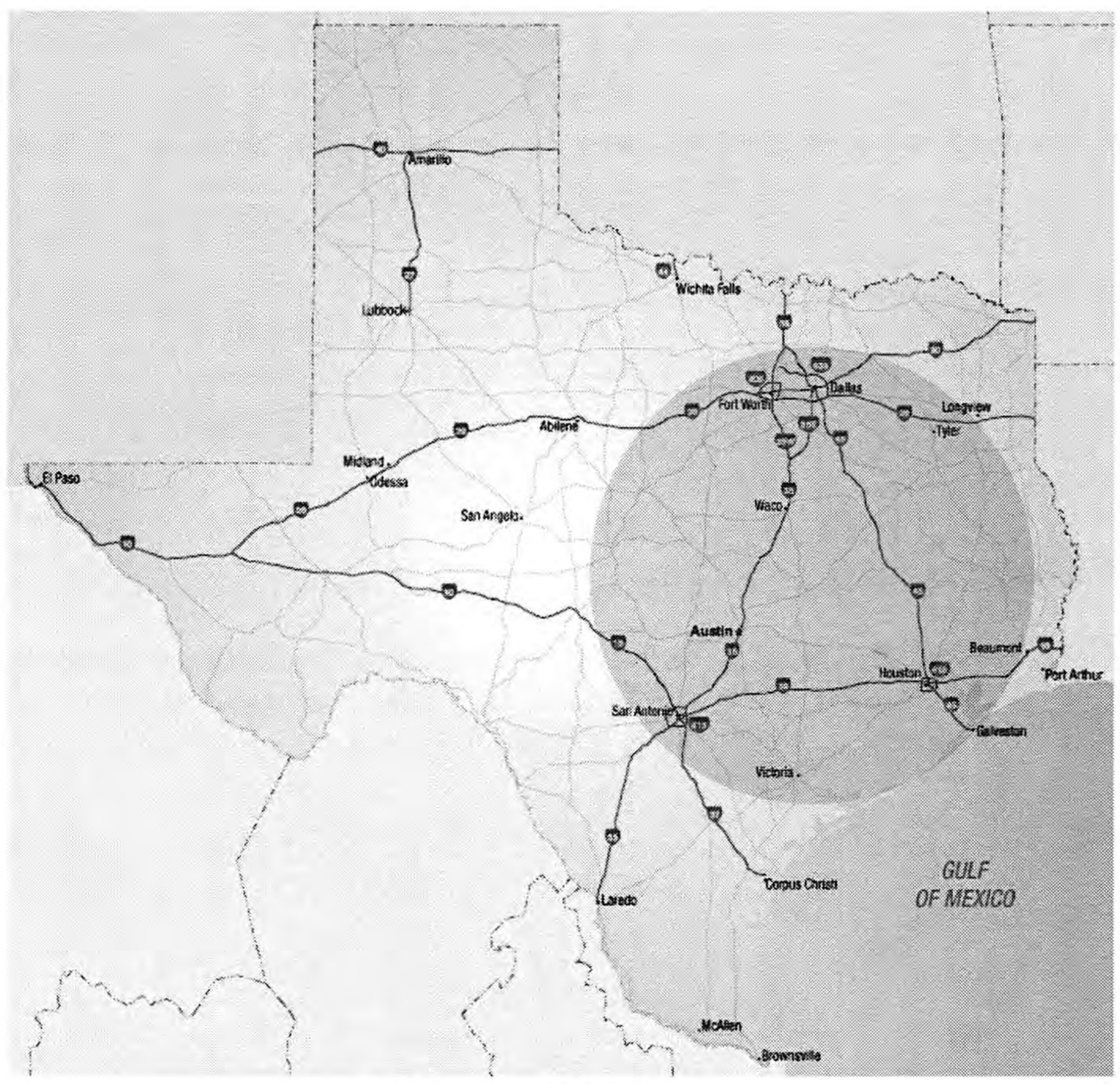


Figure 13c: 2007 Texas Imports and Exports

The Triangle's Road Network

Texas has 3,233 miles of interstate highways, more than any other state in the nation (TTI, 2005). The largest cities in Texas are interconnected by the interstate system (see Figure 14). Except for El Paso, the remaining cities fall within approximately 150 mile radius from their centroid. These cities, Dallas -Fort Worth, Austin, Houston and San Antonio are connected by three major highways: Interstate Highway 35 (IH-35), IH-10 and IH-45. Interstate 35 (IH-35) is a north–south stretches from Laredo, Texas, on the U.S.-Mexico border to Duluth, Minnesota, at Minnesota Highway 61. It connects San Antonio, Austin and Dallas, and serves as a very important trade corridor between the U.S. and Mexico. IH-10 stretches west from Houston to San Antonio and further to Los Angeles, California. To the east, it stretches east to Beaumont, and further to Jacksonville, Florida. Majority of the land transportation mode along this corridor is by trucks (Villa et al., 2008). IH-45 connects the Galveston, Houston, and Dallas metropolitan regions and is 285 miles long. A large amount of the traffic along IH-45 is intercity traffic, with vehicles traveling to and from these three cities. Average speeds and reliability are quite volatile along this highway; nonetheless, the average speed along the entire length of IH 45 during 2005 was 54 mph (Freight Performance Management, 2006). Table 1 summarizes the approximate road distance between these major cities.



Source: TTI, 2005

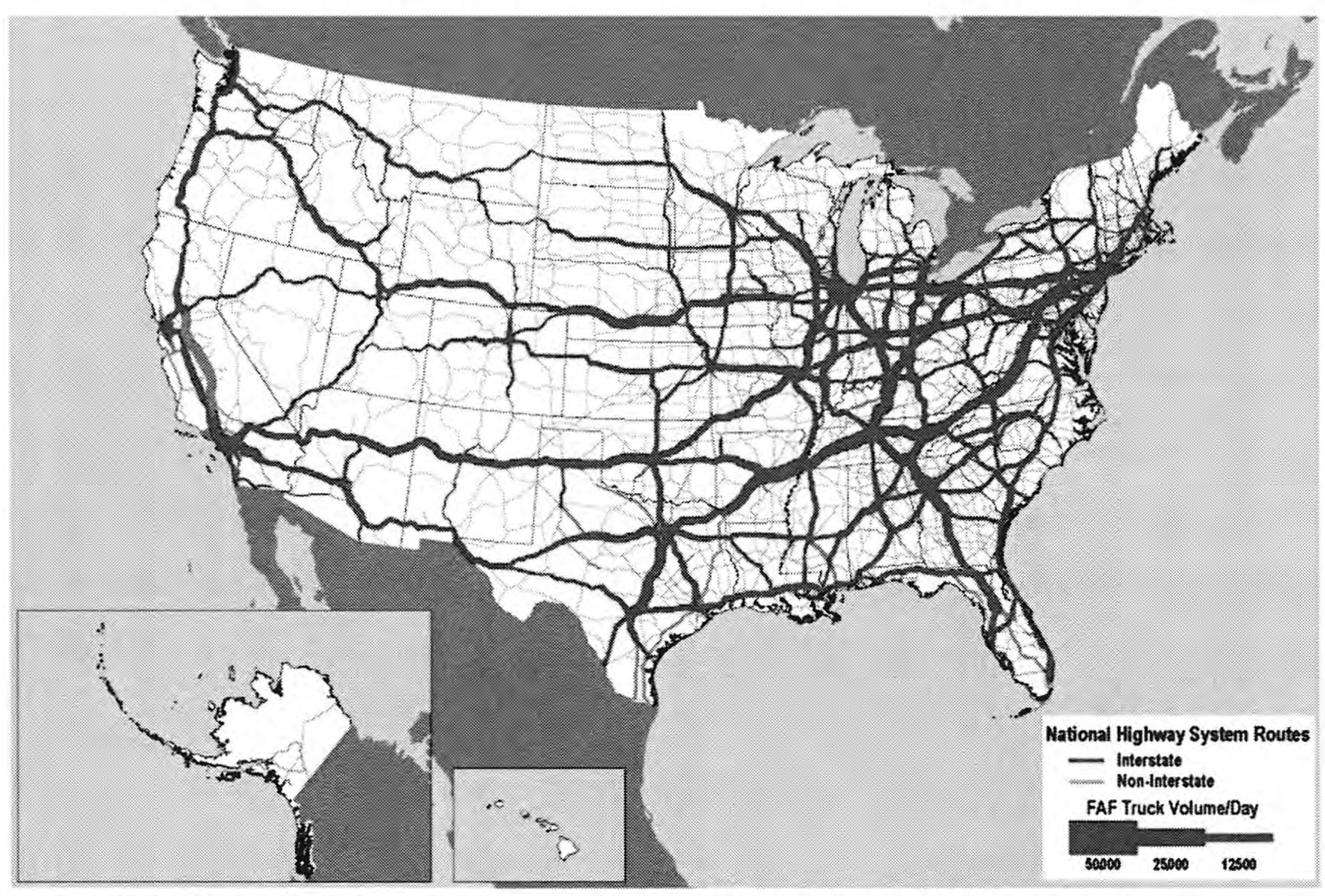
Figure 14: Texas's Interstate System

Table 1: Approximate Travel Distances between the Triangle's Major Cities.

From/ To	Austin	Dallas/Fort Worth	Houston	San Antonio
Austin	-	200 mi.	165 mi.	80 mi.
Dallas/Fort Worth	200 mi.	-	240 mi	275 mi
Houston	165 mi.	240 mi	-	200 mi.
San Antonio	80 mi.	275 mi	200 mi.	-

In 2007, average daily long-haul truck traffic on the National Highway System (NHS) through the Triangle was between 12,000 to 25,000 movements a day (see Figure 15). The IH-35 Corridor between San Antonio and Dallas accounted for the highest truck volumes in Texas. This figure is expected to double to between 25,000 and 40,000 movements a day by 2040 (see Figure 16). The San Antonio–Houston IH-10 corridor and the Dallas/Fort Worth–Houston corridor are all expected to have significant increases in truck traffic in 2040 as well[9].

Average Daily Long-Haul Freight Truck Traffic on the National Highway System: 2007



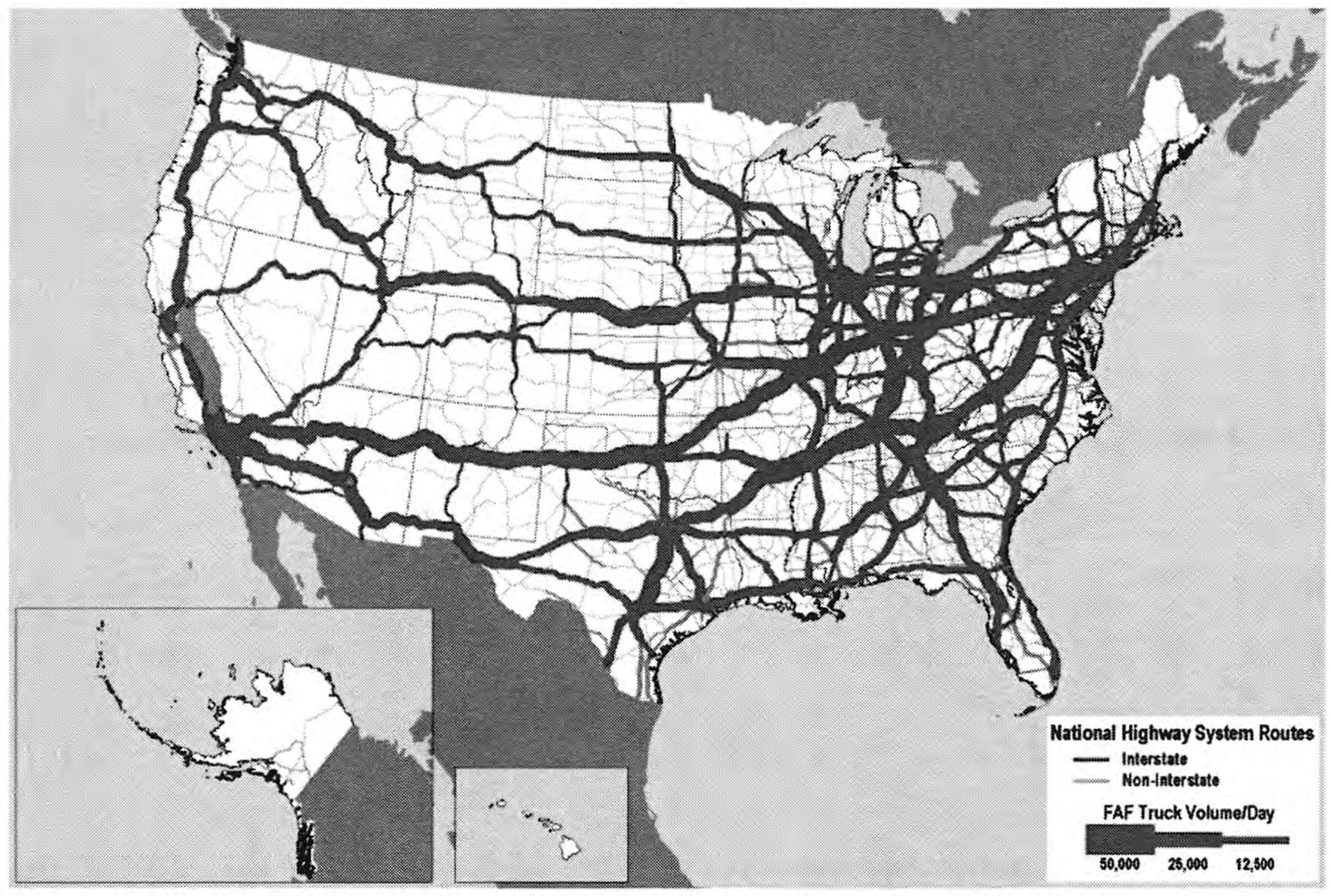
Note: Long-haul freight trucks typically serve locations at least 50 miles apart, excluding trucks that are used in movements by multiple modes and mail.
Source: U.S. Department of Transportation, Federal Highway Administration, Office of Freight Management and Operations, Freight Analysis Framework, version 3.1, 2010.

Figure 15: Average Daily Long-Haul Truck Traffic on the National Highways System, 2007[10]

[9] These forecasts are based on the federal government not allowing larger, more productive trucks to operate on the Interstate Highway system.

[10] Long-haul freight trucks typically serve locations at least 50 miles apart, excluding trucks that are used in movement by multiple modes and mail. Source: U.S. Department of Transportation, Federal Highway Administration, Office of Freight Management and Operations, Freight Analysis Framework, version 3.1 2010.

Average Daily Long-Haul Freight Truck Traffic on the National Highway System: 2040



Note: Long-haul freight trucks typically serve locations at least 50 miles apart, excluding trucks that are used in movements by multiple modes and mail.
Source: U.S. Department of Transportation, Federal Highway Administration, Office of Freight Management and Operations, Freight Analysis Framework, version 3.1, 2010.

Figure 16: Average Daily Long-Haul Truck Traffic on the National Highway System, 2040[11]

As shown in Figure 17a, IH45, IH-35 and IH-10 experienced an average annual daily truck traffic (AADTT) greater or equal to 8,500 in 2007 and an AADTT to AADT[12] ratio of 0.25 (i.e., truck traffic accounted for more than 25% of overall traffic). This trend is expected to continue into 2040 (see Figure 17b), thus resulting in similar volumes along other highways such as IH-20 and IH-30.

