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16. Abstract The Trans-Texas Corridor (TTC) will provide relatively few links to by-passed metropolitan areas, and it is highly likely that inland ports or groups of "big box" outlets will be developed close to such connections to promote more efficient freight distribution. Project 0-4702 evaluated data, models and developed potential guidelines for Texas Department of Transportation (TxDOT) staff, or its consultants, to use when addressing issues of location, design, and impacts of such inland ports. Metropolitan traffic flows, as well as traffic impacts on linkages to nearby urban centers, were simulated using a state-of-the-art location model developed by the team. Furthermore, a chapter on the economic development dimension of inland ports provides complementary information to the location model. The products of the research should permit planners—particularly those in a TxDOT District or MPO—to understand the traffic consequences of a specific inland port location, and make recommendations focused on improving metropolitan traffic flow at the chosen location.					
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Robert Harrison
Yi-Chang Chiu
Mike Schofield
Russell Henk
Lisa Loftus-Otway
Peter Siegesmund
Rajat Rajbhandari
Hua Yang
Brenda Bustillos
Swapnil Samant

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Center for Transportation Research
The University of Texas at Austin
3208 Red River
Austin, Texas 78705

www.texas.edu/research/ctr

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Research Supervisor: Robert Harrison

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Products

Several products were developed as part of the 0-4702 project activities. Product 1—the locational model—was developed within the first 15 months of the research and then went through several revisions. The final version is provided as a CD with this document, and additional copies can be obtained from the TxDOT library at CTR or through Dr. Yi-Chang Chiu, formerly at the University of Texas at El Paso and now at the University of Arizona. Product 2—Traffic Analysis—was incorporated into the locational model and subsequently tested in the two case studies reported in this document. Product 3—Economic Impacts—could not be incorporated into the locational model due to data disaggregation issues and appears as Chapter 6 in this report. Finally, Product 4—Project Guide—which is the user guide to the locational model, appears both as Appendix A in this report and on the CD containing the model.

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Chapter 1. Introduction and Project Background

1.1 Introduction

President Dwight Eisenhower signed legislation in 1956 that began the construction of what became the largest public works project ever undertaken in the United States (U.S.). This program, initially named the *National System of Interstate Defense Highways*, is now more commonly termed the *Interstate Highway (IH) System*. Completed in the early 1990s at a total cost of more than \$130 billion, it consists of approximately 46,000 miles of divided highway containing over 45,000 structures. Economists, historians, and social scientists have debated its impact on the U.S. economy and many have concluded that it exceeded the impact achieved by the railroads 100 years earlier.

The interstate system is a strategic system of highways originally designed to link all U.S. communities with populations exceeding 50,000 residents through a national highway system that would include international boundaries with Canada and Mexico. The final network of high quality, high-strength highways profoundly enhanced U.S. economic development and the quality of U.S. personal and business mobility. The interstate system created new markets, significantly increased personal and commercial vehicle miles of travel, and had an impact on the distribution of freight, and the modes carrying it, within the U.S.

Senator James Inhofe recently stated when introducing Senate Resolution number 427, celebrating 50 years of the Interstate Highway System. *“The resolution recognizes the vital role the system has played in transporting people and goods to make the United States the world’s leading free society and economy”* (Inhofe, 2006).

Truckers were presented with a rapid, efficient, and inexpensive state and national network. Intercity trucking operations increased from around 190 miles to more than 400 miles per vehicle per day, raising the productivity of the trucking industry and providing a clear competitive advantage over the rail industry, which it still maintains. The post-interstate system era also witnessed a change in U.S. demographic patterns after the economy shifted from a Northeastern to a Southern-Midwest locus, generating change in how the nation’s goods are planned, assembled, and distributed.

In Texas, the IH system was viewed not only as a way of increasing personal mobility but also as a catalyst for economic development. An executive decision in the Texas Highway Department, as the Texas Department of Transportation (TxDOT) was known in the mid-1950s, resulted in frontage roads being provided on all Texas interstate routes, providing access to landowners abutting the new facility. This decision had such a major impact on how Texans live, work, shop, travel, and play that it would have been unimaginable to those living in the first half of the last century. However, this success created demand patterns on the system that cannot be met during peak periods of daily travel. This has led to decreased mobility within major urban areas in Texas. Interstates are now used for commuting and urban mobility—a feature not part of the original concept. Moreover, increases in vehicle-

miles of travel on the system are also now affecting both personal mobility of travelers and the efficiency of trucking companies in the rural areas of Texas.

A Center for Transportation Research (CTR) team in 1994 examined alternative systems to the current interstate network. CTR Project 0-1326 found that vehicular traffic moving through rural sections of IH 35 in Central Texas had been growing at a dramatic rate since 1985. Some rural sections exhibited traffic growth rates as high as 10 percent per annum between 1970 and 1993. The project addressed the capacity dilemma by proposing a solution for how IH transport might be approached in the future. Originally termed a *super corridor* by the team, a concept was proposed that blended a variety of approaches to congestion management in urban settings, primarily by capitalizing on the benefits of multi-modality, as well as providing financial mechanisms to sustain its operation and maintenance.

1.2 Trans-Texas Corridor

In 2002, Governor Rick Perry announced his vision for a new corridor system for Texas, modifying the work undertaken by CTR for TxDOT in a number of important ways. Texas cities would be connected by a 4,000-mile network of corridors up to 1,200 feet wide with separate lanes for passenger vehicles and trucks. Figure 1.1 shows the initial conceptual location of all TTC segments.

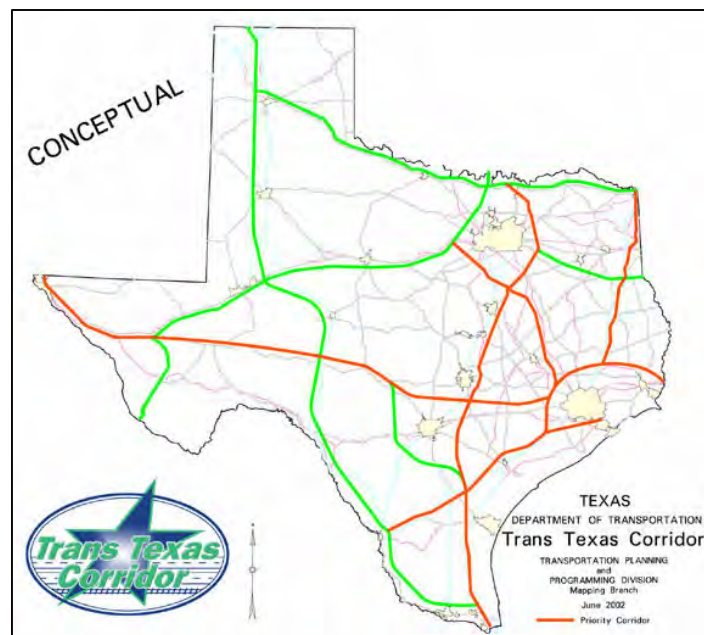


Figure 1.1. Planned Trans-Texas Corridor

The corridor “vision” included three railway routes: one for high-speed passenger travel, one for high-speed freight, and the other for conventional commuter and freight trains. The final component of the corridor included a 200-foot dedicated utility zone. The elements are similar to those recommended in Project 0-1326, with the exception of different types of rail systems and the magnitude of the right-of-way. In December 2004, the Texas Transportation Commission awarded the Cintra-Zachary (CZ) consortium a Comprehensive Development Agreement (CDA) to begin development of the first portion of the TTC, known as TTC-35. Figure 1.2 shows a conceptualized rendering of the Trans Texas Corridor layout with separated lanes for car, truck, rail, and utilities.



Figure 1.2. Conceptualized Layout of Separated Lanes for Cars, Trucks, Rail and Utilities

Source: TxDOT

TxDOT planners identified four TTC priority corridors to complement existing interstates. These comprised IH 35/IH 37, the proposed IH 69 from Dennison to the Rio Grande Valley, IH 45 from Dallas–Fort Worth to Houston, and IH 10 from El Paso to Orange. Cost

“Connection between the Corridor and nearby cities can be accomplished with the existing highway system. Proposed corridor segments would require interconnection with additional modes of transportation to enable passengers and freight to reach their final destinations.”

Trans Texas Corridor Plan, June 2002

estimates were prepared as a part of a preliminary analysis conducted by TxDOT in 2002 (TxDOT 2002). In the initial proposal, a variety of funding methods were suggested, including public–private partnerships, and state legislation was subsequently changed to enable toll equity, Regional Mobility Authorities, and the Texas Mobility Fund initiatives to contribute to the TTC. However, a critical element to the funding system would come from private consortia that would raise bonds on the U.S. and foreign markets and receive revenues from the variety of system beneficiaries. A key issue with the Managed Transportation System (MTS) and the TTC—and the key element of study 0-4702—is how best to connect the TTC to urban areas. When evaluating the MTS, CTR staff proposed tying in the highway element to the outer city highway loops and the rail into the existing lines that would allow connectivity to the central city rail yards, where these existed. The TTC faces a similar dilemma. Where should it most effectively connect to the existing highway system? Clearly this is an important issue, because the economic feasibility of the TTC will depend on shippers profitably assembling, trans-shipping, and delivering goods to the growing Texas urban population centers along and/or adjacent to its network. Project 0-4702 was to provide guidance on the appropriate development and location of such trans-shipment centers, which will be intermodal in nature and situated at specific points on the TTC network near urban population centers.