[11] Long-haul freight trucks typically serve locations at least 50 miles apart, excluding trucks that are used in movement by multiple modes and mail.
[12] AADT – Average Annual Truck Traffic

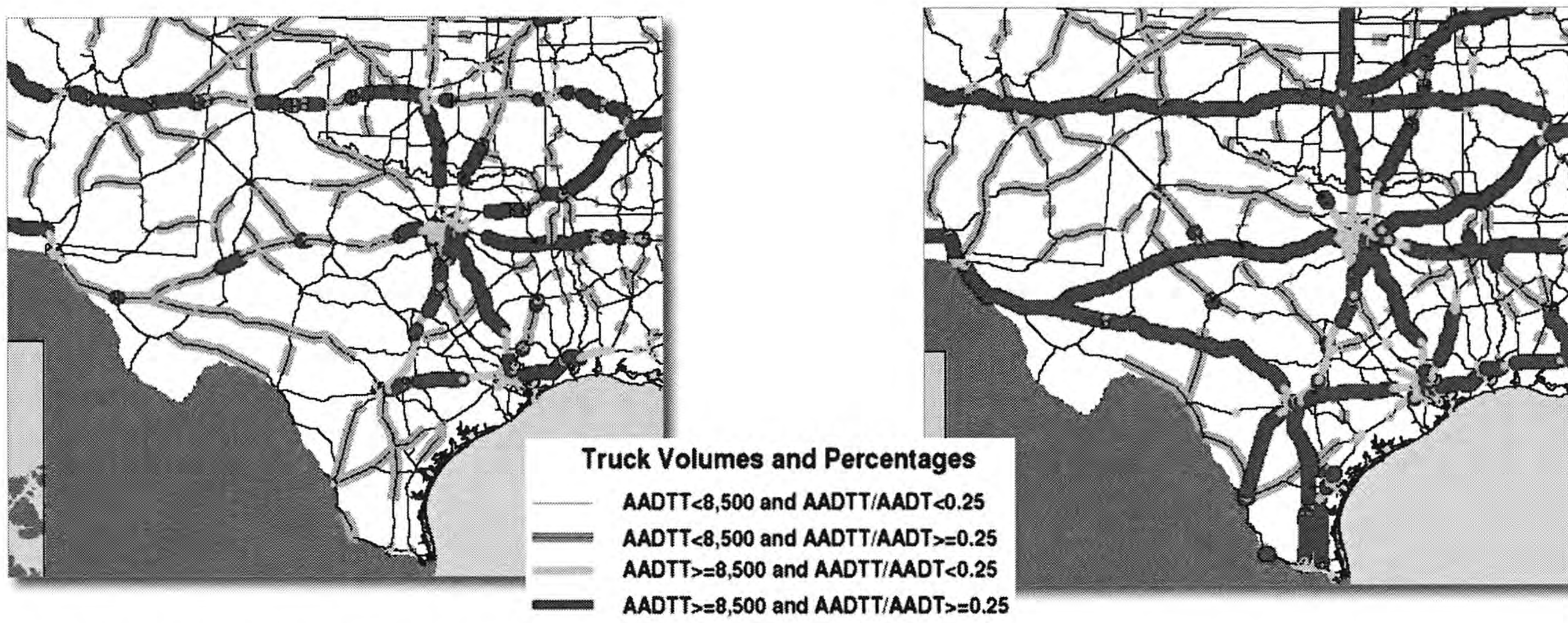


Figure 17a: 2007 Major Truck Routes on the National Highway System

Figure 17b: 2040 Major Truck Routes on the National Highway System

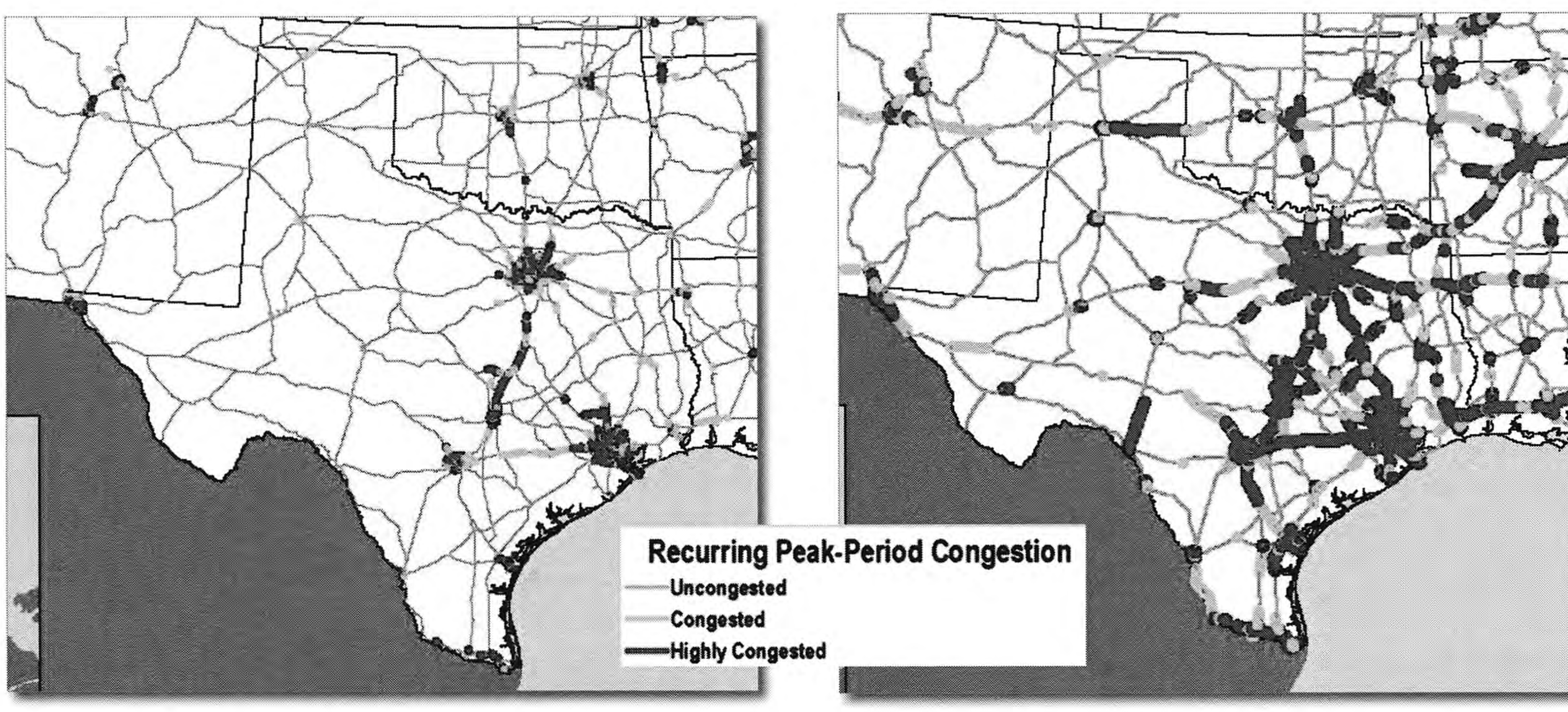


Figure 17c: 2007 Peak-Period Congestion on the National Highway System

Figure 17d: 2040 Peak-Period Congestion on the National Highway System

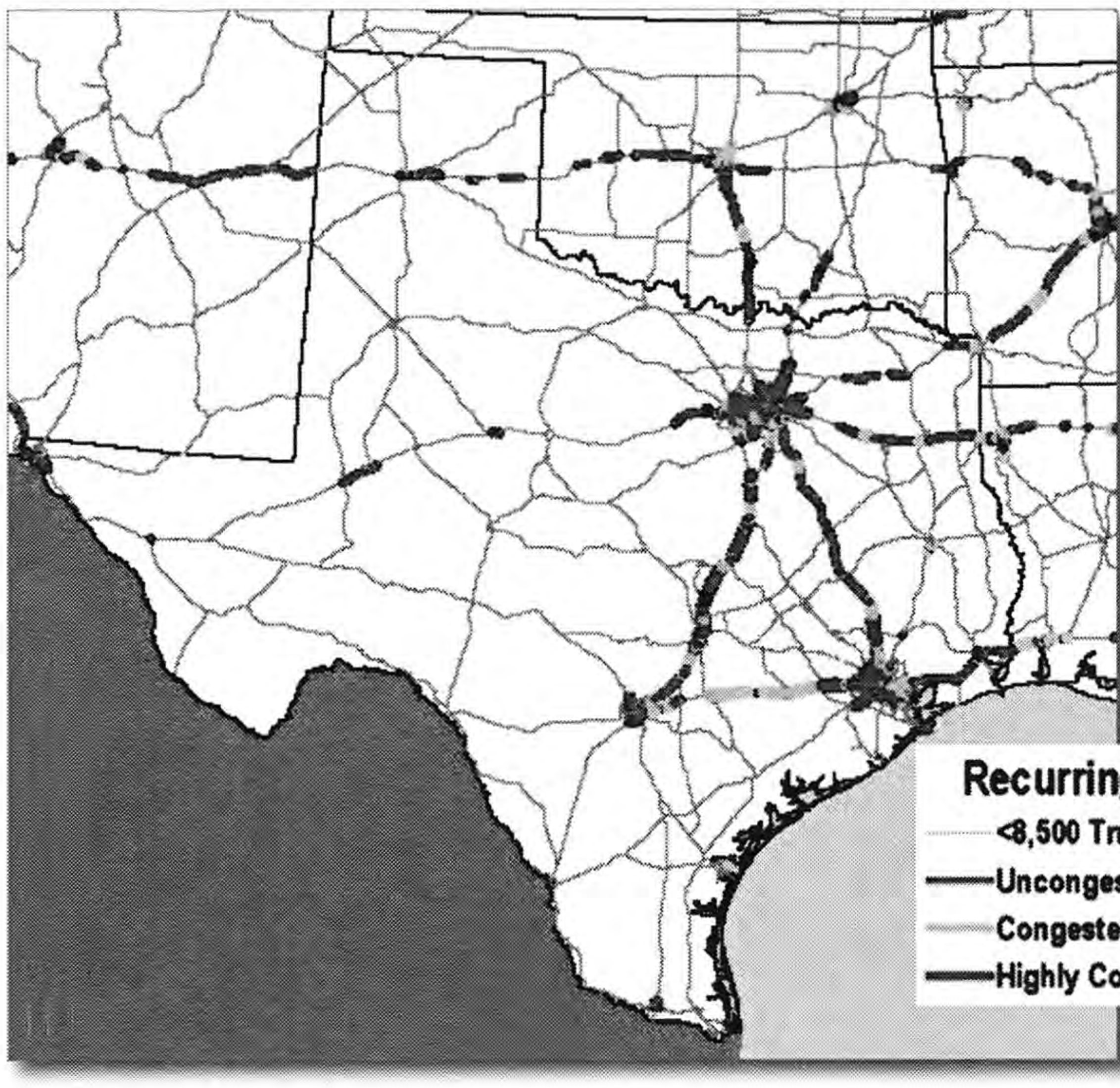


Figure 17e: 2007 Peak-Period Congestion on High-Volume Truck Portions of the National Highway System

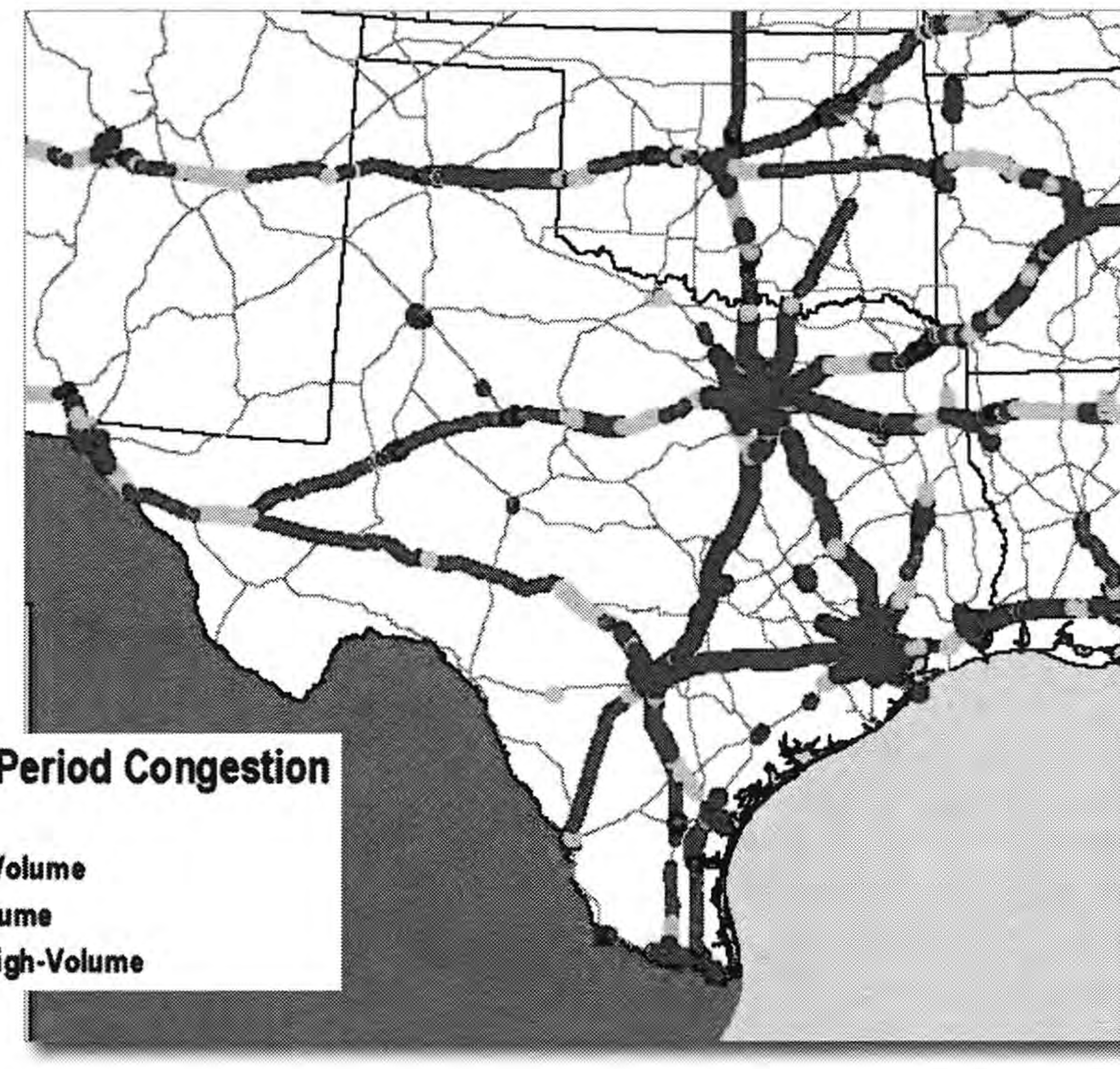


Figure 17f: 2040 Peak-Period Congestion on High-Volume Truck Portions of the National Highway System

As illustrated in Figures 17c to 17f, peak period congestion on all the national highway system entering or exiting the major cities of Dallas, Houston, and Austin experienced highly congested traffic conditions in 2007, and this is expected to spread further unto the system interconnecting these cities by 2040. With truck traffic being a large percentage of movements on these corridors, these highly congested conditions are expected to negatively impact intercity truck freight movements in the Triangle.

For only truck movements, the Texas Triangle accounted for 51.20% of commodities by weight and 53.02% of commodities by value. This number is expected to increase by 54.08% and 55.25% by weight and value respectively in 2040 (see Table 2). In 2007, a large portion of the movements were intracity truck movement: e.g., Houston to Houston deliveries (20.2% weight, 21.30% value) and Dallas/Fort Worth (DFW) to DFW deliveries (15.30% weight, 17.33% value). Top commodities moved (by weight) within Houston in 2007 include nonmetallic mineral products, gravel, natural sands, waste/scrap and mixed freight. By 2040, the trend is expected to similar to that of 2007 except that gravel drops from the top list, and gasoline is ranked number five on the list. By value, top commodities moved in Houston in 2007 included machinery, articles-base metal, and motorized vehicles. By 2040, the top five commodities expected to be moved within Houston include machinery, mixed freight, articles-base metal and motorized vehicles (FHWA, 2010). Similar commodity trends for truck movements were also reported in DFW, Austin, and San Antonio except for the inclusion of a few commodities in the top five lists such as precision instruments, other foodstuffs, fuel oils, and pharmaceuticals.

Table 2: Texas Triangle Truck Flows including Domestic, Import, and Export Flows[13]

Source: FHWA, 2010

Origin	Destination	2007				2040			
		Tonnage (KT)	*% of Texas*	Value (Million $)	*% of Texas*	Tonnage (KT)	*% of Texas*	Value (Million $)	*% of Texas*
Dallas-Fort Worth	Austin	1,967	0.20%	$ 2,583	0.36%	3,568	0.23%	$ 5,769	0.37%
Austin	Dallas-Fort Worth	1,583	0.16%	$ 1,729	0.24%	2,333	0.15%	$ 1,720	0.11%
	Total	3,549	0.36%	$ 4,312	0.59%	5,900	0.38%	$ 7,490	0.48%
Dallas-Fort Worth	San Antonio	3,197	0.33%	$ 4,813	0.66%	6,002	0.39%	$ 10,437	0.68%
San Antonio	Dallas-Fort Worth	2,013	0.21%	$ 2,374	0.33%	3,171	0.21%	$ 7,683	0.50%
	Total	5,210	0.53%	$ 7,187	0.99%	9,173	0.59%	$ 18,119	1.17%
Dallas-Fort Worth	Houston	11,567	1.18%	$ 13,192	1.82%	25,156	1.63%	$ 39,538	2.56%
Houston	Dallas-Fort Worth	9,351	0.96%	$ 15,321	2.11%	14,725	0.95%	$ 29,609	1.92%
	Total	20,918	2.14%	$ 28,513	3.93%	39,881	2.59%	$ 69,147	4.48%
Houston	Austin	2,516	0.26%	$ 4,007	0.55%	3,586	0.23%	$ 6,139	0.40%
Austin	Houston	5,987	0.61%	$ 1,043	0.14%	13,324	0.86%	$ 6,140	0.40%
	Total	8,503	0.87%	$ 5,050	0.70%	16,909	1.10%	$ 12,280	0.79%
Houston	San Antonio	2,888	0.30%	$ 4,691	0.65%	3,924	0.25%	$ 6,091	0.39%
San Antonio	Houston	4,311	0.44%	$ 4,713	0.65%	12,255	0.79%	$ 43,792	2.83%
	Total	7,199	0.74%	$ 9,404	1.30%	16,179	1.05%	$ 49,883	3.23%
San Antonio	Austin	8,348	0.85%	$ 3,512	0.48%	20,790	1.35%	$ 10,552	0.68%
Austin	San Antonio	2,630	0.27%	$ 700	0.10%	3,858	0.25%	$ 1,372	0.09%
	Total	10,978	1.12%	$ 4,212	0.58%	24,648	1.60%	$ 11,925	0.77%
Dallas-Fort Worth	Dallas-Fort Worth	149,564	15.30%	$ 125,630	17.33%	245,912	15.94%	$ 272,829	17.66%
Austin	Austin	57,628	5.89%	$ 20,414	2.82%	74,566	4.83%	$ 35,552	2.30%
Houston	Houston	197,550	20.20%	$ 154,404	21.30%	335,157	21.73%	$ 323,699	20.95%
San Antonio	San Antonio	39,517	4.04%	$ 25,227	3.48%	65,942	4.27%	$ 52,733	3.41%
Texas	**Texas**	**977,756**	**51.20%**	**$ 724,854**	**53.02%**	**1,542,688**	**54.08%**	**$ 1,545,037**	**55.25%**

[13] **Note:** Data excludes commodity flows to other states.

For intercity commodity movement, top commodities transported between DFW and Austin, in 2007, by weight were waste/scrap, mixed freight, and nonmetallic mineral products. This ranking is expected to remain the same in 2040. Mixed freight, motorized vehicles, electronics, and alcoholic beverages were the top commodities transported by value in 2007, and in 2040, precision instruments, chemical products are expected to be the second and third largest commodities by value to be transported by truck from DFW to Austin (mixed freight retains its top spot). From Austin to Dallas/Fort Worth, nonmetallic mineral products and waste/scrap were the major commodities moved by weight in 2007, and electronics was the major commodity moved by value. In 2040, Cereal grains are expected to be the third largest commodity moved by weight, and miscellaneous manufacturing products are expected to surpass electronics in terms of value of commodities moved by truck (FHWA, 2010).

Two examples of intercity freight movement that can be further reviewed using the FAF 3 data are those between DFW and Houston, and San Antonio and Austin. Between DFW and Houston, the data shows that in 2007, waste/scrap, basic chemicals, nonmetallic mineral products, coal, and other foods stuffs where the top five commodities by weight moved by truck. Mixed freight, motorized vehicles, electronic vehicles and basic chemicals were the top commodities moved by value. In 2040, "other foodstuffs" is expected to surpass basic chemicals as the second most moved commodity by weight. And mixed freight, electronics, and chemical products are expected to be the top three commodities by value moved by truck in 2040 (FHWA, 2010). From San Antonio to Austin, gravel, nonmetallic mineral products, and gasoline where the top commodities moved in 2007 by weight and the trend is expected to remain the same in 2040. By value, mixed freight, gasoline and nonmetallic mineral products were the top commodities moved in 2007. By value, pharmaceuticals are expected replace nonmetallic mineral products as the third largest commodity moved in 2040 (FHWA, 2010).

The Triangle's Rail Network

Texas has 44 railroads including 3 Class One Railroads, 14,965 miles of rail track (including trackage rights), and moved 385 million rail tons and 9.5 million rail cars in 2008. As illustrated in Figure 18, the Texas Triangle cities of Dallas/Fort Worth, Austin, San Antonio and Houston are connected by some of these rail tracks. UP has lines connecting San Antonio to Houston, Houston to Dallas, Dallas to Fort Worth, and Fort Worth back to San Antonio via Austin. BNSF also connects Houston to Dallas and Fort Worth, and cuts through Temple, located between Austin and Dallas/Fort Worth.

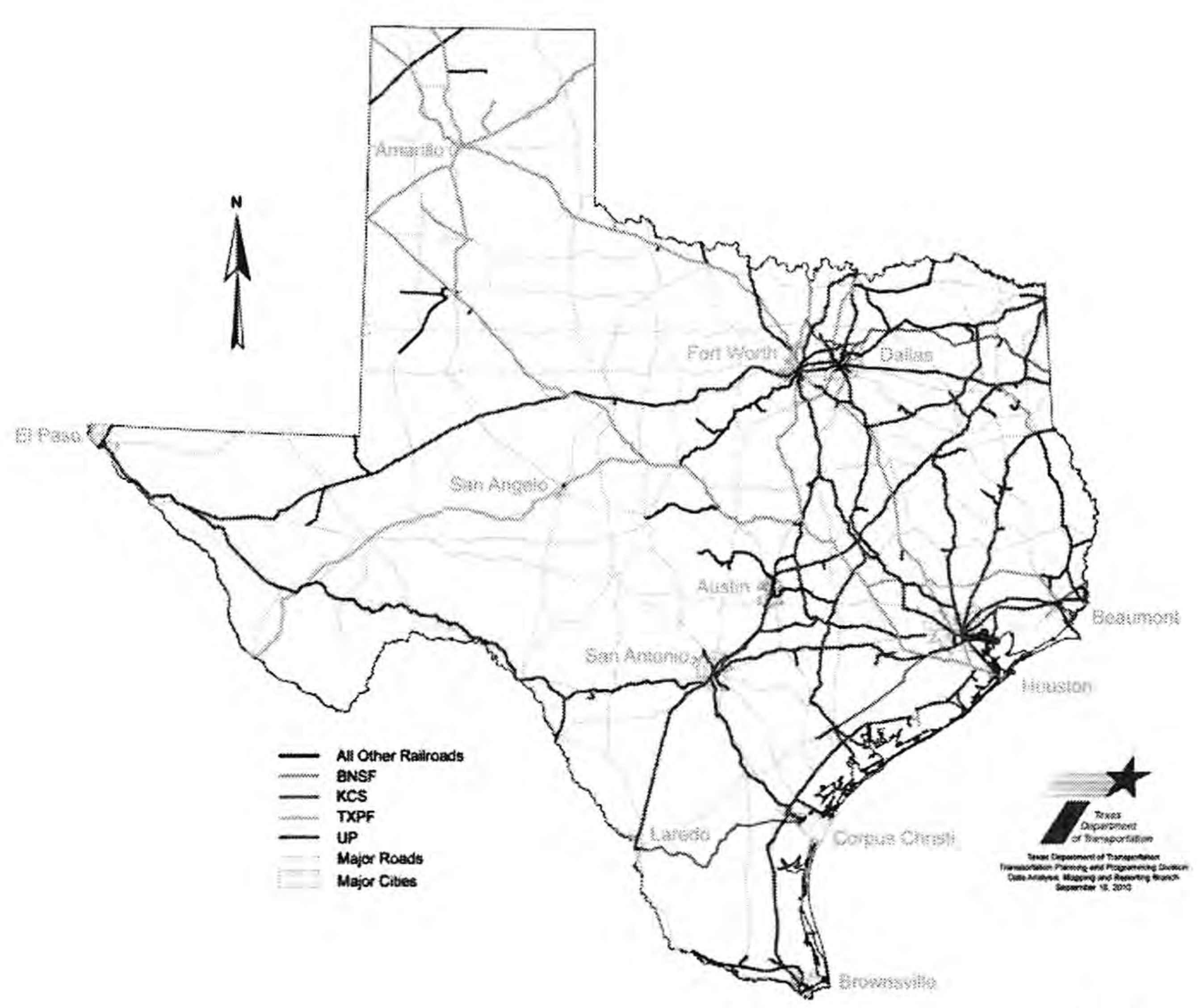
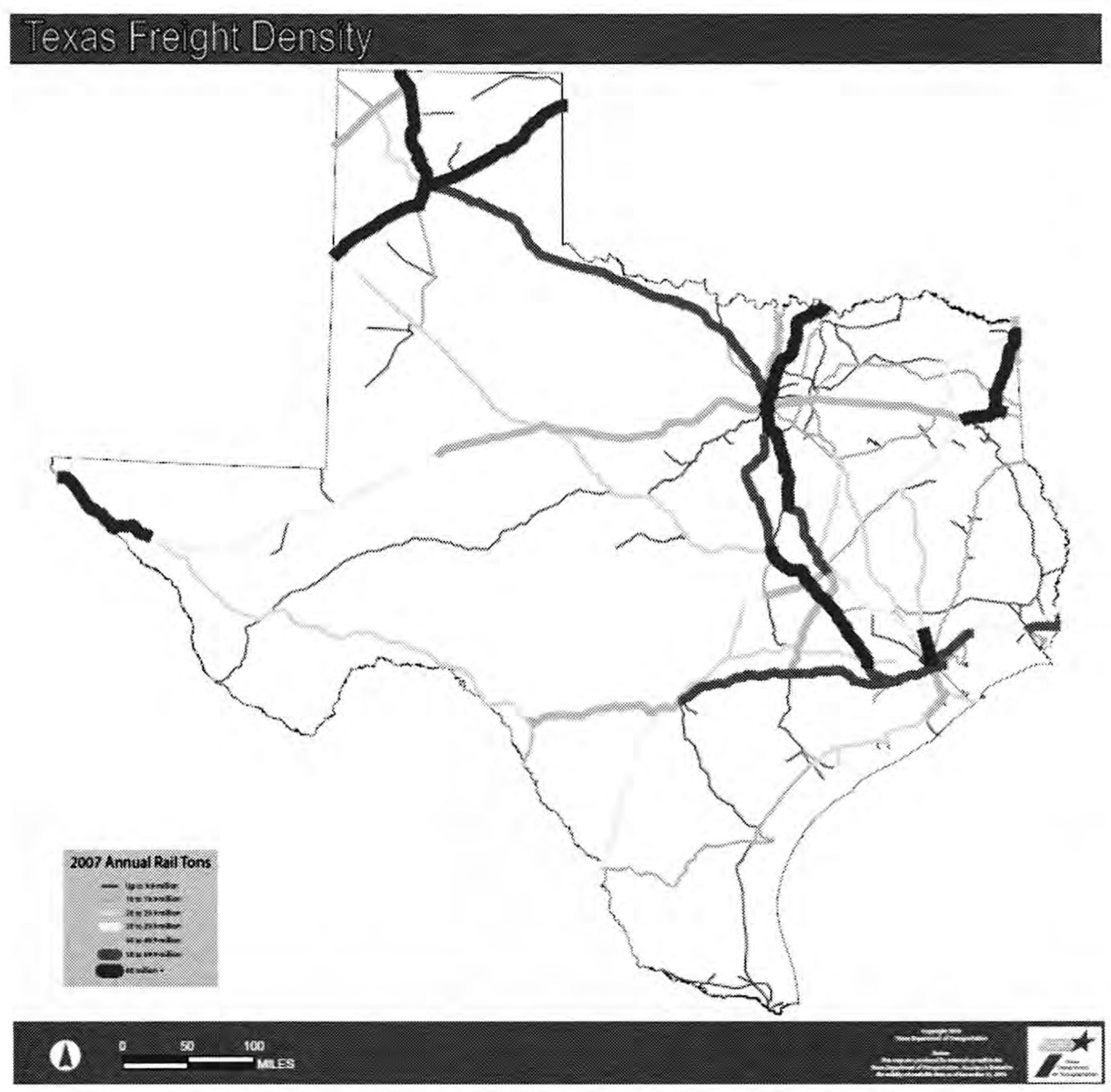


Figure 18: Texas Rail Network

Source: Texas Rail Plan, 2010

Figure 19 depicts the annual rail tons moved on Texas's rail system in 2007. As is evident, the freight rail routes linking Dallas/Fort Worth and Houston, with New Mexico, Colorado and Kansas through Amarillo, Texas; and Tulsa, Oklahoma have experienced the highest freight rail densities in the state in 2007 (Prozzi et al., 2011). BNSF owns most of these routes. In addition, BNSF owns the rail lines from El Paso to Sierra Blanca, and the line from Long View, TX to Arkansas. More than 60 million tons of rail freight was moved on these two BNSF-owned routes in 2007. The El Paso to Sierra Blanca rail line splits into two UP-owned routes, one to Houston through San Antonio, and the other to Dallas/Fort Worth through Sweetwater (Prozzi et al., 2011).

Other major rail routes are: UP's Amarillo to Dallas/Fort Worth and San Antonio to Houston (i.e., 50–59.9 million tons) segments; UP's Spofford (near Eagle Pass) to San Antonio, Odessa to Dallas/Fort Worth, Dallas/Fort Worth to Long View, and BNSF's Dallas/Fort Worth to Oklahoma City (i.e., 40–49.9 million tons) segments. Relatively lower density routes include UP's El Paso to Sweetwater segment, Laredo to San Antonio, Tyler to Texarkana, and BNSF's Palestine to Long View (30–39.9 million tons) segment. The remaining Texas rail lines moved less than 29.9 million tons of rail freight in 2007, with the short lines carrying between 10 and 20 million tons of freight (Prozzi et al., 2011).



Source: Texas Rail Plan, 2010

Figure 19: Annual Rail Tons on Texas Rail Routes, 2007

The Houston-Galveston region acts as a major rail hub for the Gulf Coast region. Freight trains serve the Houston, Dayton, Baytown, Bayport, and Beaumont industrial complexes. Traffic is predominantly local business for local customers (Houston Region, 2007). Five rail yards are located in the area, with the rail network being dominated by UP and BNSF. UP trains transport the majority of the tonnage on the rail system (HGAC, 2007) and UP has an intermodal facility at the Port of Houston. BNSF has two intermodal facilities in the region: one near Hobby Airport and one near the Port of Houston. BNSF also serves the ports of Galveston and Texas

City (HGAC, 2007). Kansas City Southern Railway Company (KCS) has contracted to operate its trains on UP and BNSF tracks.