1.3 Inland Ports

The TTC is seen as a transportation network that will enable the Texas economy to continue competing effectively in both regional and global marketplaces in future years. The manufacturing focus in many industries has already shifted to include international operations and, consequently, this produces long transportation supply chains. This shift requires

planners to evaluate the importance and location of both transportation corridors and distribution centers. Traditional nodes on supply chains include ports at land, sea, and coastal borders where international trade is processed. However, planners in the logistics sector now recognize that a growing amount of trade can be processed at inland sites. An inland port is a location where a variety of value-added transportation services is offered at a common location. Project 0-4083 examined the identification and classification of inland ports and the roles that these ports play in distribution processes. Two reports and a guide (Harrison and Leitner 2002 and Prozzi et al. 2002) were produced from this project for transportation planners to use in TxDOT central and district offices.

The TTC users will comprise two broad groups—namely, passengers and freight. Freight movements could flow on a variety of modes and types of highway—for example, on separate truck-only lanes where higher weights were permitted. The TTC network is not going through existing urban areas, so it will be necessary to develop freight centers at urban limits where distribution and other services can be undertaken. An obvious candidate for such a freight center is one of the several inland port types identified in Report 0-4083-1. These ports can be relatively small and simple at the start, yet grow to be large centers encompassing a variety of value-added services, and can serve as an economic and employment stimulus to the local economy. If the community served by the TTC were relatively small, then a more modest inland port would be needed, whereas a port linking a metroplex like Dallas-Fort Worth would be larger and more complex.

1.4 Project Purpose

TTC elements such as SH 130 will bypass current metropolitan areas. TTC users will travel to destinations within these areas by exiting the TTC and using arterial links within the current highway network. Changes in the logistical systems currently used to move products within the U.S suggest that large distribution centers will be the primary destination of much inter-city truck traffic. Possible consequences of using the TTC for freight include the potential for such centers to move close to the exit/entrance ramps, so enhancing the efficiency of inter-city truck operations and reducing congestion by permitting smaller sized trucks to undertake urban deliveries to final retail and manufacturing sites.

This relocation can be done either piecemeal or through the development of inland port sites where a variety of companies can operate their facilities. Inland ports create many urban impacts, and the full range of both benefits and costs should be clearly understood. These benefits include increased property values, jobs creation, reduced transportation costs, and increased tax revenues (Figliozi and Walton 1999). Localized negative traffic impacts also occur in the inland port vicinity due to increased truck volumes that may create congestion-related environmental impacts. Such impacts highlight a potential need for industrial zoning restrictions to prevent incompatible land-uses from being developed in these areas.

Location may be a critical element in determining whether the value added from the inland port justifies the cost of its construction and operation. It is highly likely that inland ports will be built by the private sector and will not be part of the basic TTC design. This is unfortunate since it would almost certainly strengthen the economic viability of the TTC. In any event, there will be economic activity generated around the relatively few ramps of the TTC; TxDOT will be consulted and involved when this is being planned. The purpose of Project 0-4702 was to study the planning impacts of any inland port designed to enhance freight efficiencies at the junctions of arterials and the TTC. These impacts relied upon on a model to

determine traffic impacts of each possible site being considered as an inland port location. The proposal was based on the assumption that the consortium selected for the first element of the TTC (TTC 35) would be in place and likely to be a willing partner in developing this approach. As it transpired, the C-Z consortium chosen by TxDOT was not selected until 18 months into this project and their planners were therefore unable to comment on the work until after the project report was drafted. In this important respect, the main product of this study—the locational model—could not be used as part of their initial SH 130 master plan and is therefore more likely to be useful to TxDOT and metropolitan planning organizations (MPOs) when the SH 130 proposals move into detailed planning. Finally, as discussed in the conclusions, the model could be used to evaluate the traffic consequences of new super-distribution (“big-box”) centers now being built on or near Texas highways.

1.5 Organization of Report

The remainder of this report is as follows. Chapter 2 examines the changing face of Texas and examines how these changes have contributed to the development of the TTC concept. The chapter also reviews the importance of TTC connectivity to metropolitan areas. Chapter 3 provides an overview of the location model developed during this study. Chapters 4 and 5 discuss the case studies on potential inland port sites undertaken in Austin and San Antonio using the location model. Chapter 6 discusses the economic benefits and impacts that inland port nodes could create for local, regional, and state economies. Chapter 7 summarizes the project’s findings and conclusions. Finally, Appendices A, B, and C, respectively, provide a location model software guidebook; background information on the Managed Transportation System developed in TxDOT Research Project 0-1326; and a technical description of the inland port selection decision model. Appendix D contains an annotated bibliography on the economic impacts of transportation investment.

Chapter 2. The Changing Face of Texas

2.1 Texas Demographics—New Challenges

Texas is expected to undergo rapid changes in its demographic make-up, economic health, and trade growth over the next 25 years. In the face of such changes, the TTC continues to be seen as a next step in promoting TxDOT's Strategic Plan goals to improve mobility, enhance safety, improve air quality, promote trade, preserve the value of its transportation assets, and ensure a healthy and vibrant economy for Texans during the new millennia.

2.1.1 Population

The state of Texas has undergone intense population growth. Throughout the 1990s the population grew by 23 percent. Texas is now second only to California as the most populous state in the U.S.. Census figures project that this increase will continue and, by 2040, Texas' population is estimated to be 35 million people. That is a 58 percent increase over the current population.

Much of the projected growth will be concentrated in the state's metropolitan areas, specifically within the triangle formed by San Antonio, Dallas–Fort Worth, and Houston, and in the Rio Grande Valley. This is because Texas is not only experiencing intense growth but also a rural-to-urban shift of its population. Since the last census in 2000, the 58 metropolitan counties in Texas accounted for 95 percent of the state's population growth. By 2040, the Houston metropolitan area is expected to grow by 81 percent, the Dallas-Fort Worth metropolitan area by 102 percent, and the Austin metropolitan area by 107 percent. According to 2000 census data, 57 percent of Texas growth was located in central city metropolitan areas and 43 percent in suburban metropolitan areas. Five counties—Harris, Tarrant, Collin, Bexar and Denton—accounted for 45 percent of the state's population growth. These counties include the central cities of Houston, Fort Worth, and San Antonio, as well as two suburban counties in the Dallas metropolitan area. Currently, 82 percent of the Texas population resides in urban or metropolitan areas.

2.2 International Trade

The Texas transportation network is the linchpin of economic growth in the state, particularly within the Dallas-Fort Worth, San Antonio, and Houston “triangle.”

The Texas interstate highway system has been crucial to this success, offering easy movement of people and goods within the state. Texas is also fortunate that other modes have contributed to its transportation system, including:

- A deepwater port network, linked to the Gulf Intercoastal Waterway
- Dallas-Fort Worth and George Bush Intercontinental international airports
- Railway infrastructure

This transportation system has played an important role in supporting growth in the state economy over the past 30 thirty years. The growth in U.S.–Mexico trade following ratification of the North American Free Trade Agreement (NAFTA) placed additional demand along the Texas–Mexico border region and the major transportation corridors in Texas carrying NAFTA traffic. Growth in international trade has also had a dramatic effect

on the growth of truck, port and rail traffic across Texas. In recent years, support has weakened because highway and rail investments have been unable to match the user demand. Highways have experienced congestion and maintenance backlogs made worse by the diminishing value of the gasoline tax—last increased in 1991—which forms a major revenue base for TxDOT. Congestion, while representing an indicator of successful growth also influences corporate location and impacts state economic growth. Dell Corporation, for example, indicated that local transportation conditions would affect future decisions regarding their corporate growth within the Austin metropolitan area. The planning challenge is to balance investments in highway infrastructure so that congestion is mitigated to acceptable levels.

In the ten-plus years since NAFTA's implementation, trade with Mexico and Canada has grown dramatically. According to testimony before the Senate sub-committee on International Economic Policy, Export, and Trade Promotion (Aldonas 2004), total trade among the NAFTA partners doubled from \$302 billion in 1993 to \$652 billion in 2003 and represented over one-third of total U.S. exports. U.S. exports to Canada and Mexico increased during NAFTA's first decade from \$142 billion to \$267 billion. Figure 2.1 shows U.S. NAFTA trade growth. It is estimated that over 40 percent of U.S.–Mexico trade has origins or destination in Texas (Weissmann and Harrison 1994) NAFTA trade is predicted to continue to grow throughout Texas over the next ten to twenty years at more modest rates than those reached in the first decade of the treaty.