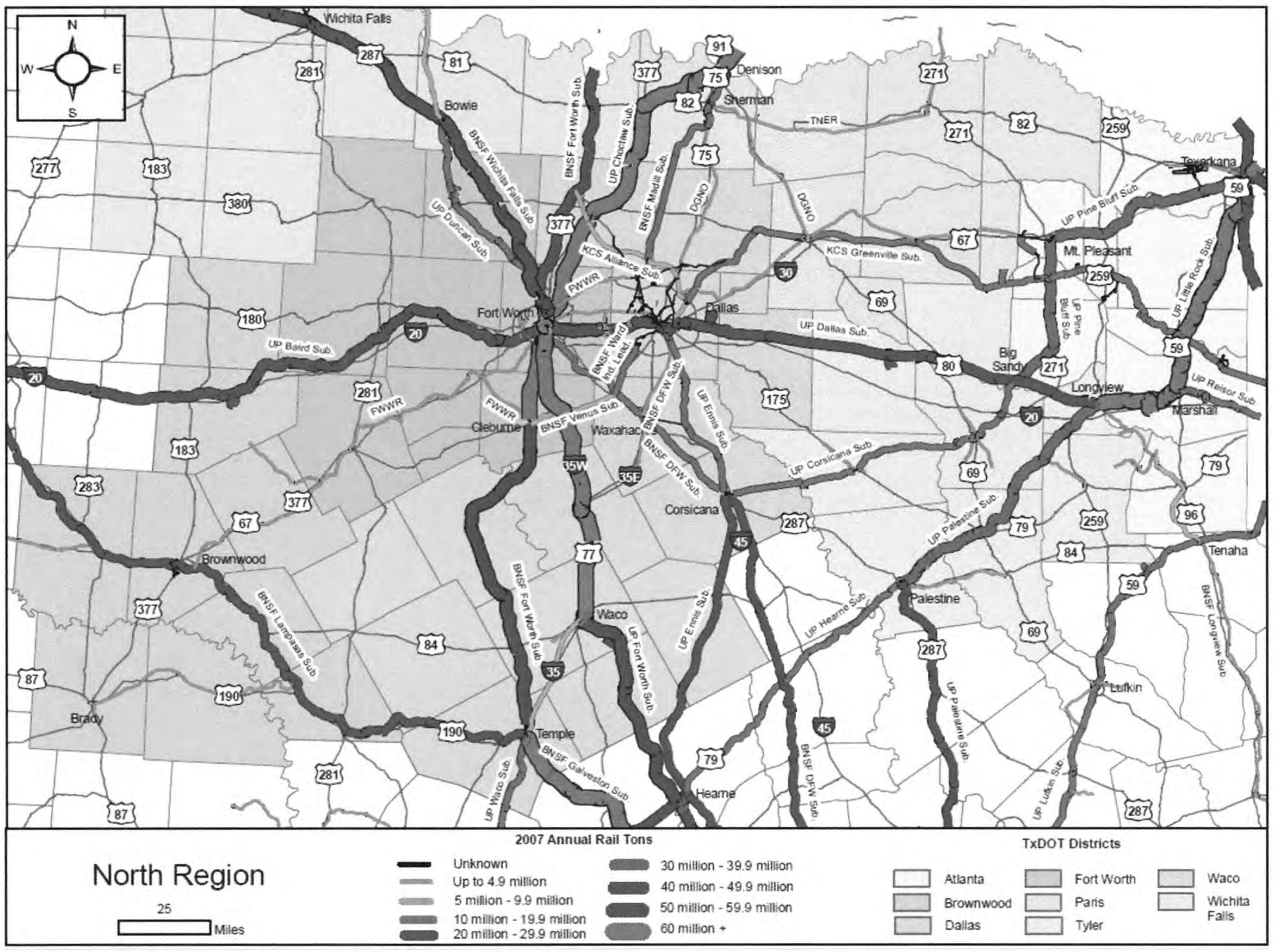
As illustrated in Figure 20, a significant volume of rail freight either originates or terminates in Houston. In addition, the Port of Houston is also an important gateway for international freight. The BNSF route from Houston to Temple recorded the highest freight rail flows in the region in 2007, i.e., more than 60 million tons. Other important rail subdivisions in the region include UP's Navasota, Beaumont, Fort Worth, Lafayette, and Gidden subdivisions and BNSF's Galveston subdivision (Prozzi et al., 2011).

Source: HNTB Corporation, derived from STB Waybill Sample Data. In Texas Rail Plan, 2010

Figure 20: Annual Rail Tons on South East Texas Rail Routes, 2007

Altogether, approximately 2,200 trains per week travel within the Houston regional rail network, which consists of over 800 miles of mainline tracks and 21 miles of railroad bridges (Houston Region, 2007). Of these trains, 84% are carrying chemicals and/or heavy bulk commodities such as coal, grain, rock aggregate, and coke. Of all the trains in the network, 48% are local trains and rail yard engines, and less than 5% of all trains in the region travel straight through without stopping to pick up or drop off cargo (Houston Region, 2007). Houston's freight movement is forecasted to approximately double by 2025 (Houston Region, 2007). This will require significant and careful planning of the expansion of rail facilities in order to handle such an increase. Identified bottlenecked locations include single track bridges that connect double mainline tracks. There are over 1,200 roadway railroad crossings with a daily volume of almost 5 million vehicles in the area (Houston Region, 2007).

Dallas/Fort Worth serves as an important interchange point for three of the Class I railroads and other short line railroads in Texas. The rail lines converge at DFW and diverge to in almost every part of the U.S.



Source: HNTB Corporation, derived from STB Waybill Sample Data. In Texas Rail Plan, 2010

Figure 21: Annual Rail Tons on North Texas Rail Routes, 2007

UP owns five rail corridors headed in all directions (north, south, east, and west) from the Dallas/Ft. Worth area and has trackage rights on BNSF's two rail corridors that head north. One of the corridors heads northwest to Colorado and the other heads north through Oklahoma to Chicago (see Figure 21).

Operating from an intermodal hub near Fort Worth Alliance Airport, BNSF owns several rail corridors that are connected to a network of intermodal facilities throughout the U.S. (see Figure 21) The Class I rail company is also looking at adding another intermodal facility in the Dallas Logistics Hub located south of Dallas and next to an existing UP facility. The smallest of the big three railroads, KCS, serves the central and south central part of the U.S., operating on 3,226 miles of track. KCS offers a direct line from Dallas to Shreveport and New Orleans. As is evident from Figure x6, one of the busiest rail lines is UP's north-south line between Waco and Denison, which moved more than 60 million tons of freight in 2007. BNSF's Galveston subdivision, heading south from Temple, and UP's Little Rock subdivision also moved more than 60 million tons (Prozzi et al., 2011).

In San Antonio, there are five major rail lines owned and operated by the UP Railroad in the San Antonio area and three active rail yards in the region (Kirby Yard, East Yard, and SoSan Yard). East Yard is primarily used as an industrial service yard for local and regional customers. Kirby Yard is also equipped for unloading auto racks and provides some local service. In 2009, UP opened up a new $100 million San Antonio Intermodal Terminal on their transcontinental Sunset Limited route which traverses the southern section of San Antonio, relatively close to the Toyota truck and auto plant. The terminal is expected to serve trade from U.S. West and East Coast ports, Mexican maquiladoras, and the U.S. Midwest. The facility has been equipped to process commodities such as clothing, electronics, and other household items. It can process approximately 180,000 containers per year with the added capacity and has growth potential for 250,000 containers per year (UP, 2009). It is located near Interstate 35 and Loop 410, and will assist in serving San Antonio customers who in the past had to truck containers delivered to Houston by trains that by-pass San Antonio. The new facility is expected to generate $2.48 billion in cumulative economic impact for the area over a 20-year period (UP, 2009).

Major rail subdivisions in the area include UP's Gidden, Giddings, Laredo, and Del Rio subdivisions, which moved more than 40 million tons of freight in 2007. KCS also owns a rail line in the area, which connects Laredo to Corpus Christi. The KCS line moved between 10 and 20 million tons of freight in 2007 (Prozzi et al., 2011).

Source: HNTB Corporation, derived from STB Waybill Sample Data. In Texas Rail Plan, 2010

Figure 22: Annual Rail Tons on South West Texas Rail Routes, 2007

According to the HNTB study, approximately 100 trains per day travel within the San Antonio region and areas extending north to Taylor and east to Flatonia with a significant volume of the rail freight moving into and/or out of San Antonio not originating or terminating in the area. It is estimated that approximately 70 to 75% of the trains moving into/out of San Antonio perform operations such as dropping off or picking up rail cars, maintenance services, fueling, and crew changes at SoSan Yard, located near the Port Authority of San Antonio (formerly Kelly USA) (HNTB, 2008).

According to Table 3, in 2007, 61.61% of commodities moved (by weight) by rail in Texas were within the Texas Triangle cities. This number is expected to increase to 67% by 2040. By value, the Triangle cities accounted for 58.13% of freight movement in 2007 and this number remains almost the same in 2040 at 58.06%. Aside significant freight movement between San Antonio and Houston (6.51%), the majority of the freight moved by rail were intracity movements. In 2007, San Antonio to San Antonio movements were at 28.30% by weight and 0.41% by value, and Houston to Houston movements were at 18.70% by weight and 55.91% by value. A review of commodities moved within San Antonio shows that 99.9% of the commodities moved (by weight) were gravel and in Houston, 87% of commodities moved (by weight) were plastics/rubber, coal and basic chemicals. By value, those same commodities accounted for 84% of goods moved, with plastics/rubber making up the majority.

Table 3: Texas Triangle Rail Flows including Domestic, Import, and Export Flows[14]

Source: FHWA, 2010

Origin	Destination	2007				2040			
		Tonnage (KT)	*% of Texas*	Value (Million $)	*% of Texas*	Tonnage (KT)	*% of Texas*	Value (Million $)	*% of Texas*
Dallas-Fort Worth	Austin	0.04	0.00%	$ 0.03	0.00%	0.14	0.00%	$ 0.11	0.00%
Austin	Dallas-Fort Worth	-	0.00%	$ -	0.00%	-	0.00%	$ -	0.00%
	Total	0.04	0.00%	$ 0.03	0.00%	0.14	0.00%	$ 0.11	0.00%
Dallas-Fort Worth	San Antonio	0.18	0.00%	$ 0.08	0.00%	0.34	0.00%	$ 0.18	0.00%
San Antonio	Dallas-Fort Worth	-	0.00%	$ -	0.00%	-	0.00%	$ -	0.00%
	Total	0.18	0.00%	$ 0.08	0.00%	0.34	0.00%	$ 0.18	0.00%
Dallas-Fort Worth	Houston	776	0.63%	$ 101	0.20%	946	0.44%	$ 168	0.16%
Houston	Dallas-Fort Worth	421	0.34%	$ 513	1.02%	781	0.36%	$ 976	0.95%
	Total	1,197	0.96%	$ 613	1.23%	1,728	0.80%	$ 1,144	1.12%
Houston	Austin	31	0.02%	$ 11	0.02%	72	0.03%	$ 27	0.03%
Austin	Houston	1,352	1.09%	$ 14	0.03%	2,397	1.10%	$ 66	0.06%
	Total	1,383	1.11%	$ 24	0.05%	2,469	1.14%	$ 94	0.09%
Houston	San Antonio	31	0.03%	$ 31	0.06%	63	0.03%	$ 45	0.04%
San Antonio	Houston	8,052	6.49%	$ 101	0.20%	32,578	15.00%	$ 533	0.52%
	Total	8,083	6.51%	$ 132	0.26%	32,640	15.03%	$ 578	0.57%
San Antonio	Austin	-	0.00%	$ -	0.00%	-	0.00%	$ -	0.00%
Austin	San Antonio	0	0.00%	$ 0	0.00%	0	0.00%	$ 0	0.00%
	Total	0	0.00%	$ 0	0.00%	0	0.00%	$ 0	0.00%
Dallas-Fort Worth	Dallas-Fort Worth	577	0.47%	$ 80	0.16%	793	0.37%	$ 110	0.11%
Austin	Austin	6,897	5.56%	$ 52	0.10%	8,762	4.03%	$ 66	0.06%
Houston	Houston	23,223	18.70%	$ 27,978	55.91%	44,288	20.39%	$ 57,057	55.80%
San Antonio	San Antonio	35,134	28.30%	$ 207	0.41%	54,862	25.25%	$ 323	0.32%
Texas	**Texas**	**124,154**	**61.61%**	**$ 50,042**	**58.13%**	**217,238**	**67.00%**	**$ 102,258**	**58.06%**

[14] **Note:** Data excludes commodity flows to other states.

A review of commodity flows between San Antonio and Houston shows that of that 97% of the commodities moved (by weight) were gravel and by value, 70% of the commodities moved were gravel, gasoline, coal, and basic chemicals.

Air Infrastructure

Each city in the Texas triangle has at least one major freight international airport: the Dallas/Fort Worth (DFW) International Airport, George Bush Intercontinental, Port San Antonio, and Austin-Bergstrom International Airport.

DFW International Airport ranks high nationally for the value of imports and exports going through compared to all other freight gateways (air, sea, and land ports) in the United States. Typically air cargo consists of value commodities of smaller weight but of very high value. In the case of DFW, the most common commodities flowing through are high-tech products like semiconductors, computer equipment, aircraft parts, and medical and electrical equipment.

George Bush Intercontinental acts as both a passenger and cargo facility and is one of the largest airports of both types in the country, containing a $125 million air cargo complex (Air Cargo, 2009). The airport, which has five runways, is the second largest in Texas, after DFW International Airport, and the eighth busiest for total passengers in 2008 (Community Profile, 2009). IAH offers 1 million square feet of cargo space in two separate areas of the airport: IAH Central Cargo and the state-of-the-art IAH Cargo Center (Fly2Houston.com, 2011[15]).

San Antonio is served by the San Antonio International Airport (SAT), located in northern San Antonio, approximately 8 miles or 15 minutes from the downtown area. Loop 410 and US 281 are the two highways providing access to the main entry points. SAT has two terminal facilities, two all-weather air carrier runways, and one general aviation runway. As of end-of-year 2008, SAT had an average of 260 daily domestic and international departures and arrivals with a total number of 8,358,515 passengers (SAT, 2010). The San Antonio Airport System is operated by the City of San Antonio Department of Aviation. Airport operations and improvements at SAT and Stinson are paid for by user fees, bond funds and money from the Aviation Trust Fund, which is disbursed by the Federal Aviation Administration (SAT, 2010).
Kelly Air Force Base is located in Bexar County, Texas, approximately 7 miles southwest of downtown San Antonio. The base encompasses 4,660 acres and is bounded on the west by Lackland AFB and to the south by Military Drive and Leon Creek. The northern and eastern boundaries are Growdon Road and the UP Railroad Yards, respectively (GlobalSecurity, nd).

Port San Antonio, formerly Kelly Air Force Base, is a multi-purpose, 1,900-acre facility established to serve as an aerospace complex, international airport, and industrial hub with two railroads and close access to three interstate highways. Port San Antonio's Kelly Field (SKF) has a 11,500-foot (3,505 meter) runway that can handle all types of heavy lift aircraft. The runway opened to domestic air cargo planes in 2007 and includes a new air cargo terminal with ample ramp space that allows for quick refueling and efficient turnarounds (Port of San Antonio, 2010). The facility includes an 89,600 square-foot Class A Air Cargo Terminal that is ready for occupancy. The terminal has 14 acres (5.6 hectares) of available ramp space that can accommodate up to four wide body aircraft simultaneously. There is a 50,000 square-foot (4,600 square-meter) cargo staging area on the airside. The terminal also features a 131-foot (39-meter) truck staging area; 50-foot (15-meter) shipping bay; 24 landside dock high doors; 4 ramp doors; and security services (Port San Antonio, 2010).

[15] http://www.fly2houston.com/iah-Air-Cargo

Nine million square feet of industrial space at Port San Antonio is currently occupied by global aerospace leaders such as Boeing, Lockheed Martin, Standard Aero, Pratt & Whitney, Gore Design Completions and two divisions of Chromalloy Gas Turbine Corporation. Approximately 14,000 professional, technical, and highly skilled employees work at the Port (Port San Antonio, 2010). The Port's 11,500 foot runway can handle all types of fully loaded, heavy lift aircraft. A test cell complex at the south end of the field provides a unique engine testing facility. The Alamo Community College District's St. Philips College has a campus which offers technical training in a broad array of courses. Because of their proximity to the large population of aerospace workers, St. Philips offers degree programs specifically for the aerospace and aviation industry as well as customized courses.

In addition, the entire Port San Antonio complex is covered by a general purpose U.S. foreign-trade zone designation (FTZ #80-10), offering Port customers significant economic advantages, including deferral, elimination, or reduction of duties. An on-site Federal Inspection Services (FIS) facility operated by U.S. Customs and Border Protection is adjacent to Kelly Field and can promptly inspect foreign shipments entering the U.S., including agricultural products (Port of San Antonio, 2010).

Freight-related airport infrastructure in Austin is located at the Austin-Bergstrom International Airport (ABIA) as illustrated in Figure 23. According to the Greater Austin Chamber of Commerce, the airport has a "$20 million state-of-the-art cargo facility" and has been "recognized in the freight industry for its highly effective cargo port design." Many air freight companies provide service at ABIA, including UPS, FedEx, and DHL, along with commercial airlines providing cargo services (MACTEC Engineering & Consulting, Inc. and Alliance Transportation Group, Inc., 2008). CAMPO's 2008 Austin Area Freight Transportation Study suggests that other general aviation airports in the region handle freight as well, but no additional data could be found to provide any specifics. Some of the larger general aviation airports in the area include Georgetown Municipal Airport, Taylor Municipal Airport, and San Marcos Municipal Airport.

Capacity for ABIA in terms of freight is a little bit difficult to determine, but the airport's master plan (P&D Aviation, 2003) sheds some light on related specifications as recent as 2003. ABIA was seeing 28 flights per hour during peak times, but could handle anywhere from 89 to 121 flights per hour as a maximum depending on the conditions. It contains two runways, one that is 9,000 feet long and the other 12,250 feet long, located next to the cargo/freight facilities. These runways have a weight-bearing capacity between 75,000 lbs. and 618,000 lbs. depending on the aircraft's landing gear setup.

The facilities for all-cargo planes contained 226,908 square feet of storage space and 1.5 million square feet of apron parking space, while belly freight facilities (for passenger planes carrying freight) offered 75,652 square feet of space. The master plan marks out different levels that the airport would desire to expand to. Which expansions have been fully or partially implemented since 2003 is uncertain, although all levels beyond the current capacity are planned for beyond 2009. Also uncertain from the 2003 master plan was the cargo/freight handling capacity; however, its peak handling for a given year has been 357.3 million pounds, which is roughly 150 million more pounds than what was handled in 2008 (Austin-Bergstrom International Airport, 2009).

Source: Austin-Bergstrom International Airport, 2009

Figure 23: ABIA Cargo Facility Map

Air freight handling at ABIA grew dramatically during the 1990s, but has been on the decline since 2000. The mode's importance in freight movement is heavily dependent on Austin's tech industry, which accounts for a high portion of the region's air freight (Capital Area Metropolitan Planning Organization, 2006). Despite the most recent trend, it is predicted that air freight out of Austin will grow between now and 2020 (MACTEC Engineering & Consulting, Inc. and Alliance Transportation Group, Inc., 2008). This, however, does not take into account the recent economic recession. Recent data from the airport's website shows monthly cargo handling metrics to be down significantly compared to the past, and has indeed been on a decline in terms of poundage handled (Austin-Bergstrom International Airport, 2009).

As shown in Table 4, 98% of Texas's air freight by weight was handled in the Triangle's cities. The majority of these were intracity movements: Houston to Houston (48.87% weight, 32.93% value), DFW to DFW (43.64% weight, 57.36% value), Austin (2.99% weight, 3.93% value) and San Antonio (2.28% weight, 3.01% value). Major commodities moved in Houston (by weight) include machinery, electronics, articles-base metal and precision instruments. In DFW, major commodities moved by value include electronics, machinery, precision instruments, and transport equipment. Similar commodities were moved in both San Antonio and Austin airports. The commodity trends are expected to remain the same all the major cities up to 2040. No air movements were recorded between San Antonio and Austin; the cities are barely 80 miles apart from each other.

Table 4: Texas Triangle Air Flows including Domestic, Import, and Export Flows[16]

Origin	Destination	2007				2040			
		Tonnage (KT)	*% of Texas*	Value (Million $)	*% of Texas*	Tonnage (KT)	*% of Texas*	Value (Million $)	*% of Texas*
Dallas-Fort Worth	Austin	0.05	0.01%	$ 104.3	0.31%	0.07	0.01%	$ 170	0.17%
Austin	Dallas-Fort Worth	0.06	0.02%	$ 34.7	0.10%	0.50	0.05%	$ 79	0.08%
	Total	0.11	0.03%	$ 138.9	0.42%	0.57	0.05%	$ 250	0.25%
Dallas-Fort Worth	San Antonio	0.05	0.01%	$ 33.8	0.10%	0.15	0.01%	$ 116	0.11%
San Antonio	Dallas-Fort Worth	0.02	0.01%	$ 0.7	0.00%	0.12	0.01%	$ 5	0.01%
	Total	0.07	0.02%	$ 34.5	0.10%	0.27	0.02%	$ 122	0.12%
Dallas-Fort Worth	Houston	0.08	0.02%	$ 65.7	0.20%	0.50	0.05%	$ 307	0.30%
Houston	Dallas-Fort Worth	0.38	0.11%	$ 52.4	0.16%	0.99	0.09%	$ 128	0.13%
	Total	0.46	0.13%	$ 118.1	0.36%	1.49	0.13%	$ 435	0.43%
Houston	Austin	-	-	$ 10.5	0.03%	0.00	0.00%	$ 5	0.01%
Austin	Houston	-	-	$ 1.7	0.01%	0.05	0.00%	$ 8	0.01%
	Total			$ 12.1	0.04%	0.05	0.00%	$ 13	0.01%
Houston	San Antonio	0.00	0.00%	$ 0.0	0.00%	0.00	0.00%	$ 0	0.00%
San Antonio	Houston	0.05	0.01%	$ 3.2	0.01%	0.15	0.01%	$ 10	0.01%
	Total	0.05	0.01%	$ 3.2	0.01%	0.15	0.01%	$ 10	0.01%
San Antonio	Austin	-	-	-	-	-	-	-	-
Austin	San Antonio	-	-	-	-	-	-	-	-
	Total								0.00%
Dallas-Fort Worth	Dallas-Fort Worth	150.38	43.64%	$ 19,029.0	57.36%	487.05	44.01%	$ 58,574	57.89%
Austin	Austin	10.32	2.99%	$ 1,303.7	3.93%	33.35	3.01%	$ 4,189	4.14%
Houston	Houston	168.42	48.87%	$ 10,922.2	32.93%	540.50	48.84%	$ 32,592	32.21%
San Antonio	San Antonio	7.85	2.28%	$ 997.1	3.01%	24.49	2.21%	$ 2,753	2.72%
Texas	**Texas**	**344.61**	**97.98%**	**$ 33,172.6**	**98.15%**	**1106.65**	**98.31%**	**$ 101,173**	**97.79%**

[16] **Note:** Data excludes commodity flows to other states.

Marine Infrastructure

The Texas Triangle is served by four main ports, the Port of Houston, the Port of Beaumont, the Port of Galveston, and the Port of Texas City.

The Port of Houston is ranked first in the country in foreign waterborne tonnage and second in total tonnage (Port of Houston, 2009a). It has 70% of container market share in the Gulf of Mexico, and 94% in Texas (Villa et al., 2008). The container ship facilities at Barbours Cut in Houston make up the largest container port on the Gulf Coast (Port of Houston, 2009b) and handled 1.8 million 20-ft equivalent units (TEUs) in 2008 (Port of Houston, 2009c). The port's new terminal Bayport, will add 300,000 TEUs per year of capacity after phase II is complete, and 2.3 million TEUs per year when the project is fully complete in approximately 20 years.

The Port of Houston is connected to 2 major railroads and more than 150 trucking companies, and has easy access to the 2 large Houston airports (IAH and Hobby) in addition to inland and intracoastal waterways. Petroleum and petroleum products account for the largest fraction of imports and exports, but the Port of Houston also handles large numbers of chemicals, automobiles, machinery, and iron and steel (Port of Houston, 2009c).

The Houston Ship Channel is a limiting feature of the Port of Houston. At 45 feet deep and 530 feet wide (when properly dredged), it can be a tight squeeze for two ships to pass one another. Widening the channel further, however, will be difficult because the surrounding area is largely built up[17].

The Port of Beaumont is the second largest U.S. military port in the world. According to the Port website, about 48% of military cargo shipped overseas for operations in Afghanistan and Iraq passed through the port, and more than 400 vessels called at the Port of Beaumont in 2008. The total combined cargo moved by ships, 7,700 trucks, and 24,000 railcars amounted to more than 3.2 million tons (Port of Beaumont, 2010). The Port is accessible from the Gulf of Mexico and Intracoastal Waterway via the federally maintained Sabine-Neches Ship Channel, 42 miles upstream from the Gulf. The Sabine-Neches Channel is a minimum of 400 feet wide and maintained at a depth of 40 feet. Air draft is 136 feet (Port of Beaumont, 2010). The Intracoastal Waterway and Mississippi River connect Beaumont with a vast inland waterway system serving such cities as Minneapolis, Chicago, St. Louis, Kansas City, Louisville, Omaha, and Memphis (Port of Beaumont, 2010). Goods flowing through the port were exported to 37 countries in 2008, and imports were received from 21 countries. Canada, India, Iraq, Russia, and Norway were the top five points of origin for cargo imported to the Port of Beaumont in 2008, and South Africa, Venezuela, Iraq, Qatar, and Italy were the top five destinations for cargo leaving the port in 2008 (Port of Beaumont, 2010).

The Port of Galveston consists of 850 acres of facilities located on the Gulf Intracoastal Waterway. While it was once the second-largest port in the country, after New York, the port today handles cruise passengers nearly as often as it does cargo. Galveston sees more than 600,000 cruise passengers yearly and can also handle all types of cargo: containers, bulk, break-bulk, and roll-on/roll-off. Drydock and rig repair facilities are also located at the port (Facilities and Maps 2009). In 2008, the port's revenues were nearly $21 million, very nearly its record 2007 revenues, despite undergoing significant damage from Hurricane Ike (Texas Ports, 2009).

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[17] The ship channel may be considered a terrible neighbor in another way; according to studies undertaken by the University of Texas, children living within 2 miles of the ship channel have a 56% higher risk for childhood leukemia than those living more than 10 miles away (Cahill, 2007).

The Port of Texas City is privately owned and managed as a for-profit entity. This port handles primarily bulk liquid products, such as chemicals and crude oil (HGAC, 2007). The Port of Beaumont is connected to inland distribution centers by three rail carriers (UP, BNSF, and Sabine River), five major roadways, and global steamship lines (Facilities and Services, 2009). The nearby Port of Orange is served by the same three rail carriers and also provides intermodal access via its network of highways and surface streets.

Intermodal Infrastructure

Intermodal facilities serve as trans-loading centers for truck, rail, and marine freight. The Texas Triangle has multiple intermodal facilities in the region. Table 5 presents the characteristics of the intermodal facilities in the Triangle, the services they provide and which areas of the Triangle they serve.

Table 5: Texas Triangle Intermodal Freight Centers

Dallas/Fort Worth
BNSF Intermodal and Carload Transportation Center at Alliance Airport Direct Asian import/export from the West Coast. Includes FedEx Southwest Regional Sort Hub with daily flights to Asia. **Kansas City Southern Intermodal Terminal (Garland, TX)** KSC's line from Dallas leads to the Meridian Speedway, a rail corridor ending in Meridian, Mississippi. **UP Dallas Intermodal Terminal** COFC terminal capability, adjacent to Dallas Logistics Hub, south of Dallas on IH 45. 10-lane Automated Gate System entrance to reduce truck congestion; 24/7 operation. Most containers are overseas shipments arriving by UP train from LA/Long Beach port[18]. **UP Intermodal Truck-Rail Facility (Mesquite, TX and Arlington, TX)** TOFC/COFC Terminal capability. Serves General Motors (in Arlington) and Chrysler and Nissan (in Mesquite) automobile manufacturers. **Dallas/Fort Worth International Airport and Fort Worth Alliance Airport** Air cargo terminals
Houston
UP Bayport COFC facility in partnership with the Port of Houston and dedicated to their business. Located at 515 East Barbours Cut Boulevard in La Porte, 2 miles from the Barbours Cut Terminal and seven from the Bayport terminal. **UP Englewood** COFC facility located at 5500 Wallisville Road in Houston, and 24 miles from Barbours Cut and

[18] http://www.dallashub.com/thehub_ektid386.aspx

30 miles from Bayport. The UP relates that its chief businesses today is international containers run through the Los Angeles ports.

UP Settegast
TOFC and COFC facility located at Kirkpatrick Boulevard in Houston, 28 miles from Barbours Cut and 32 from Bayport.

UP Westfield
Auto ramp located at 24125 Aldine Westfield Road in Spring.

BNSF Pearland
COFC, TOFC, and auto terminal at 214 Brisbane Road in Houston, 22 miles from Bayport and 24 miles from Barbours Cut.

KCS Rosenberg
COFC, TOFC, and auto terminal at 11538 Gin Road in Beasley, 62 miles from Freeport.

PTRA
Portside auto ramp handling import automobiles delivered by ship or by rail from Mexico. Serves the POHA, adjacent to Barbours Cut and will be linked into container flows through Bayport. Serves over 100 key chemical plants on the channel.

San Antonio

UP San Antonio Intermodal Terminal (SAIT)
Located south of IH-35 between Loop 410 and Charles W. Anderson Loop, this facility serves COFC and TOFCs.

Port San Antonio and East Kelly Railport
A 1,900 acre master-planned aerospace, industrial complex and international logistics platform. Created from the former Kelly Air Force Base. Includes an airport with an 11,500 foot runway, accessibility by two Class I railroads (UP and BNSF), and three interstate highways, IH-35, IH-10 and IH-37. Adjacent to UP's South San Antonio Classification Yard.

There are no reported intermodal facilities for truck and rail in Austin. However, there is likely intermodal activity between truck and air modes occurring at Austin Bergstrom International Airport.

As shown in Table 6, 66.45% (by weight) of multimodal freight was moved in the Texas Triangle cities in 2007. Majority of these movements were within Houston alone (51.45%). Top commodities moved by weight include coal, basic chemicals, fuel oils, plastics/rubber, and gasoline. By value, top commodities include basic chemicals, coal, fuel oils, electronics, machinery, and plastics/rubber. In San Antonio, by weight, top commodities moved include nonmetallic mineral products, gravel, and motorized vehicles. By value, commodities such as basic chemicals, miscellaneous manufacturing products, printed products, newsprint/paper, nonmetallic mineral products, and pharmaceuticals were some of the commodities moved in

Table 6: Texas Triangle Multiple Mode Flow including Domestic, Import, and Export Flows[19]

Source: FHWA, 2010

Origin	Destination	2007				2040			
		Tonnage (KT)	*% of Texas*	Value (Million $)	*% of Texas*	Tonnage (KT)	*% of Texas*	Value (Million $)	*% of Texas*
Dallas-Fort Worth	Austin	57	0.09%	$ 1,236	1.92%	$ 119	0.12%	$ 4,484	2.21%
Austin	Dallas-Fort Worth	6	0.01%	$ 116	0.18%	$ 11	0.01%	$ 748	0.37%
	Total	63	0.10%	$ 1,353	2.10%	$ 130	0.13%	$ 5,232	2.58%
Dallas-Fort Worth	San Antonio	9	0.01%	$ 395	0.61%	$ 18	0.02%	$ 1,118	0.55%
San Antonio	Dallas-Fort Worth	33	0.05%	$ 826	1.28%	$ 72	0.07%	$ 11,311	5.58%
	Total	42	0.07%	$ 1,221	1.90%	$ 90	0.09%	$ 12,429	6.13%
Dallas-Fort Worth	Houston	857	1.36%	$ 1,890	2.94%	$ 862	0.86%	$ 7,252	3.58%
Houston	Dallas-Fort Worth	939	1.49%	$ 797	1.24%	$ 1,590	1.60%	$ 1,760	0.87%
	Total	1796	2.84%	$ 2,686	4.18%	$ 2,452	2.46%	$ 9,013	4.45%
Houston	Austin	225	0.36%	$ 369	0.57%	$ 291	0.29%	$ 536	0.26%
Austin	Houston	202	0.32%	$ 213	0.33%	$ 661	0.66%	$ 1,899	0.94%
	Total	427	0.68%	$ 581	0.90%	$ 952	0.96%	$ 2,435	1.20%
Houston	San Antonio	952	1.51%	$ 500	0.78%	$ 1,331	1.34%	$ 767	0.38%
San Antonio	Houston	403	0.64%	$ 2,925	4.55%	$ 964	0.97%	$ 40,712	20.08%
	Total	1355	2.14%	$ 3,425	5.32%	$ 2,294	2.30%	$ 41,479	20.46%
San Antonio	Austin	1020	1.61%	$ 684	1.06%	$ 1,426	1.43%	$ 2,221	1.10%
Austin	San Antonio	1	0.00%	$ 104	0.16%	$ 2	0.00%	$ 370	0.18%
	Total	1021	1.62%	$ 788	1.22%	$ 1,428	1.43%	$ 2,591	1.28%
Dallas-Fort Worth	Dallas-Fort Worth	733	1.16%	$ 9,307	14.47%	$ 1,441	1.45%	$ 36,254	17.88%
Austin	Austin	117	0.18%	$ 1,060	1.65%	$ 173	0.17%	$ 3,094	1.53%
Houston	Houston	32509	51.45%	$ 27,491	42.73%	$ 56,100	56.30%	$ 55,265	27.26%
San Antonio	San Antonio	3928	6.22%	$ 2,042	3.17%	$ 6,920	6.94%	$ 5,104	2.52%
Texas	**Texas**	**63187**	**66.45%**	**$ 64,341**	**77.64%**	**$ 99,652**	**72.23%**	**$ 202,737**	**85.28%**

[19] **Note:** Data excludes commodity flows to other states.