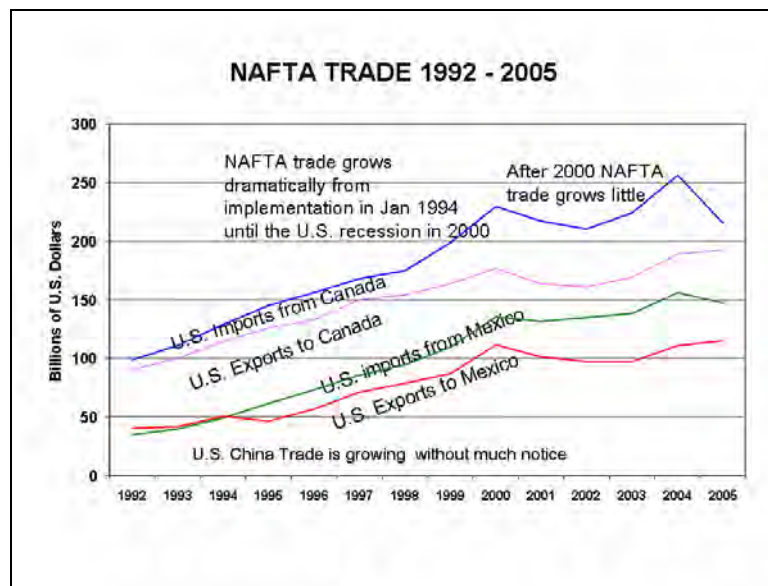


Figure 2.1. NAFTA Trade Post Implementation

Source: John P. McCray, Presentation for the Conference on Transportation and Economic Development, Little Rock, Arkansas 2006

McCray's 2006 analysis also spotlights the rising growth in trade with China, which has now become the dominant U.S. trade partner in the Pacific. At current projections, China will become the overall dominant U.S. trade partner within ten years. Figure 2.2 shows the phenomenal growth in U.S.-China trade since 2000.



Figure 2.2. Growing U.S-China Trade

Source: John P. McCray 2006

U.S.-China trade is predominantly containerized and moves through West Coast seaports to distribution centers throughout the U.S by truck or “double stack” rail service. However, this distribution pattern may be slowly changing; recent CTR analysis (Harrison et al. 2006) finds that shippers are reviewing a number of alternative corridors to those centered on southern Californian ports. These include other Californian and Northwestern ports, the water services throughout the Panama and Suez Canals, and Mexican Pacific ports served by rail. The latter would take containers cleared at Mexican ports to Texas ports of entry, which could, in turn, create new distribution and manufacture patterns within the existing state transportation network and proposed Trans Texas Corridor network.

With the predicted trade growth expected over the next ten to twenty years, the need to move freight throughout Texas and its metropolitan areas in an efficient manner will become paramount. The growth of containerized and non-bulk trade that is predicted to come to Texas and transship through Texas will require efficient, modern, and fast transportation systems, corridors that are multi-modal in nature, and transshipment and logistic centers such as inland ports to provide value-added service.

2.3 Texas Transportation Corridors and Inland Port Node Connectivity

The projected population growth, changes in migration shifts, and the demographic and economic characteristics of Texas citizens will also present many challenges for the state, one of which is the ability of the transportation system to meet the needs of a growing and increasingly concentrated population. Demographic changes expected to occur in Texas will also have an effect upon funding of state activities. Education, health care, and retirement are all expected to require a larger share of state and local funds in the foreseeable future and will impact the state’s budget and ability to pay for transportation infrastructure.

The TTC will play a vital role in ensuring access and opportunities for citizens of Texas. Inland port nodes on the TTC could also, therefore, provide employment for the growing and diversifying Texas population. These urban population increases will have an impact not only

on the economies of the urban areas, but also on the truck traffic generated, the need for inland ports, and the traffic impact of building inland ports. Inland ports will become a vital component within this transportation network—creating jobs, economic development and ensuring the smooth flow of goods and services to the Texas population.

2.3.1 Inland Port and Logistic/Distribution Center Development in Texas

In 2006 Texas had two large inland port developments. Alliance, owned and operated by the Hillwood Group, is located north of Fort Worth on IH 35 West. KellyUSA is situated on a former Air Force base in San Antonio. An inland port is also in the planning stages in South Dallas, centered on the new UP intermodal terminal at Wilmer on IH 45. Texas is also home to distribution and logistics centers for major U.S. retailers such as Wal-Mart, JC Penney, Target, Family Dollar, and Lowe's. These centers have become intensive traffic generators on the Texas highway network, especially in rural areas. A recent *Journal of Commerce* article stated “the role of Distribution Centers (DCs) in international logistics is critical and DCs, in their various forms, are a growth business” (Tirschwell 2005). It is logical, therefore, to link DCs with the TTC, because they could form natural transfer points linking the segments of the TTC with the metropolitan road and rail systems.

2.4 Locating Inland Ports

So how do the TTC and inland port nodes tie into demographic changes and economic trends in Texas? Simply put, there will also be an ever-growing need for transshipments and bypasses of Texas's metropolitan areas, particularly if they become more congested due to increased population and the growth of trade. The TTC and inland port nodes will assist in facilitating this movement and will provide vital connectivity for goods and services into the metropolitan areas.

The Trans Texas Corridor Advisory Committee noted in its first report to the Texas Transportation Commission in December 2005 (TTC-AC, 2005) that of three key areas it initially focused upon, location and connectivity were critical components in ensuring trade facilitation, multimodal connectivity and financial feasibility. Tim Brown, the Chair of the Committee, stated that “the...largest piece in all of these topics that overlap—by the way—is connectivity and (*sic*)...integration into the local and regional transportation grid as a critical piece.” (TTC-AC, 2005)

The TTC, when implemented, will either be directly (planned) or indirectly (market response) linked to inland ports and/or DCs for freight distribution. The problem for the TxDOT or MPO planners then becomes one of assessing the best city location in terms of its effect on traffic flow. Locational criteria could include minimizing the impact of inland port or DC-generated truck flows on existing traffic, mitigating air quality degradation, and maintaining connectivity with other modes of transportation. Project 0-4702 was tasked with the development of such a locational model and the next chapter describes the final version of the model.

Chapter 3. Inland Port Location Decision Making Tool

3.1 Introduction

Inland port location can play a major role in metropolitan transportation planning, as it may create a variety of negative impacts, including those on traffic (metropolitan accessibility and congestion), the environment (air and water pollution, and intrusion on environmentally sensitive areas), and economic (economic growth and employment) development. Therefore, site selection of both inland ports and DCs is a critical step in (a) ensuring that these broader issues are treated equitably and (b) that the chosen location(s) complement TTC operations.

The location-selection decision problem centers on selecting from one to several pertinent inland port sites, based on selection criteria related to the existing infrastructure and/or operating characteristics of inland ports. Research project 0-4083 showed that a range of potential inland port sites exists, from brown fields like KellyUSA to green fields like Alliance. This is a complex process to model in its entirety, so the development of the 0-4702 inland port locational model focused on a decision process that incorporated existing macro-level site selection criteria, ignoring any potential investment required to improve a specific site criterion.

3.2 Multiple Criteria Decision Making

Given the complexity of inland port location selection and the potential conflicts of interest from multiple players, it is clear that traditional single-objective/criterion methods (Wang, Sarker, et al. 2003) will not provide decision makers (DMs) with sufficient tools and/or guidance to make an informed decision. For this reason, the location selection model decision analysis employs distinct features that depart from these traditional methods.

Multiple criteria decision-making (MCDM) approaches were preferred for development of the location selection model. MCDM is useful when one factor alone does not influence a decision but multiple, usually conflicting, criteria are present (Hwang and Yoon 1981). It is a descriptive approach that describes the problem by defining the possible decisions, attributes, and evaluation criteria, and by incorporating, in a utility function, the set of retained criteria (T'kindt and Billaut 2002). Despite these diverse fields of application, MCDM methods have certain aspects in common. The four critical elements in an MCDM problem are *attributes*, *objectives*, *goals*, and *criteria*. In other words, one MCDM problem can be a problem of multiple attributes, objectives, goals, or criteria (Greiner et al. 2005). Inland port location selection is a typical MCDM problem, which is why this method was selected for developing the location selection model in study 0-4702.

Specifically, for the inland port location-selection problem, the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) (Hwang et al. 1981) was deemed a suitable method, as it is a compensatory decision model that permits trade-offs between attributes. In addition, this model can also select an alternative location closest to the ideal solution. As an example, Hwang et al. applied TOPSIS to select the location of a manufacturing plant—although normalizations for cost and benefit criteria were not considered in their model (Hwang et al. 1981). TOPSIS requires all criteria to have the same unit length of vector and assumes each criterion takes either monotonically increasing or monotonically decreasing utility. However, the normalization minimum and the maximum

values of the scale are not equal to each criterion, so straightforward comparisons are still difficult. This study adopted a different normalization for benefit and cost criteria, which in location of inland ports is often expressed as a verbal opinion and converted these linguistic terms to their corresponding fuzzy numbers (Chen and Hwang 1992). This generates a scale of measurement that varies from zero to one for each stated criterion; the scale is discussed later in this chapter and in Appendix C.

The model developed in this study was alpha tested in the El Paso metropolitan area because city data—including two prior studies commissioned by El Paso—were accessible to the study group. The first study determined the feasibility and operation of an intermodal transportation hub in the El Paso area (Kimley-Horn and Associates 2004). The second study supplemented the first as it focused on the railroad elements of the intermodal facility (Moffatt and Nichol 2003).

The following topics are presented in the remainder of this chapter. First, a model based on various input characteristics is outlined to select the best inland port from a group of candidate sites. Second, a systematic procedure to address the decision problem is elaborated. Third, a program is described that implements the process of inland port selection using the Caliper Corporation's Geographic Information System Developer's Kit (GISDK). Fourth and finally, the application of the alpha model in the El Paso case study is discussed.