2007. From Houston to DFW, top commodities moved by both weight and value include fuel oils, basic chemicals, machinery and coal. From DFW to Houston, top commodities moved by weight include cereal grains and basic chemicals. By value, top commodities moved from DFW to Houston include electronics, miscellaneous manufacturing products, pharmaceuticals, mixed freight, machinery, basic chemicals, and chemical products.

Summary

Table 6 above estimates the changes in tonnage and value of freight moving through the Texas Triangle, compared to the entire state, in 2040. The tonnage climbs from 66 to 72% while the value increases from 78 to a staggering 85%. Transportation performance underlies these forecasts, so it should be remembered that if service levels fall and cost rise, economic activity will shrink and expansion will move elsewhere. So, is the transportation infrastructure in good shape for the next decade? The railroad industry sponsored a Cambridge Systematics study examining rail network bottlenecks[20] which reported in 2007 that $148 billion (in 2007 dollars) was needed for rail infrastructure expansion to accommodate the 88% growth in rail freight out to 2035. Class I railroads share of the figure was $135 billion, of which $96 billion would accrue through increased earning and the balance—about $1.4 billion per year—would come from tax incentives and other sources. It now seems likely that rail profitability may meet these targets with additional infusions of money from public-private partnerships and federal, state or MPO support—as in the case of Tower 55. Highway investment, however, is more uncertain at this time and the unwillingness of Congress to sanction raising fuel taxes to meet current and future needs makes it less certain that trucking will maintain the predicted growth in market share. And while Texas Gulf terminals may be able to cope with substantial growth through internal expansion, the channels that link deep water with those terminals will need to be at least maintained to the design draft and deepened if larger vessels, particularly the new containerships are to be serviced. Megaregional transportation planning would take into account these needs and perhaps use the considerable political power that comes with economic success to keep the freight systems upgraded and efficient. This is discussed in more detail in the recommendations of this report.

The next chapter identifies opportunities and challenges related to megaregional planning in the Texas Triangle.

[20] National Rail Freight Infrastructure Capacity and Investment Study, prepared for the Association of American Railroads for Cambridge Systematics, Inc. September 2007.

Chaper 5. Megaregional Planning in the Triangle: Opportunities and Challenges

Megaregional planning theoretically provides benefits better than the traditional planning schemes of MPOs. According to Ross et al. (2008), the current system where states or local governments compete for funds can be replaced by inter-jurisdictional cooperation: "planning at an inter-jurisdictional level, with an emphasis on how economic and network interactions are set in a spatial context which could lead to more efficient public investments resulting in increased global economic competitiveness" (Ross et al., 2008). In addition to the above, megaregional planning presents "a new perspective on defining regionalism that captures the economic, political and spatial level at which planning should be conducted in order to respond to the challenges of agglomerations of economic activity and population" (Ross et al., 2008). It also "recognizes the new context in which large-scale regions exist—one of global economic and environmental issues taking place on a larger scale" (Ross et al., 2008). Megaregional planning presents a new way of approaching large-scale transportation systems, green infrastructure, and economic development (Zhang, 2007). In summary, megaregions provide an effective strategy for researchers, planners, engineers, politicians, and decision makers to tackle regional issues, economic development planning, and transportation planning.

The Texas Triangle can take advantage of the megaregional planning perspective to facilitate future transportation planning goals. Preliminary steps that this megaregion can follow include:

a) Identifying current and future metropolitan transportation links which impact regional goods movements

b) Identifying the current bottlenecks and future needs for these links

c) Setting up benchmarks and future planning goals for the links and cities

d) Examining Alternative Freight Systems, Transportation Improvement Strategies and Cost Models

e) Exploring alternative funding sources

a) Identifying Metropolitan Transportation Links which Impact Regional Goods Movements

The concept of megaregions enables local planning organizations to identify corridors which have an impact on other cities. For example, roadway congestion in Houston may delay the delivery of goods to Dallas thereby resulting in increased transportation cost for shippers and transportation operators. Walton et al. (2011), noted in study that rail stakeholders in Central Texas for example, are being impacted by rail congestion in Houston and Dallas/Fort Worth. Shippers experience delays when these cities are back logged. Stakeholders reported that shipments sometimes arrived quicker when shipped to Los Angeles, California, than to some cities in Texas (Walton et al., 2011). A megaregional planning approach enables local planning organizations to act swiftly on issues which have a much broader impact on the Texas economy than just their locality.

In this chapter, the road, rail, air, and port connectors that impact intercity goods movement are identified in each metropolitan area in the megaregion. This work seeks to lay the foundation for future megaregional planning approaches and provides only a preliminary list of connectors. A similar initiative is the National Highway System (NHS) Intermodal Connectors inventory. The NHS inventory is a list of roads important for intermodal access to ports, truck and rail transportation facilities. There are 32 such connectors in the Triangle alone: 21 in Houston, 8 in Dallas/Fort Worth, 2 in San Antonio and 1 in Austin. The list is useful as starting point for identifying critical connectors that serve not just the surrounding metropolitan area but other cities as well.

In 2006, NCTCOG initiated the Freight Bottleneck Study to identify and quantify freight bottlenecks in the Dallas/Fort Worth area. This study identified federally designated intermodal connectors which provide critical access between major intermodal facilities and principal highway arterials, facilitating multi multimodal freight movement (NCTCOG, 2009[21]).These intermodal connectors despite being located within the Dallas/Fort Worth area, can negatively impact the movement of goods to other cities because of delays on those connectors.

Figures 24 to 27 show the designated truck routes in each of the major cities. A megaregional planning perspective will enable cities and MPOs to designate and prioritize specific intersections, highways, bridges and connectors as important links that serve not just the vicinity they are located in, but the entire megaregion as well. This will enable transportation planners and stakeholders to ensure that these links are preserved from encroachment or development that may lead to the decline of the level of service of these roadways.

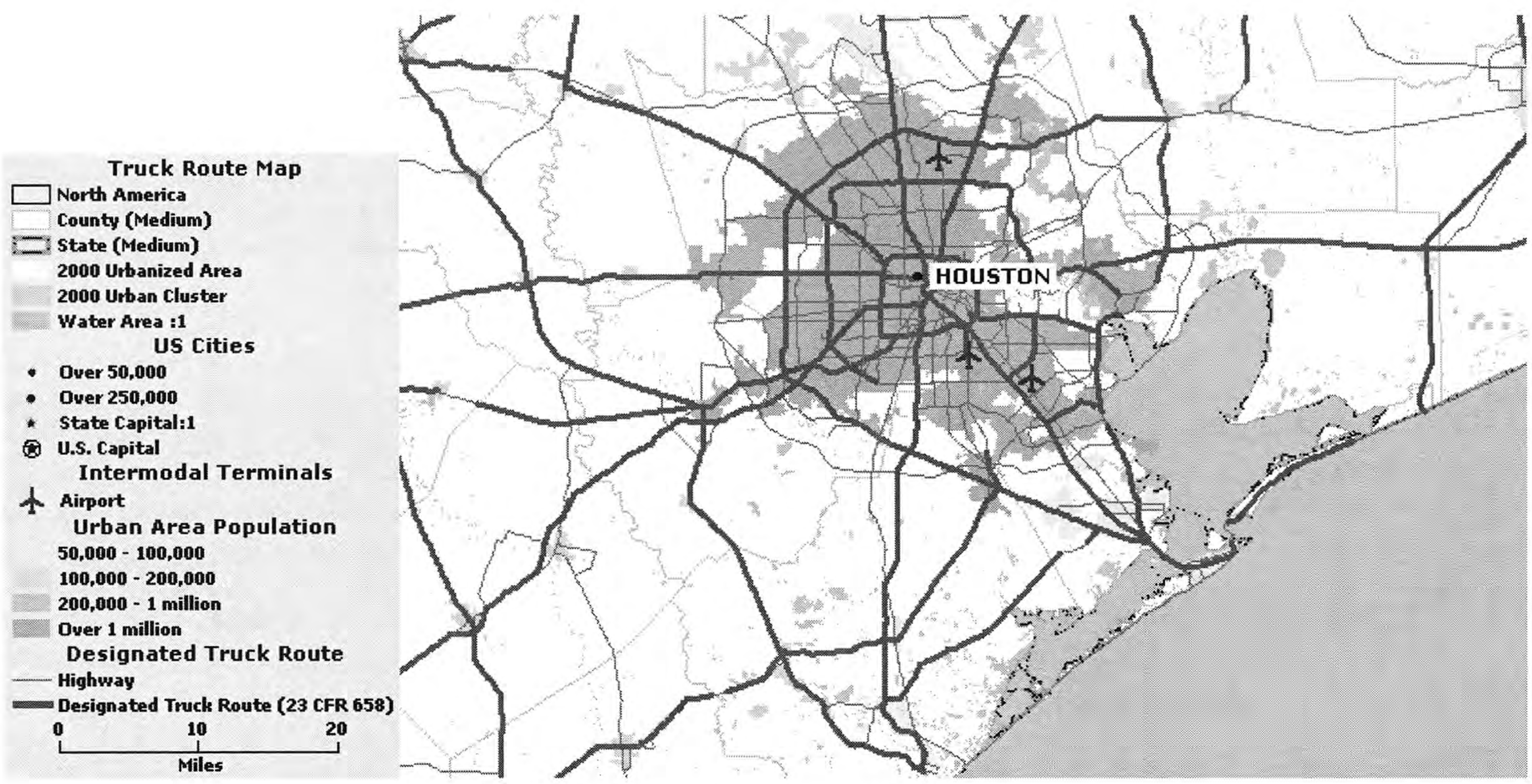


Figure 24: Truck Route Map of Houston, FHWA[22]

[21] http://www.nctcog.org/trans/mtp/2030/8.GoodsMovement.pdf

[22] http://hepgis.fhwa.dot.gov/hepgis_v2/Highway/Map.aspx

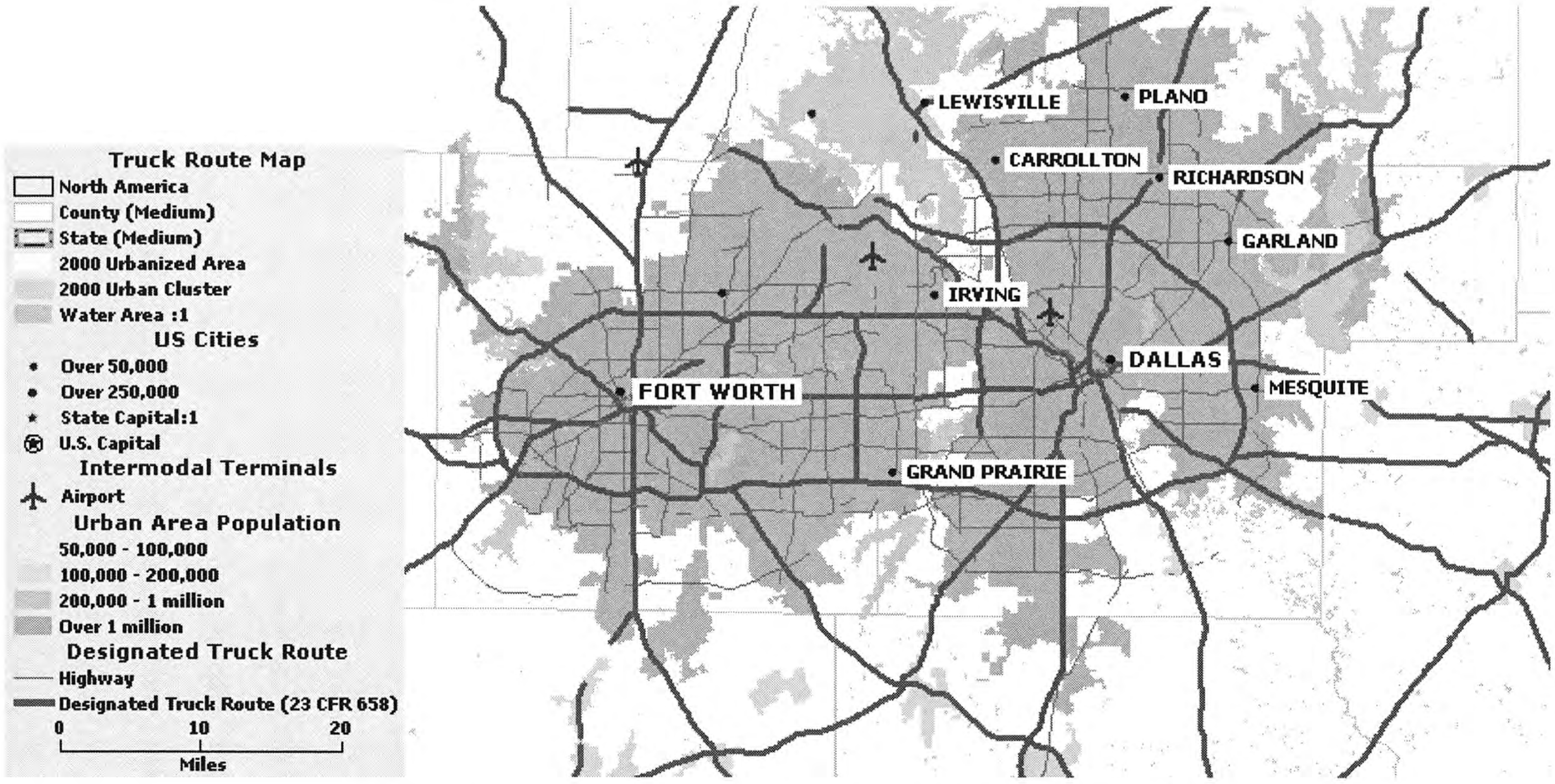


Figure 25: Truck Route Map of Dallas, FHWA[23]