3.3 Methodology

3.3.1 Introduction

If inland ports are to act as nodes on the TTC, then their location will be critical in reducing transportation costs. In developing a local selection decision tool the study team chose to adopt methods used in MCDM, which allows a user to input various criteria (verbal and numeric) into the selection tool software, which will be used to generate a final recommendation. The entire decision process was also designed to include a pre-screening stage and a MCDM decision stage to enhance the decision process. As shown in Figure 3.1, the decision process starts from a set of preliminary candidate sites. Existing single-mode and multi-mode freight terminals, and other potential sites, can be selected into the set of preliminary sites. If multiple hard requirements are applied, only those that meet all the requirements are eligible to enter the second-stage decision process. The designation of the hard requirements is subject to localized considerations. For example, if concerns of environmental protection arise, a hard requirement such as “the site needs to be 10 miles away from the designated environmentally sensitive area” can be a specified requirement. For those sites that qualify for further consideration, the proposed modified fuzzy TOPSIS approach is applied to select the most preferred sites. If major changes in policy, scenario, or preference occur, the process reiterates and selects new sites according to the changes; otherwise, the model terminates with a final recommendation.

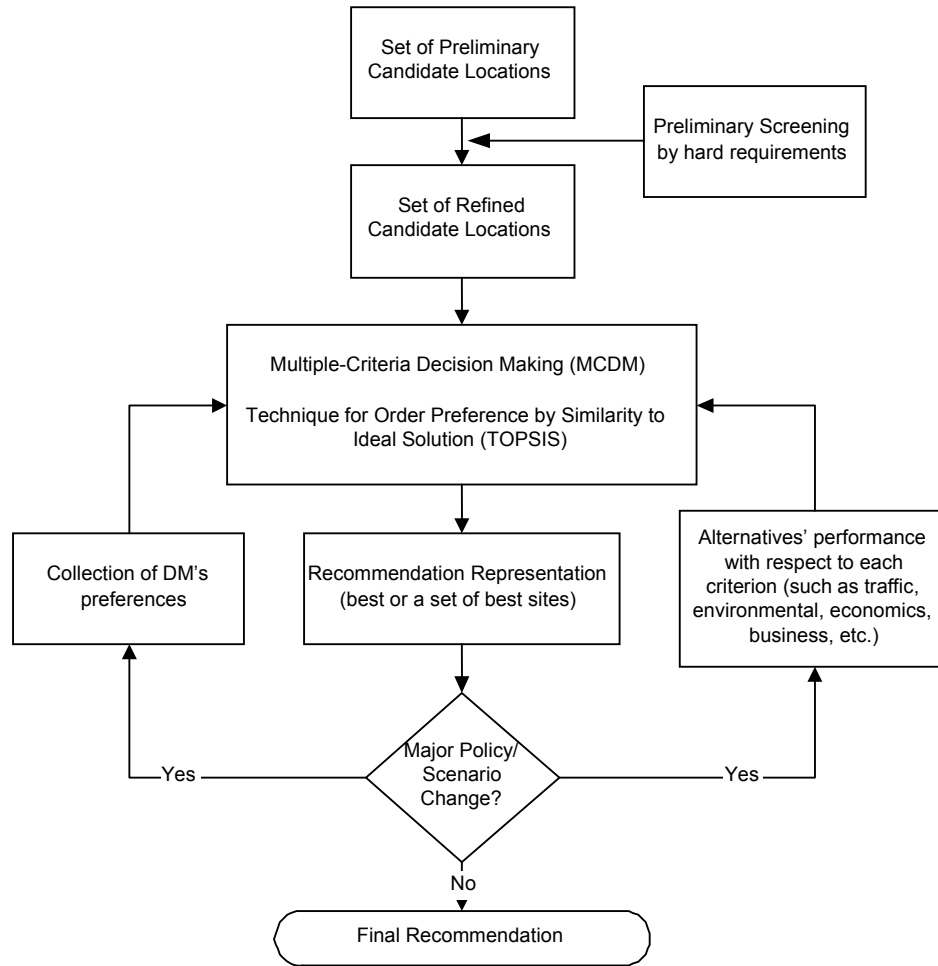


Figure 3.1. Decision Framework for TTC Inland Port Location-Selection Problem

The proposed modified TOPSIS approach considers multiple inland port location attributes (criteria) in a group decision-making environment. Examples of such criteria include investment cost, availability of land area, traffic impacts, environmental factors, and economic impacts. Based on the inland port definition and classification (Harrison and Leitner 2002), seven attributes are recommended as the minimum selection criteria. These attributes are *accessibility to the TTC*, *land area availability*, *existing modal capacity*, *economic impacts*, *environmental factors*, *construction costs*, and *traffic impacts*. The proposed fuzzy TOPSIS model is aimed at flexibly incorporating both qualitative and quantitative attributes, recognizing that at the planning/decision phase, data and information may be available at varying degrees of resolution and accuracy. As an example, the traffic impact for each site can be captured accurately via traffic impact study using various tools, such as regional planning models or traffic simulation models. However, it is also likely that such detailed analysis may be unavailable due to time or budget constraints at the time of analysis. As a result, subjective and qualitative assessment becomes inevitable.

Because qualitative and quantitative attributes are likely to be used, a unifying treatment on both types of attributes is needed. The qualitative attributes are best represented using linguistic terms. The quantitative attributes may also have dissimilar units (e.g., \$, ft²). Next, both qualitative and quantitative types of attributes need to be normalized into a common

scale to ensure compatibility and consistency in model computation. Furthermore, all attributes can be defined as benefit attributes (the larger attribute value, the greater preference) and cost attributes. Different normalization techniques are required for benefit and cost attributes.

In the present model, linguistic terms are represented as fuzzy numbers and are later converted into crisp numbers for further computation with other quantitative attributes. The proposed TOPSIS analysis entails the following seven steps:

1. Transform all linguistic fuzzy numbers into crisp scores,
2. Normalize both benefit and cost criteria,
3. Determine criteria weights using the entropy measures,
4. Compute the weighted normalized decision matrix,
5. Calculate the ideal and negative solutions,
6. Measure the separation between each alternative by the n-dimensional Euclidean distance, and
7. Calculate the relative closeness to the ideal solution and rank the final preference order.

A detailed discussion of the TOPSIS mathematical process is provided in Appendix C.

3.4 Inland Port Selection Problem Based on the Geographic Information System Developer's Kit

Using this method, a program using Caliper Corporation's Geographic Information System Developer's Kit (GISDK) was developed to implement the process of inland port selection. The program is operated in the environment of TransCAD, which is a commonly used geographic information system (GIS) designed specifically for use by transportation professionals to store, display, manage, and analyze transportation data. TransCAD combines GIS and transportation modeling capabilities in a single integrated platform, providing capabilities that are unmatched by any other package. TransCAD can be used for all modes of transportation, at any scale or level of detail. GISDK is a collection of software tools and documentation that come with TransCAD and make it possible to automate repetitive TransCAD tasks, create user-designed add-ins, integrate other programs, or build custom applications.

3.4.1 TransCAD

TransCAD is widely used at TxDOT and in many MPOs in Texas. It integrates GIS with planning, modeling, and logistics applications, and allows a user to store, retrieve, analyze, and visualize all types of transportation and related geographic data.

TransCAD combines a unique set of capabilities for digital mapping, geographic database management, and presentation graphics, with tools to apply sophisticated transportation, operations research, and statistical models. It has applications for all types of transportation data and for all modes of transportation and is ideal for building transportation information and decision support systems.

TransCAD has five major components:

- (1) A powerful GIS that is available in the Windows operating environment. TransCAD provides tools to create and edit maps and geographic data sets, produce thematic maps and other graphic output, and perform spatial and geographical analyses.
- (2) An extended data model that provides the input to display and manipulate transportation data display. TransCAD allows the user to manipulate all these data types in conjunction with the more traditional GIS entities in a natural, convenient, and powerful manner.
- (3) A collection of transportation analysis procedures assembled in one software package. The complete TransCAD package includes a core set of transportation network analysis and operations research models, a set of advanced analytical models for specific applications, and a set of supporting tools for statistical and econometric analysis.
- (4) It provides broad and comprehensive sets of transportation, geographic, and demographic data. TransCAD includes an extensive library of geographic, demographic, and transportation data that helps users get their projects started quickly.
- (5) It uses a powerful development language for creating macros, add-ins, server applications, custom interfaces and products, and web applications. TransCAD includes GISDK and the Caliper Script programming language.

3.4.2 Geographic Information System Developer's Kit Overview

TransCAD, out of the box, is a powerful and versatile computer program. However, if users require specific functionalities that are not available in the standard software package, they may be able to use GISDK for this purpose. GISDK provides a tool kit for users to customize TransCAD.

The primary component of GISDK is a programming language called Caliper Script, which is a BASIC-type programming language that provides a way to interact with the TransCAD program and data. Also, code written in other languages, such as C or FORTRAN, can be intermixed with GISDK programs written in Caliper Script, facilitating compatibility with existing software.

The primary use of Caliper Script is to interact with TransCAD. There are over one thousand GISDK functions in TransCAD, all of which can be called from Caliper Script. These functions give users a wide variety of tools that range from managing maps and display characteristics to creating, accessing, updating, and analyzing data and data structures, including matrices and networks. In addition, the GISDK functions can be called using Windows Automation, since TransCAD can both act as an Automation Server browser and call TransCAD to provide maps, driving directions, and other services. Caliper Script also provides the capability to program complete custom Windows interfaces for TransCAD applications.

GISDK also allows users to customize TransCAD in three different ways:

- (1) Create add-ins that extend the capabilities of TransCAD or that automate repeated operations.

- (2) Build custom applications that extend or replace the standard interface to provide customized program operation.
- (3) Use TransCAD as an automation server to add maps or transportation analysis functions to fit the user's own programs.

3.4.3 Programming of Inland Port Selection Model in the Geographic Information System Developer's Kit

The inland port location-selection model is implemented in GISDK so that the data and/or functions available in TransCAD can be utilized. For instance, the distance from TTC to an inland port can be calculated by executing the shortest path function in GISDK. Furthermore, measuring traffic impact requires professional transportation tools; GISDK can accomplish this by combining the traffic analysis function of TransCAD. In addition, GISDK can easily calculate the inland port site area using intrinsic function calls.

A flowchart showing how the inland port selection model operates is presented in Figure 3.2. This program first specifies a number of preliminary candidate sites. At this stage, the DM choices and criteria can be as thorough as desired and include any number of possible sites. The sites must be specified in TransCAD using the developed inland port selection tool. The DM must specify the hard criteria. By definition, the hard criteria are those which if violated will disqualify a candidate site. Preliminary sites are filtered based on the hard criteria specifications. After the process of initial screening, the DM will specify criteria for the TOPSIS analysis. The criteria selected will depend upon different users' requirements. Criteria performances can be input according to subjective or quantitative criteria categories. Users can also input criteria performance directly. As discussed previously, the performance information can be either measured by using a subjective assessment or based on other supporting approaches such as relative prior reports or traffic models.

Furthermore, this approach allows users to add more criteria than those specified in the program. When inland port sites and criteria are defined, criteria weights need to be determined. The current version of the inland port selection model automatically generates the criteria weights. Finally, the program provides the TOPSIS analysis results based on the information input by a user. Sensitivity analysis is also operated within in this program. Using sensitivity analysis, users can modify the present model in order to fit the new requirements. This gives users more flexibility to attenuate the model's decision-making process to their requirements. A detailed user's guide for this program can be found in Appendix A.

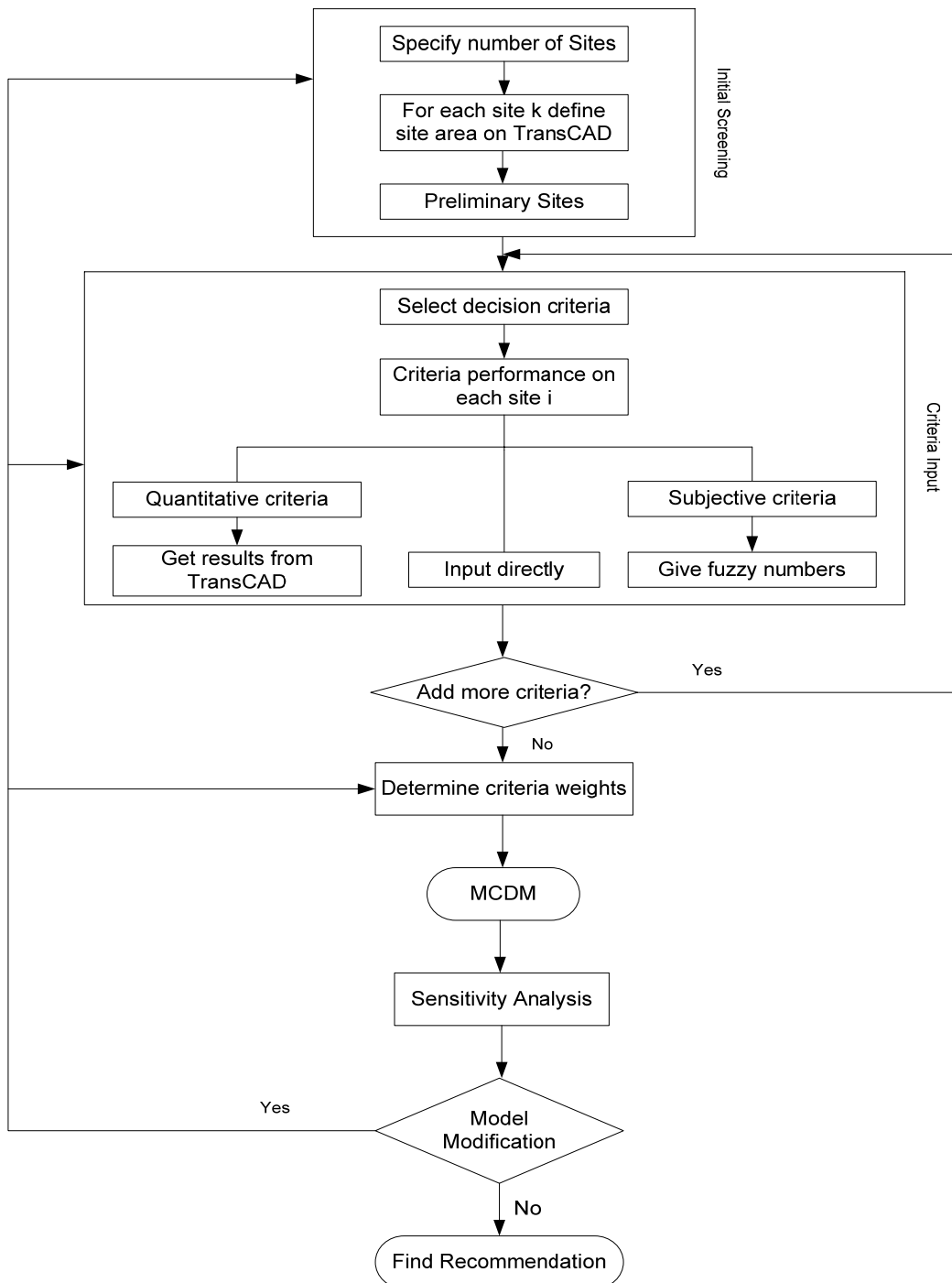


Figure 3.2. Inland Port Location-Selection Programming Flowchart

3.5 Case Study—El Paso

The alpha case study was undertaken to evaluate the performance of the proposed inland port selection model. The proposed scenario was to determine the best location for an inland port in El Paso under a hypothetical TTC route. The choice for undertaking this hypothetical case study was based on several considerations. First, a detailed transportation data set of the El Paso area was readily available to the researchers. Second, the El Paso Metropolitan Planning Organization (MPO) sponsored a study to determine the feasibility of implementing and operating an intermodal transportation hub in the El Paso Urban Transportation Study area (Kimley-Horn and Associates 2004). An intermodal transportation hub has many common elements with that of an inland port and data from this study could be used by the 0-4702 modeling team. Therefore, both data sets could be efficiently accessed to form the inland port location-selection alpha case study.

The preliminary TTC concept includes one corridor to originate/terminate in the El Paso region. Two possible TTC alignment scenarios were considered in this case study, despite a lack of detailed TTC information at the time of the test. The first TTC alignment was assumed to terminate on the northeastern side of El Paso. The second alignment is further away from the city, terminating at the southeastern side of the city. It was decided that the TTC alignment scenario would not extend to the west side of the city because the Franklin Mountains extend northward from the heart of the city to the New Mexico border.

In this alpha case study, five candidate sites were proposed based on a prior study (Kimley-Horn and Associates 2004). Figure 3.3 illustrates the two hypothetical TTC alignment scenarios along with the five candidate sites. The criteria for inland port location selection includes *accessibility to TTC*, *land area availability*, *existing modal capacity*, *economic impacts*, *environmental factors*, *construction costs* and *traffic impacts*. The first four criteria are benefit criteria, and the rest are cost criteria. The *accessibility to TTC* criterion is measured based on the distance between the particular inland port and the TTC node. The *land area availability* criterion reflects the available land size at each site. The criterion for *existing modal capacity* represents the extent of the existing intermodal infrastructure. The *economic impact*, qualitatively measured, is a benefit criterion. The *environmental factor*, measured as a cost criterion, captures the possible environmental impacts of sites. Finally, the *construction cost* represents the amount of capital investment for making the site an operational TTC inland port. A decision matrix was created primarily using both City of El Paso and El Paso MPO expert opinions, in addition to actual measures. For the *accessibility to TTC* criterion, the shortest distances between each candidate site and the TTC were used.