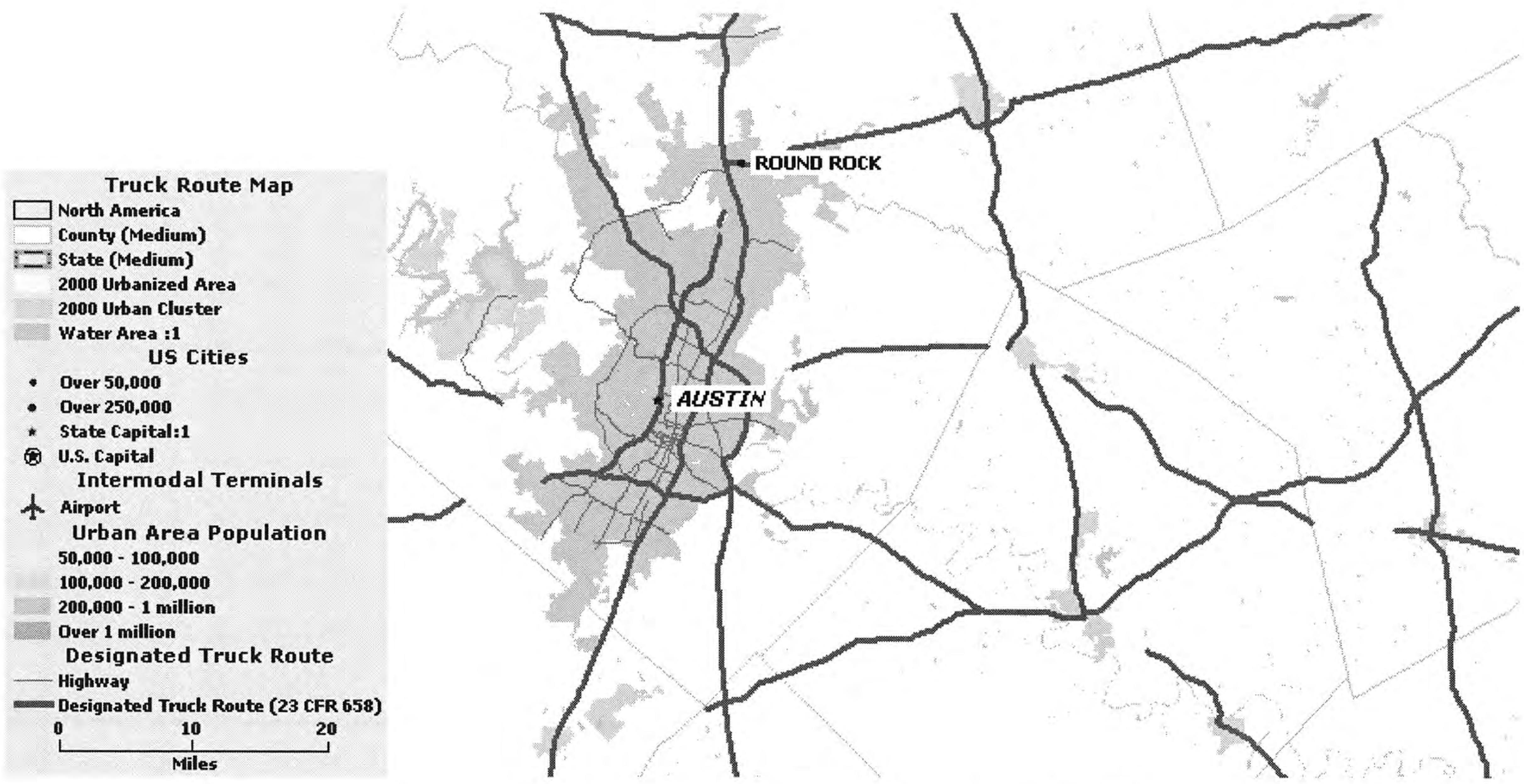


Figure 26: Truck Route Map of Austin, FHWA[24]

[23] http://hepgis.fhwa.dot.gov/hepgis_v2/Highway/Map.aspx
[24] http://hepgis.fhwa.dot.gov/hepgis_v2/Highway/Map.aspx

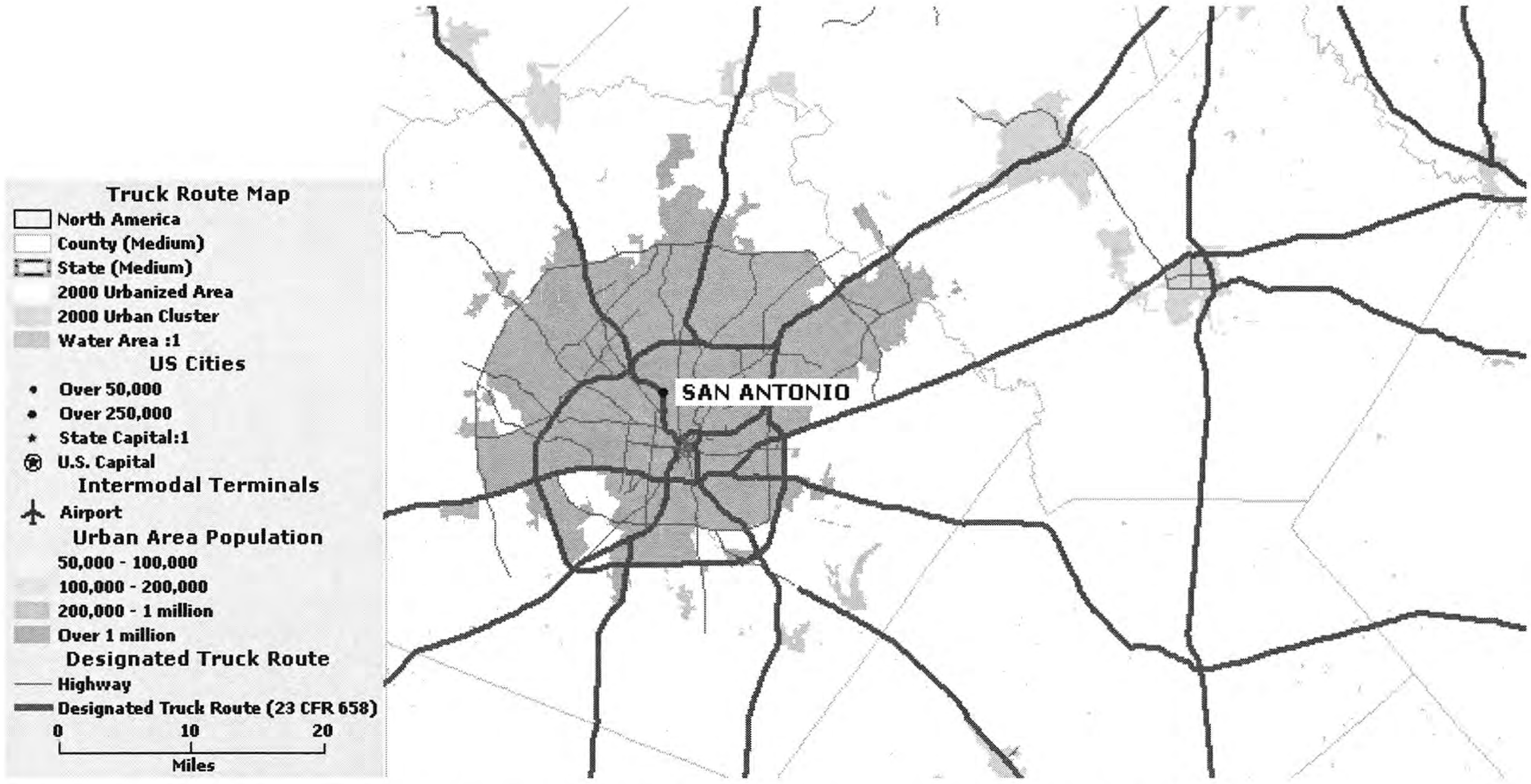


Figure 27: Truck Route Map of San Antonio, FHWA[25]

b) Identifying the current bottlenecks and future needs for these link

A review of the Metropolitan Transportation Plan of all the major cities in the Texas Triangle will reveal some similarities in their transportation needs. Common challenges within the cities include

- Capacity constraints leading to increased congestion and delays on the freight system.
- Community impacts such as safety, air quality, noise, vibrations, water pollution, and damage to the infrastructure
- Environmental and permitting regulations, as well as security concerns

The major challenge for these metropolitan areas is whether they will be able to sustain any future growth in freight movement in addition to passenger vehicles. For example, in Houston, truck volumes are projected to increase by 77% by 2035, which means that for every 100 trucks on the roads today, there will be 177 trucks in 2035 (HGAC, 2011) Congestion on Houston's rail system results in 300 daily train hours of delay (Houston Region Freight Study, 2007[26]), and the total impact of the Panama Canal expansion on the region's deep water port is still unknown (HGAC, 2011).

c) Setting up benchmarks and future planning goals for the links and cities

Benchmarks and planning goals are essential for the intra-city and inter-city planning as it enables metropolitan areas to become better prepared for future economic growth. Goals can be set through the development and implementation of freight performance measures. These measures can (a) provide an insight into the performance of the current transportation system, (b)

[25] http://hepgis.fhwa.dot.gov/hepgis_v2/Highway/Map.aspx
[26] http://www.txdot.gov/project_information/projects/houston/railway/default.htm

provide a means to establish realistic goals and targets, (c) allow agencies to determine funding needs, rank capital investments, and evaluate alternative programs, (d) provide a rationale for allocating scarce resources, and (e) assist in monitoring the progress made towards achieving specific goals and targets (Prozzi et al., 2011[27]). Benchmarks and goals can be set in the areas of:

- Maintenance and preservation;
- Mobility, reliability and congestion;
- Safety/environmental impact; and
- Accessibility and Connectivity.

d) Examining Alternative Freight Systems, Transportation Improvement Strategies and Cost Models

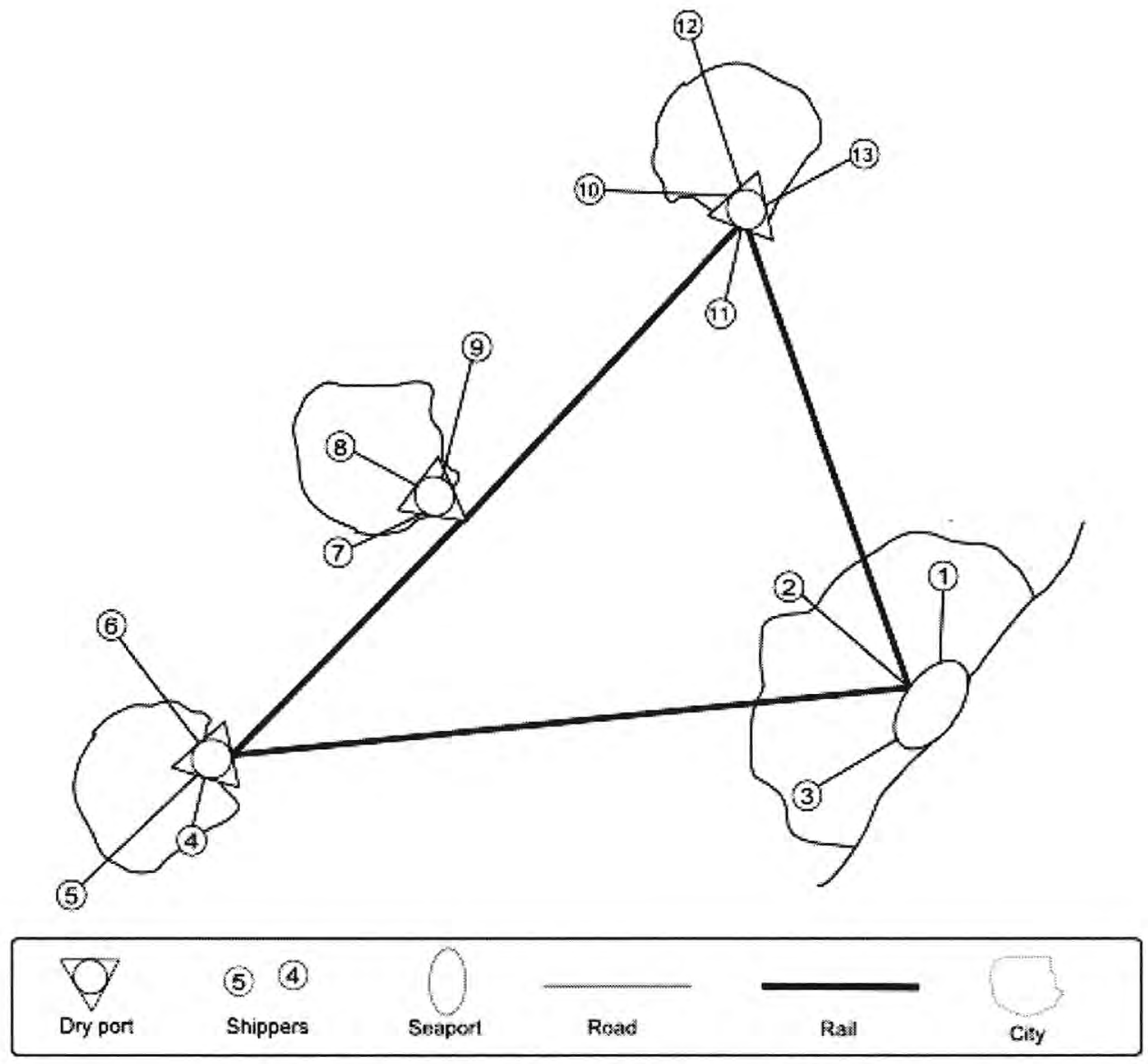
Alternative freight modes such as long combination vehicles, hybrid trucks, and competitive short haul rail can all play a role in the movement of goods from, to, and within the Texas Triangle megaregion. Long combination vehicles are known to provide benefits such as fewer truck trips, fuel savings, and lower emissions to move the same amount of freight. However, federal law restricts truck size and weight beyond 80,000lb except for special permitting. There is also a concern about the impact of these vehicles on bridges and pavements as well as competition with rail (Walton et al., 2010). Fuel efficient hybrid trucks are also being tested and utilized by companies such as UPS and FedEx. Studies to determine the economic costs of using such vehicles in comparison to conventional delivery trucks is still in its infancy but hybrid trucks seem to be a promising alternative transportation mode. Cities and MPOs should also examine the feasibility of investing in competitive short line railroads. Studies by Blaze et al (2003) and Seedah and Harrison (2010) determined that for short haul rail to be competitive, terminal operations and drayage costs should remain low. This can be achieved through cities providing incentives to short haul railroads such as tax breaks, right-of-way acquisitions and improved access to rail yards. These incentives coupled with technological advances and efficient terminal operations may assist in reducing the cost of short haul rail thus making it more competitive to trucking. Reducing cost and travel time of short haul rail can also provide shippers with an alternative to truck, thus freeing up demand for the currently congested road network.

Other strategies such as dedicated truck lanes, providing incentives to divert truck traffic to off-peak hours, dynamic tolling, and investing in intermodal facilities can be adopted by cities and transportation planning agencies. Dedicated truck lanes are believed to alleviate truck impact on congestion, reduce overall pavement consumption and alleviate passenger truck safety concerns. In a study by Prozzi et al. (2011), stakeholders in the Houston and Dallas/Fort Worth areas expressed support for dedicated truck lanes. Another strategy is the implementation of dynamic tolling based on truck weight and peak hour traffic. Dynamic truck tolling provides truckers with a much fairer weight based tolling system than what current exists where agencies use the number of axles (Harrison, 2011[28]). Using a weight based tolling system truckers are charge by the weight of the truck which is directly proportional to the damage exacted on the pavement. Having a weight based tolling system means that truckers with empty loads are charge

[27] See Prozzi et al., (2011) "Freight Planning for Texas—Expanding the Dialogue" for further discussion on feasible Freight Performance Measures for Texas.

[28] In a discussion

lesser than those with heavier loads (Harrison, 2011[30]). In addition, having cheaper tolls during non-peak hours compared to peak hours will also provide an incentive for truckers to use alternative routes. An example of a location where dynamic tolling can be implemented is in Austin where IH-35 and SH 130 toll road are competing roadways.



Source: Seedah and Harrison, 2010

Figure 28: An Example of Dry Port Concept Implementation in the Texas Triangle Megaregion

Innovative intermodal facilities such as the dry port concept introduced by (Roso et al., 2007) and expanded further for megaregions by Seedah and Harrison (2011) should also be examined (see Figure 28). The dry port concept is simply a "an inland intermodal terminal directly connected to seaport(s) with high capacity transport mean(s), where customers can leave/pick up their standardized units as if directly to a seaport" (Roso et al., 2007). When this concept is expanded, cities can have a dry port located at their outskirts, and interconnected by rail. Commodities destined for other cities would be transported via trucks to the facility, and then transported to the other facilities via rail. The ports can also serve as consolidated delivery facilities to replace the current "peddle-run" system and truck delivery can made more efficient through alternative transportation systems such as hybrid vehicles (Seedah and Harrison, 2010).

In addition to the above strategies, integrated planning and transportation cost models will need to be developed to address various scenarios of freight impacts and land-use planning. Such models can report financial costs (to the provider) and any social costs that may arise from the use of a particular facility or transportation mode. They can also assist planners in determining which transportation plans will best meets the needs of both cities and shippers. An example of such models is the Vehicle Operation Cost Model (CT-Vcost) (Welter et al., 2009) and the preliminary intermodal rail cost model (CTRail) (Seedah and Harrison, 2010). A feature in the new version of CT-Vcost[29], called Route Analysis, provides users the ability to perform route cost comparisons based on congestion, driver cost, travel speeds and toll charges. Users are able to compare how different conditions on alternative routes results in different costs for truckers. CTRail is also a first generation rail cost model which enables stakeholders to measure operational differences between trailer on flat car (TOFC) and double stacked containers on flat or "well" cars in intermodal service. It also allows for the calculation of gallons of fuel consumed, greenhouse gas emissions produced, the effect of operational differences when using multiple locomotives or car types, and the influence of delay, and other route specific characteristics such as grade changes and road curvature. This initial intermodal model is mechanistic in nature and uses as inputs various factors such as cargo weight, energy consumption, and expert estimates of maintenance and crew labor costs (Seedah and Harrison, 2011).