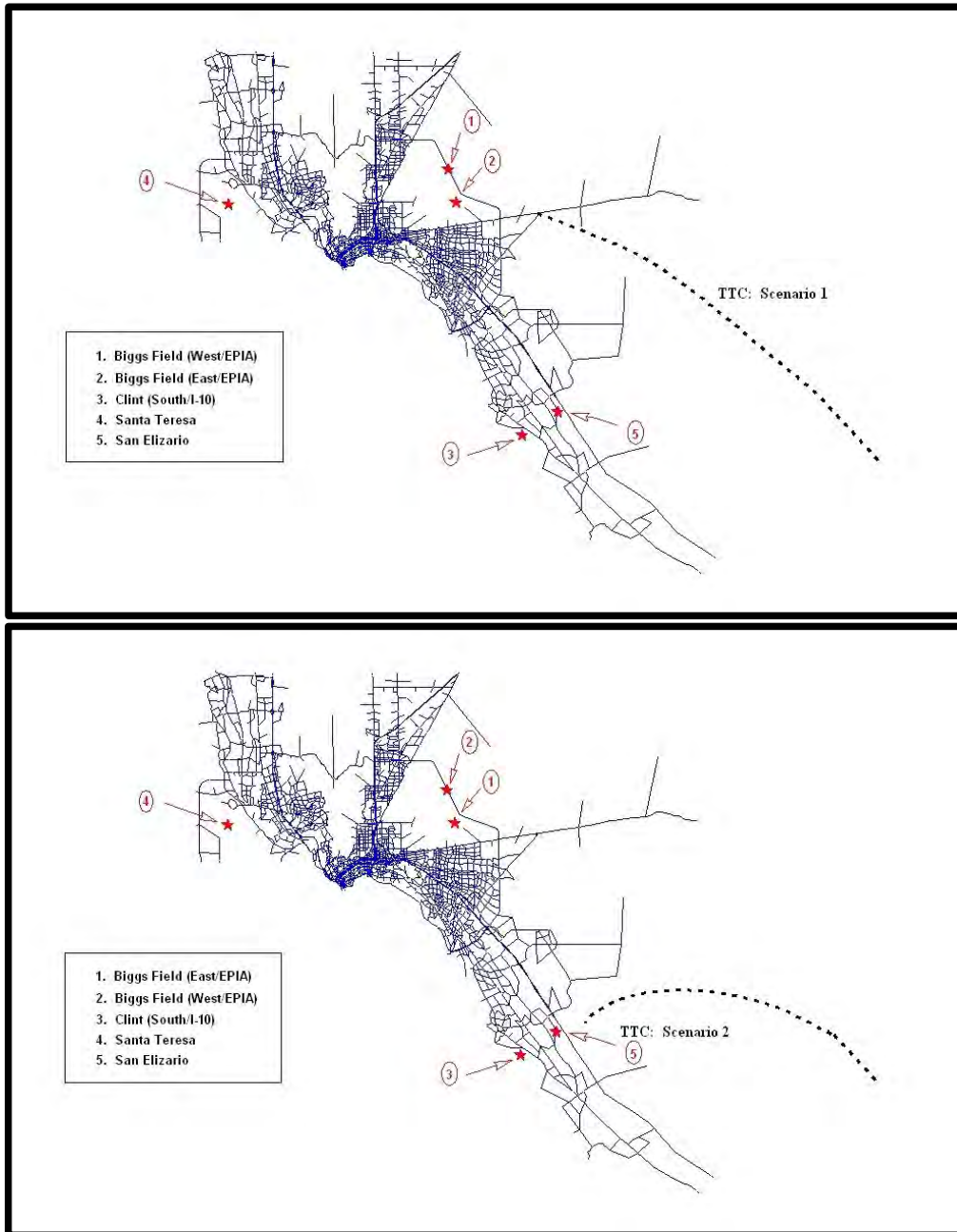


Figure 3.3. Candidate Inland Port Site Ranking under TTC Scenarios 1 and 2

As discussed previously, different TTC alignment scenarios may affect the performance of individual candidate sites and may therefore lead to different analysis outcomes. As shown in Table 3.1, such effects relate primarily to the *accessibility to TTC* and the *traffic impact* criteria. Other criteria were deemed independent from different TTC alignment scenarios. Table 3.1 shows the decision matrix with original measures with respect to all the criteria. The *accessibility to TTC* and *Land Area Availability* criteria were measured using the developed inland port selection tool. The measures of the rest of the criteria were extracted from the reports undertaken by Kimley Horn (Kimley-Horn, 2004). The *traffic impact* criterion can be measured in a variety of ways, from a subjective assessment (with possible loss of accuracy) through to a dynamic traffic assignment network modeling tool like

DYNASMART-P. This models variances in time and has other benefits such as the ability to simulate trip-chaining and report specific output statistics at both the link and the network level.

DYNASMART-P is used only to produce results for the traffic impacts criteria in the inland port location selection tool. The software is not GIS-capable like TransCAD, which can use a combination of spatial, temporal, and descriptive data to display information in layers on a map. TransCAD can also determine traffic impacts but is not as sophisticated as DYNASMART-P, as DYNASMART-P can depict travel conditions with changes in time. Although DYNASMART-P can determine traffic impacts, it cannot be used to provide information for the other criteria, and does not have add-ins available (GISDK can be added only to TransCAD). The data needed to include the other criteria must come from other sources.

The inland port location selection tool can be used without the inputs from DYNASMART-P. As mentioned, TransCAD can provide similar output for the traffic impacts criteria, but it is a static determination. However, the inland port location selection tool cannot operate without TransCAD. TransCAD uses all of the input for the seven criteria to select the best location based on the decision matrix and the objective weights of the evaluation criteria.

The normalized decision matrix and the criteria weights for both TTC scenarios are shown in Tables 3.2 and 3.3.

Table 3.1 Case Study Decision Matrix

<i>Criteria</i>									
Candidate Site	Accessibility to TTC (mile) 1 mi = 1.61 km		Land Area Availability	Existing Modal Capacity	Economic Impacts	Environmental Factor	Construction Cost	Traffic Impact	
	Scenario 1	Scenario 2						Scenario 1	Scenario 2
Santa Teresa	31	40	19	21	18	18	15	0.95	0.95
Biggs Field (West/EPIA)	9	26	34	34	28	28	35	0.5	0.05
Biggs Field (East/EPIA)	8	24	29	25	32	29	26	0.34	0.5
San Elizario	18	3	8	9	9	4	11	0.67	0.67
Clint	13	8	16	16	19	18	18	0.05	0.34

Note: "Accessibility to TTC" is in miles. All other criteria are unitless.

Table 3.2 Normalized Decision Matrix for Case Study

<i>Criteria</i>									
Candidate Site	Accessibility to TTC		Land Area Availability	Existing Modal Capacity	Economic Impacts	Environmental Factor	Construction Cost	Traffic Impact	
	Scenario 1	Scenario 2						Scenario 1	Scenario 2
Santa Teresa	0.00	0.00	0.42	0.48	0.39	0.56	0.17	1.00	1.00
Biggs Field (West/EPIA)	1.00	0.38	1.00	1.00	0.83	0.96	1.00	0.50	0.00
Biggs Field (East/EPIA)	1.00	0.43	0.81	0.64	1.00	1.00	0.63	0.32	0.50
San Elizario	0.59	1.00	0.00	0.00	0.00	0.00	0.00	0.68	0.68
Clint	0.82	0.86	0.31	0.28	0.43	0.56	0.29	0.00	0.32

The different scenarios presented in Tables 3.1–3.2 produce slightly different weights. However, the ranking and order of magnitude of the weights are similar in both scenarios. This is due to the use of entropy measures for calculating the criteria weights based on the normalized decision matrix (see Appendix C for a discussion of both entropy and the derivation of these weights.) In scenario 1, the criterion of *accessibility to TTC* has the highest weight value at 0.216 while the criterion of existing modal capacity has the lowest weight. However, for scenario 2, the *environmental* factors criterion has the highest weight at 0.183, while the existing modal capacity has the lowest weight value.

Table 3.3 Objective Weights of the Evaluation Criteria

<i>Scenario 1</i>		<i>Scenario 2</i>	
Criteria	Weights	Criteria	Weights
Accessibility to TTC	0.216	Accessibility to TTC	0.150
Land area availability	0.130	Land area availability	0.141
Existing modal capability	0.112	Existing modal capability	0.122
Economic impacts	0.132	Economic impacts	0.143
Environmental factors	0.169	Environmental factors	0.183
Cost of construction	0.120	Cost of construction	0.131
Traffic impacts	0.117	Traffic impacts	0.127
Total (rounded)	1.00		1.00

Using the steps presented in Appendix A, the rankings for all candidate sites under different TTC alignment scenarios were calculated. Table 3.4 shows that the overall rankings of sites in the two alignment scenarios are similar, with the notable exception that TTC alignment Scenario One, Biggs Field (West/EPIA), is the best alternative site. Biggs Field (East/EPIA) is the best alternative site if alignment of Scenario Two is realized. In both scenarios, West/EPIA and East/EPIA candidate sites score significantly higher than the rest of the sites, indicating a consistent outstanding performance of both sites. Selecting either of these two sites for an inland port based upon these rankings would be a robust choice. This result can also be seen in Table 3.4—a value of one represents the best inland port location according to that scenario.

Table 3.4 Relative Closeness to Ideal Solution and Final Ranking

Candidate Site	TTC Alignment Scenario 1		TTC Alignment Scenario 2	
	C_i^*	Rank	C_i^*	Rank
Santa Teresa	0.38281	4	0.44261	4
Biggs Field (West/EPIA)	0.85055	1	0.66473	2
Biggs Field (East/EPIA)	0.77061	2	0.69908	1
Clint	0.48771	3	0.47167	3
San Elizario	0.32168	5	0.33124	5

3.6 Summary

Selecting the most desirable inland port site(s) for metropolitan areas along a TTC alignment plays a critical role in ensuring the TTC makes a consistent and coherent contribution to state transportation and logistics planning. This study developed a multiple-criteria decision making approach with the primary objective of assisting planners to reach a consensus decision on a fair and commonly understood basis.

Several novel aspects of the proposed model were discussed in this section of the study. First is the employment of fuzzy theory. It is usual for many decision makers to evaluate criteria using linguistic terms. Fuzzy theory accurately transforms these linguistic terms into quantifiable numbers, which are more straightforward for evaluating every attribute. Another feature of the proposed model is application of the entropy weight method to give each criterion reasonable weights. The entropy weight method is particularly applicable when reliable subjective weights are difficult to obtain. It is also an efficient method for solving complex problems with potential conflicts of interest and objectives from multiple players. This is because the entropy weight method can resolve problems that are encountered when criteria may not be completely independent—as they are all linked and affected to some extent by the operation of the alternatives—when using an objective weighting process. In the process of inland port location selection, selecting sound criteria as an evaluation standard for each candidate inland port location is also important. The present research integrates traditional evaluation standards with special requirements based on the definition and classification of an inland port into the process of criteria selection. Finally, a program using the GISDK for TransCAD was developed to automate and facilitate the calculation of the proposed method. Because it was implemented in the TransCAD environment, this program leads to accurate estimates and evaluation of particular criteria, such as the shortest distance between the TTC and the inland port and traffic impacts. These methods aim to accommodate a variety of possible decision contexts for decision makers, given that the TTC is still at the early planning stage.

Location selections of potential El Paso transportation sites were used as an alpha case study to demonstrate the capability of the proposed model. The evaluation results showed that the proposed method gives effective, reasonable, and acceptable ranking orders for candidate sites.

This method is conceptually straightforward and computationally simple, facilitating its implementation in location selection problems.

Although the present research has proposed a systematic and comprehensive scheme for related research topics, future studies are still necessary to further the understanding and knowledge of the problem of concern. For the development of the GISDK program, additional choices and functions could be added to implement more general location selection problems. By combining the functions of TransCAD and GISDK, this program could be further improved in usability and functionality.

3.7 Utilization of Model in Texas Transportation Corridor Case Studies

This study, as already noted, was over three-quarters complete when the Texas Transportation Commission announced that Cintra-Zachary had been selected to develop the master plan for that segment of the TTC that shadowed IH 35, dubbed TTC 35. While the Commission was open to any TTC 35 alignment proposed for San Antonio, it required that SH 130 be incorporated into the TTC 35 alignment serving the Austin Central Texas region. With this in mind, the research team decided to use the location model developed in 0-4702 to analyze and rank suggested locations in both Austin and San Antonio to evaluate potential inland port nodes on TTC 35. The next two chapters provide case study analyses of these locations using the selection model described in this chapter but in a beta format, following improvements incorporated from the El Paso exercise. It should be noted that the two case studies are slightly different. The Austin case study, because of the known location of SH 130, was able to review green field sites that are currently undeveloped or modestly developed. San Antonio, conversely, required slightly different location parameters because the location of the TTC in relation to San Antonio had not been decided at the time of the study. The TTI team that undertook this case study decided to use pre-existing distribution and transportation infrastructure sites. Consequently the TTI team was also able to provide an example of how the TTC could link one of Texas's existing inland ports—KellyUSA. The next chapter considers the Austin case study issues, including the application of the model described in this chapter.

Chapter 4. The Austin Case Study

Austin was an obvious choice for a case study to evaluate the inland port selection model, since the construction of SH 130, east of downtown as an IH 35 bypass, will create conditions for the city that are similar to what may be seen under the TTC system. It also complemented the San Antonio case study, since it provided an idea of what to expect in a smaller, but quickly growing, city.

One advantage that Austin has over San Antonio for the purpose of the case study is that the alignment of SH 130 is in a relatively undeveloped area, leaving many possibilities for port location. In addition, compared to San Antonio, there is not a great deal of truck traffic traveling to major distribution centers at present. The truck trips are therefore more reasonably assumed to be distributed mainly to the areas containing the densest population.

4.1 Assumptions

A common problem in truck traffic studies is a lack of truck-related traffic data, with the focus of most data collection on overall traffic. In the course of this case study, many assumptions were made to facilitate formulating an easily usable model and to assure consistency between the case studies. More often than not, these assumptions are used when trying to generate freight-specific data where none exists.

The first matter of consistency was setting the study year to 2025, which was convenient due to the amount of data the Capital Area Metropolitan Planning Organization (CAMPO) has available for that year, for both traffic and population. In most cases, these assumptions related to the truck traffic or the added demand from the possible port location to various centers of population density in the city.

The toll feasibility study by Wilbur Smith Associates was used to estimate the total number of trucks that would use this corridor (Wilbur Smith Associates 2005). According to that analysis, the corridor will have 32,620 trucks on it daily in the 2025 study year. The analysis took place on Segments 5 and 6 of SH 130, located just south of Austin. Segments 1 through 4 are to the east and north of Austin and are of more interest to the 0-4702 project team, but as no studies were available on this area, the assumption made was that one-third of the trucks would be diverted to the Austin area while two thirds continue on the corridor. This assumption was used in both case studies and results in 10,873 trucks being diverted to the inland port or, in the no-build alternative, diverted to the entire network equally. A more precise estimate of the proportion of diverted trucks could be obtained using truck-specific traffic counts and origin-destination surveys. This same information could then be used to determine the destinations of the trucks within Austin. This process is detailed in Section 4.7 and requires a large study involving the collection of truck-specific data not currently available.

Once estimates of diverted traffic were decided, the next two alternatives were to either assign this demand equally from the zone of the inland port to every other traffic serial zone (TSZ) or to aggregate the demand and assign it to areas of dense population in the 2025 estimate. These two

alternatives are opposite extremes and neither properly represents a real-life situation, so a mixture of the two was used. The CTR team assumed that 30 percent of the diverted trucks (3,262) were equally distributed from the inland port to the other TSZs, while 70 percent (7,611) were distributed to centers of dense population in 2025.

4.2 Centers of Dense Population

The last step in determining where added demand needed to be applied was predicting the areas of high population density in the study year 2025. CAMPO keeps this information in TransCAD by TSZ. Figure 4.1 shows an aggregated map of the predicted 2025 population density in the Austin area.

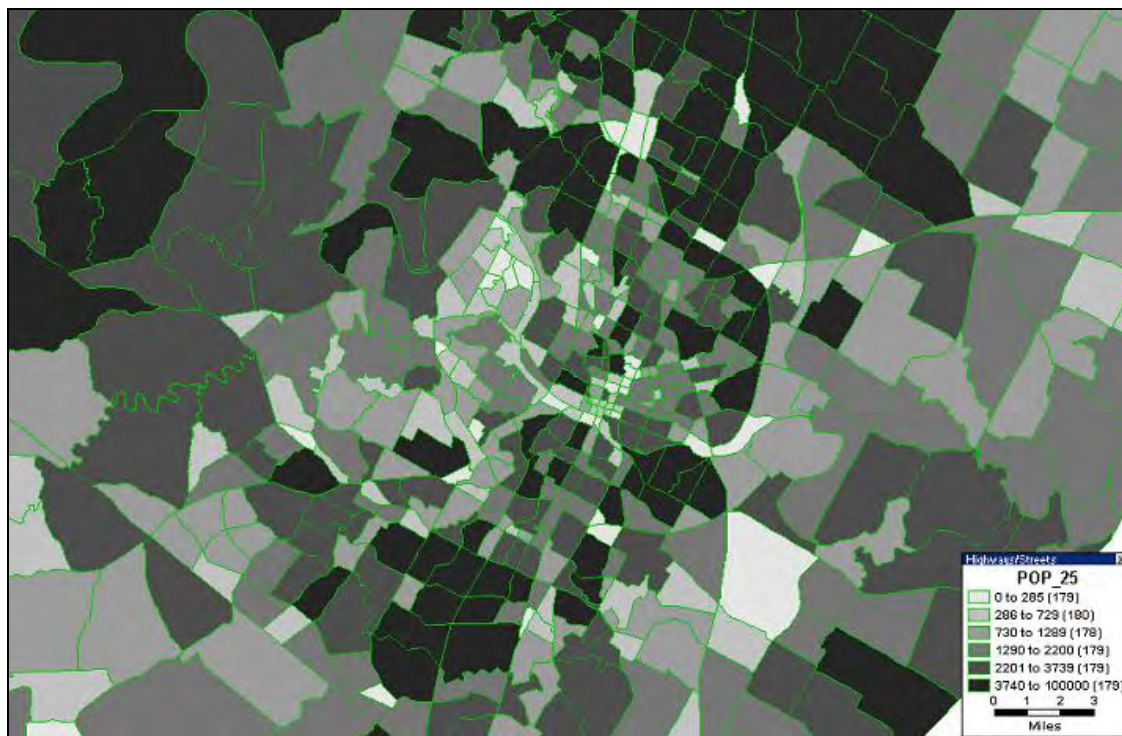


Figure 4.1. Predicted 2025 Population Density in Austin by TSZ

Given this population information, six centers of population growth, which act as attractions for the trucks leaving the inland port, were used. Rather than making these decisions visually, it is important to look at the actual populations by zone and aggregate the zones in each area to determine the proportion they should attract. Table 4.1 gives an overview of the six areas used, the TSZ nearest their center, and the attraction percentage from the 70 percent of trucks being distributed to them.

Table 4.1 Locations of Predicted Dense Population in 2025

Population Center	TSZ	Proportion of Trucks	# Trucks Daily
Cedar Park US 183 and 620	151	10%	761
Round Rock	129	10%	761
NW of IH 35 and US 183	237	25%	1903
US 290 and US 183	266	15%	1142
IH 35 N. of campus	332	15%	1142
US 290 and IH 35	480	25%	1903

Another possible solution to using truck distribution lies with employing industrial areas and employment data to estimate distribution rather than population centers. For either method, the most important part for forecasting is to consider proposed future developments that will occur before the study year. The only decisive way to determine which method is a better estimator of truck traffic is to use surveys to determine the current destinations of trucks and compare these results with current population and employment data. Unfortunately, information of this type was not available to the research team but is desirable to enhance the model's performance in future.