Figure 29 provides a simple schematic of a goods movement cost model as applied to megaregional planning. It shows a unidirectional movement that can be adapted for bi-directional (import/export) flows.

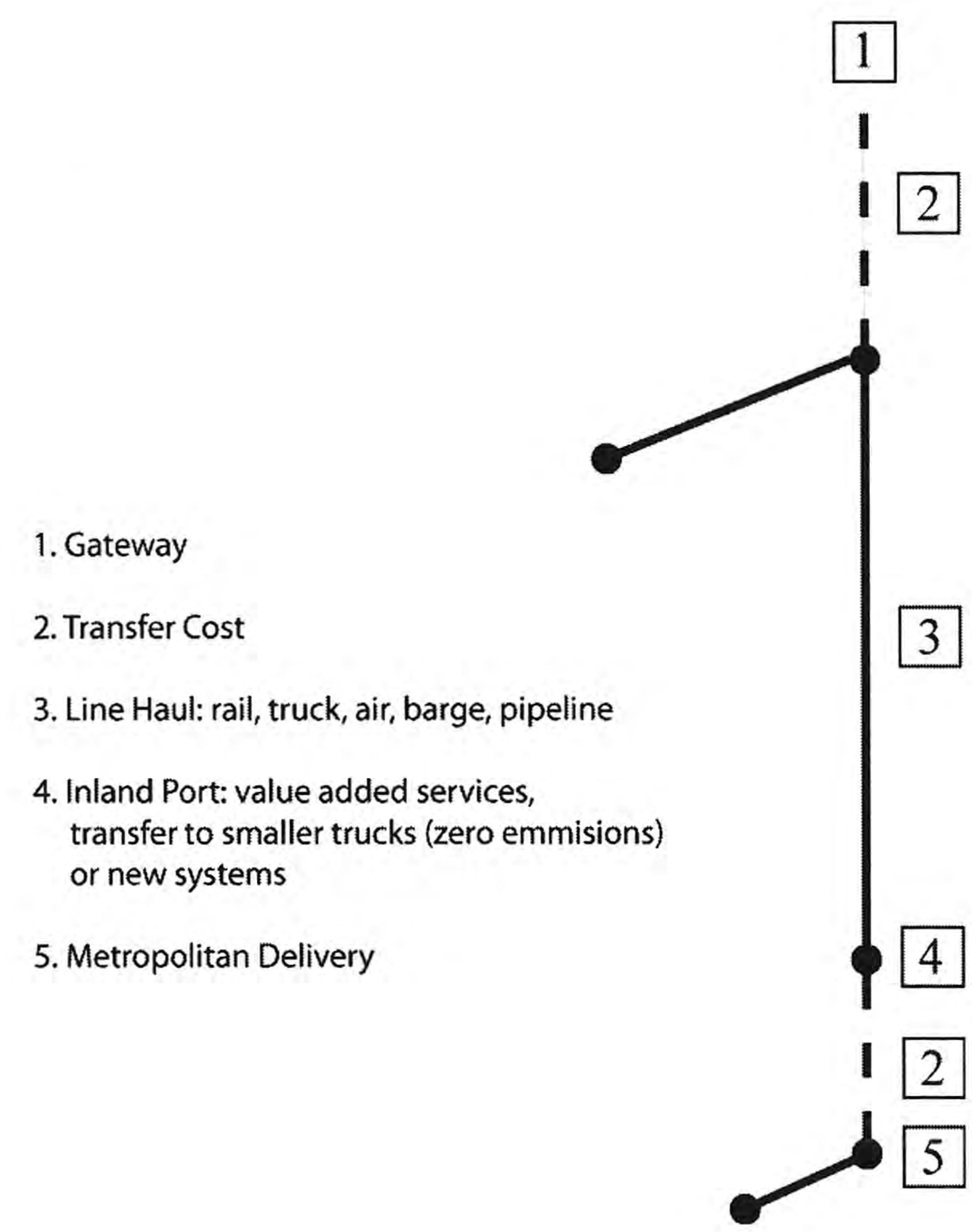


Figure 29: Schematic of a Megaregional Goods Movement Cost Model

* VMT fee estimates refer to miles traveled on Interstate System.

[29] CT-Vcost 2.0 is set to be released by CTR in September 2011.

Freight enters the megaregional system through a gateway, defined in a variety of ways depending on mode. This is then either transferred to a line haul mode (truck, rail, barge) or delivered directly to the customer in the gateway MPO. The line haul move then takes cargo to an inland port, marine or river port, distribution center or final customer. If not to the final customer, a transfer takes place for MPO delivery. It is highly likely that a greater proportion of metropolitan delivery vehicles will in future be zero emission either through hybrid or full electric propulsion. It may be that traditional diesel powered trucks may be proscribed from urban networks to meet air quality standards. There is also the likelihood that larger, more productive trucks—such as long combination vehicle (LCVs)—will be permitted to operate on the interstate system but not within specific metropolitan networks. In any event, the specific ton-mile costs for different modal configurations can be determined and help planners anticipate corridor needs and preservation, terminal locations and formally integrating freight into MPO transportation evaluations.

e) Exploring Alternative Funding and Financing Sources

Funding to enable planners to implement some of the strategies discussed is always an issue of concern. Public funding of new transportation infrastructure is practically inadequate. As a result, state policy makers and transportation planners have turned to toll roads, which face growing opposition from the public (Zhang, 2007). A report by AASHTO's Center for Excellence in Project Finance provides a broad range of tools to address the transportation "funding gap" (AASHTO, 2011[30]). The report defines *funding* as revenue available to pay for investment in transportation assets or programs, and financing relates to the use of financial tools or techniques to leverage project revenues, accelerate project development, and match the costs and benefits of long-lived assets (AASHTO, 2011). Existing and potential funding sources presented in this report include:

- Annual Driver's License Surcharge
- Annual Highway Miles Traveled Fee (All Light Duty Vehicles)*
- Annual Highway Miles Traveled Fee (All Trucks)*
- Annual Registration Fee (Light Duty Vehicles)
- Annual Registration Fee (Trucks)
- Container Tax
- Dedicated Income Tax–Personal
- Dedicated Income Tax–Business
- Diesel Tax Increase
- Gas Tax Increase
- Harbor Maintenance Tax
- HVUT Increase

[30] American Association of State Highway and Transportation Officials (AASHTO) Center for Excellence in Project Finance, The Forum on Funding and Financing Solutions for Surface Transportation in the Coming Decade Conference Report, January 2011, Washington, DC

- Imported Oil Tax
- Sales Tax on Auto-related Parts and Services
- Sales Tax on Gas
- Sales Tax on Diesel
- Sales Tax on New Light Duty Vehicles
- Sales Tax on New and Used Light Duty Vehicles
- Share of U.S. Customs Revenues
- Tire Tax on Light Duty Vehicles
- Ton Freight Charge—All Modes
- Ton Freight Charge—Truck Only
- Ton-Mile Freight Charge—All Modes
- Ton-Mile Freight Charge—Truck Only
- Truck/Trailer Sales Tax Increase
- Truck Tire Tax Increase
- U.S. Freight Bill—All Modes
- U.S. Freight Bill—Truck Only

In addition, financing tools available for surface transportation include:

- Tax-exempt Bonds
- Direct Federal Credit (e.g., TIFIA)
- Grant Anticipation Borrowing (e.g., GARVEE bonds)
- State Infrastructure Banks
- Private Activity Bonds
- Build America Bonds and other tax-credit bonds
- Public-private Partnerships
- National Infrastructure Bank

With such a broad range of options, cities and transportation planners can further examine the pros and cons of each funding alternative to determine what will work best for the region.

Challenges of Megaregional Planning in the Texas Triangle

Despite the benefits of megaregional planning, a number of challenges do exist. As stated by Butler et al. (2009), "the challenges the Texas Triangle faces require cooperation of the entire megaregion and cannot be solved in isolation." Butler et al. (2009) further suggests that in order to manage the expected population growth, the critical issues that must be addressed include "reducing suburban sprawl by identifying preferred growth areas, developing a new transportation network, ensuring the region's economic competitiveness and preserving significant natural resources as well as scenic landscapes." The location of the triangle within a single state (Texas) provides a more politically coherent environment than many of the other megaregions (Butler et al., 2009).

One great benefit of the Texas Triangle region is that it is entirely contained within the boundaries of a single state. As a result, policy changes necessary to encourage megaregional planning may be easier to implement. Currently, MPOs are responsible for transportation demand forecasting and planning for individual metropolitan areas. The scope of MPO's work typically does not go beyond their designated areas. "While individual MPOs provide rather detailed pictures of their areas, forces of growth from the interactions among metropolitan areas and between the metro areas and their hinterlands are often not accounted for" (Butler et al., 2009). In addition, the role of planning may differ throughout the region, posing a challenge to an overarching megaregion planning perspective. For example, Houston does not have zoning while Austin is generally regarded as a planning innovator (Butler et al., 2009). In addition, counties in Texas practically have no planning authority, which exacerbates the ability of county leaders to address growth problems (Zhang, 2007).

Another challenge identified by Butler et al. (2009) is the connectivity within the megaregion. As stated by the authors, "the Texas Triangle is dominated by automobile, truck and air transportation systems. Development of late 20th century metropolitan regions was made possible by the construction of interstate highways, which are uniquely suited to serve urban regions stretching 30–80 miles across. A related challenge concerns the restoration of infrastructure while building new projects for an expanding population. New roadways, bridges, parks, water and sewer lines, utility plants and wastewater treatment facilities will be needed for this first urban Texas century" (Butler et al. 2009). Although Dallas, Houston, and Austin have begun metropolitan rail systems, there is no intercity rail network among the major Texas Triangle cities (Zhang, 2007).

Another challenge for the megaregion will be how to address the conservation and use of natural resources. As cities grow larger and population growth expands, natural resources like water will become an issue. In addition, increased population density may lead to increased greenhouse gas emission and environmental pollution. Cities need to work together to determine how best to address such issues before they eventually materialize. There may be a need for memorandums of understanding or compromises by all parties involved. A megaregion approach calls for new ideas, methods, and tools for planning beyond the current toolbox of MPOs because of the geographical scale of the megaregion. Cities will need to work together to develop common standards and policies to ensure uniformity among planning organization. Finally, as discussed earlier, public funding of new transportation infrastructure is inadequate and there is therefore a need for feasible and sustainable alternative sources of funding.

The final chapter now considers conclusions and recommendations.

Chapter 6. Conclusions and Recommendations

Texas is ideally placed to embrace, and benefit from, megaregional planning. Several of the 12 areas identified as megaregions are multi-state, which carries both costs and benefits. Multi-state projects, when capable of promoting economic growth, are supported by a large number of politicians, industries, and voters. However, they can be more complex and expensive to plan and administer and thus are vulnerable to revenue shortfalls at state and federal levels. Texas has a foothold in both state and multi-state planning because the Triangle lies within the state and the Gulf megaregion links with Louisiana.

This report concludes that there is overwhelming evidence to support some level of megaregional integration into current state transportation planning. The strong growth in state population since 2000, which is predicted to continue to grow to 2030 and beyond, becomes a key driver in this conclusion, as a majority of the state population will reside within the Triangle. The research benefitted from preliminary results given at the mid-year 2011 Transportation Research Board meeting by a Volpe team[31] working on a study sponsored by the Federal Highway Administration (FHWA)[32]. The key preliminary results, linking state and MPO planning, are reproduced in their entirety and comprise the following:

- *Megaregions are successfully defined by infrastructure, social, environmental, and economic needs. However, boundaries may need to be flexible to accommodate diverse participation and projects.*

- *Megaregions institutions often convene, informally or formally, to address a specific issue, such as freight or Intelligent Transportation Systems, and expand to serve a broader strategic, coordination, or communication function across the megaregion.*

- *Megaregions institutions with more formalized structure and regular communications are effective at establishing joint priorities, engaging stakeholders through visioning, and implementing megaregions-scale initiatives.*

- *Due to funding constraints and formal responsibilities, MPOs have limited time and staff to apply to megaregions planning. MPOs are more likely to be involved if there is a clear and tangible benefit to their planning area, such as the opportunity to partner on a study or project or to access essential data.*

The Volpe research clearly supports a step-wise, hierarchical approach to megaregional planning that is of particular benefit for those Departments of Transportation—like TxDOT—that work closely with MPOs yet need to have a regional system-wide vision to ensure corridor needs are being addressed. As noted earlier, railroads have a system-wide view and megaregions allow the DOT to view highways, and other modes, in a similar fashion, thus framing transportation planning to meet the future freight needs of large multi-MPO agglomerations.

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[31] Led by Dr. William Lyons, Volpe Center Project Manager

[32] Managed by Frederick Bowers, FHWA Project Manager, Office of Planning

Table 7 summarizes this process, which describes preliminary recommendations for moving towards a comprehensive megaregional planning process that includes MPOs and other key stakeholders.

Table 7: Hierarchy of Megaregion Transportation Planning

1. Define needs, measure passenger and freight flows, and establish boundaries.
2. Conduct stakeholder outreach and development of priorities and strategies.
3. Conduct data collection, cooperative, sub-area, or modal studies.
4. Integrate findings into the MPO planning process and MPO project selection with DOT participation.
5. Implement joint megaregion projects.
6. Manage the system, update, and improve elements over time, measure benefits.

Source: Adapted from Volpe Study presentation at 2011 TRB Summer Meeting. Report forthcoming.

The process has clear sequential steps that allow transportation planners to first measure current and future demand for transportation services—in this case freight—and establish geographical boundaries. Next, priorities and strategies are determined based on stakeholder feedback and data collected to allow cost-benefit and system-wide efficiencies to be estimated. These three activities are quite familiar to most transportation planners—the difference lies in the scale and the system-wide perspective. The next step of integration goes beyond the single MPO and requires that every MPO impacted by the investment is aware of the project(s). The state DOT planning group can also play an important role in this integration. In Texas, all MPOs are represented by a single entity—Texas MPO or TEMPO—so the megaregional group in Texas would comprise individual impacted MPOs, TEMPO, and TxDOT. The final steps cover the implementation, management, feedback, and improvement of the process.

The overriding conclusion from this work is that megaregional planning has much to recommend and should be pursued at the state, multi-state, and federal levels. Work on highway corridors has been particularly disappointing in terms of new policies and investment packages that benefit corridor improvement. Segments of the interstate highway system face severe congestion that will not be relieved by additional capacity investment in the next decade. Frequently, the planners think of alternative modes and pose questions such as "can rail carry a major part of the freight growth?" Megaregional planning captures all modes and corridors and can be extended to reflect much of the transportation supply chain using basic cost models and transfer costs to evaluate financial impacts.

In summary, the findings strongly suggest that:

1. Megaregional planning, if undertaken, should include freight systems and needs.
2. The state Department of Transport should introduce elements of megaregional planning into its statewide planning, perhaps starting with corridor needs.
3. Planners at the MPO and state levels should develop levels of integration, including the private sector, to target bottlenecks to raise corridor efficiencies.
4. The use of cost models that evaluate freight transportation chains are part of that integration process.

The results of this study led to the award, in 2010, of a one year TxDOT sponsored study 0-6627 entitled "Megaregion Freight Issues in Texas: A Synopsis," which reviews in greater detail freight issues and megaregional planning at the state and MPO levels in Texas, with specific reference to TxDOT. The TxDOT study will examine the literature, interview stakeholders, MPO staff and freight providers and hold workshops to examine how megaregional planning can be formally included in Texas state-wide transportation planning, what benefits and costs are associated with its adoption, and what issues are of specific interest to TxDOT and the MPOs lying within megaregion boundaries. The final report is currently in draft prior to review by the sponsor and should be available by early 2012.

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