4.3 DYNASMART-P Details and Application

The network analysis and evaluation tool chosen for use in both the Austin and San Antonio case studies was DYNASMART-P. It was chosen mainly on its merits as a dynamic tool, allowing for time-varying properties, although other benefits include the ability to simulate trip-chaining and producing specific output statistics at both link and network levels. A drawback, however, is the amount of computational power required, which often requires running simulations overnight. For this case study, TransCAD was also used to provide a side-by-side comparison of the two.

The demand input for DYNASMART-P can either be the same origin–destination (O–D) matrix used by static evaluation tools, such as TransCAD, or a series of O–D matrices varying by time. For the purposes of this case study, a single O–D matrix for the peak two-hour morning period was used for each of the eight cases. The first case is the no-build base case with no inland port, which uses an unmodified 2025 O–D matrix. The other seven cases represent the seven chosen site locations for testing an inland port. The modification to these O–D matrices included adding the 30 percent dispersed demand from the port alternative TSZ to all other TSZs and adding the 70 percent centralized demand to each of the six population centers, based on the percentages shown in Table 4.1. These changes had to be made to produce trip data both going to and coming from the ports.

Peak period k-factors were required to find the base 2025 O–D matrix for the 7–9 a.m. peak period, given the 24-hour matrix. It is generally accepted that for most urban areas, the k-factor for one peak hour is approximately 0.10; 10 percent of the trips made in the network take place in a single peak hour. However, for two peak hours (needed for Austin), CAMPO’s diurnal distribution of 24-hour internal person trips, based on a 1997 survey, was used. This distribution shows that for the peak 7–9 a.m. hours, the factor in Austin is approximately 0.17. This factor was used for all eight of the O–D matrices after the added demand was applied. This factor, however, is based on all current traffic, the only trip data available. To more accurately assign truck trips, a second factor should be used for trucks only, determining the share of daily trucks that will be assigned to the network in the a.m. peak. The two factors may be quite different, as truck traffic tends to vary from auto traffic, but for the Austin case studies, they are assumed equal.

The measure of traffic impact agreed upon for the two case studies is average speed along lengths of highway near the hypothetical ports, as well as the average speeds in the case of no port. Each average speed is weighted by length to represent the average speed of the average mile of that length of highway. Since only the single value of average speed was used and the dynamic properties of DYNASMART-P are not being used, DYNASMART-P and TransCAD should not be significantly different in use and results throughout the study. For each highway analyzed, there is also a listed percent change between the alternative and the base, as a means of comparison.

4.4 Locations and Results

Several elements need to be taken into account when seeking possible locations for an intermodal city inland port before impacts such as environmental, economic and traffic are considered. For instance, an inland port requires sufficient space for vehicles and transferring cargo, which may vary. For this study, a minimum of 200 acres was used. Sites were also chosen based on their connectivity. This word has several definitions, but for the Austin study, it was defined as reasonable proximity to SH 130 and other major highways, as well as to Bergstrom International Airport and rail. In addition, for an initial case study such as this, it was important to select a good variety of locations to allow testing of location differences. Figure 4.2 shows the seven locations chosen for study in the Austin area, and Table 4.2 gives further information about the size and connectivity of the sites.

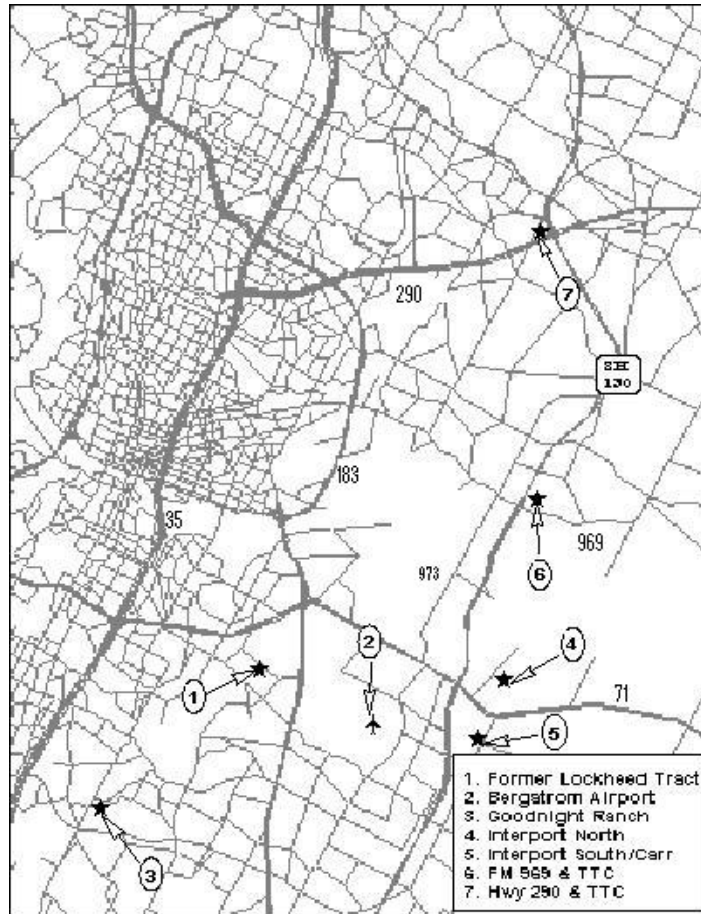


Figure 4.2. Seven Tested Alternatives for Port Location

Table 4.2 Seven Possible Inland Port Locations for Austin and Details

Alt	Name	Size (sq. mi.)	Located Residential?	Proximity to Airport	Proximity to Rail	Connectivity to Highways	TSZ
1	Former Lockheed Tract	1.54	No	Close	Runs through	US 183 and SH 71	498
2	Austin-Bergstrom Airport	6.48	No	Inside	Adjacent to	US 183, SH 71, SH 130	499
3	Goodnight Ranch	1.30	Yes	Medium	3 miles	IH 35, SH 45	600
4	Interport North	1.05	No	Close	4–5 miles	SH 130, SH 71	501
5	Carr Partnership /Interport South	1.11	No	Close	4–5 miles	SH 130, SH 71	612
6	FM 969 and SH 130	1.27	No	Medium	2.5 miles	SH 130, SH 71	401
7	SH 290 and SH 130	1.02	No	Far	<1 mile	SH 130, US 290	227

(Austin Chronicle 2001; Dwyer Realty Companies 2005)

4.4.1 No-Build Alternative

The first alternative tested was a no-build alternative, in which the network was used in its unchanged 2025 form. SH 130 remains in the network as the assumed TTC 35 but without an inland port. No demand was added for any port area for this reason. The results of this alternative are revealed in the following seven alternative selections as a basis for comparison.

4.4.2 Former Lockheed Tract

This property, just over 600 acres, sits between Burleson Road, McKinney Falls Parkway, and US 183. This position, just across US 183 from Austin-Bergstrom International Airport, would allow easy connectivity to airfreight transport. Steps have been taken to turn the area into subdivisions, but the relatively undeveloped area could be converted into an inland port. There is a rail line running directly through the property, making it the best connected of all the locations with rail. Also, it serves as a good indicator of the effects of locating the port closer to the downtown area, as it is the closest of all the suggested locations, while still close enough to SH 71, US 183, and Bergstrom to be well connected. This location will be referred to as Alternative 1, or A1.

4.4.2.1 Testing of Lockheed Location

As with most of the locations near an interchange, the Lockheed location has four lengths of highway of interest that are nearby and likely to be affected. The four selected groups of links are listed in Table 4.3, along with the results of DYNASMART-P and TransCAD, the average speeds on each highway in this alternative, and those speeds in the no-build alternative. Unless otherwise stated, all lengths of highway tested are analyzed to a distance of approximately two miles.

Table 4.3 Traffic Impact Due to an Inland Port at the Lockheed Location (A1)

Highway Section	Average Speed A1 (mph)	Average Speed Base (mph)	Decrease Due to Inland Port
DYNASMART-P			
SH 71 between US 183 and SH 130	50 (freeflow)	50 (freeflow)	0%
SH 71 between IH 35 and US 183	45.8	50 (freeflow)	8.4%
US 183 North of SH 71	44.6	44.2	-0.9%
US 183 South of SH 71	50 (freeflow)	50 (freeflow)	0%
TransCAD			
SH 71 between US 183 and SH 130	40.6	39.2	-3.6%
SH 71 between IH 35 and US 183	33.0	39.4	16.2%
US 183 North of SH 71	35.8	37.7	5.0%
US 183 South of SH 71	45.6	45.3	-0.7%

4.4.2.2 Impact of Lockheed Location

The result of the assignment shows that there is a slight increase in the average speeds on SH 71 between SH 130 and US 183 as well as on US 183 north of SH 71. These represent the links to the east and south of the site. The fact that the volumes decreased on these links shows that the inland port is properly distributing its trips to the north and west, toward the population centers of Austin, and that very few trucks are heading back to SH 130 to distribute from there. The significant decreases in speed are mostly on SH 71 to the west, with a 16.2 percent decrease in speed, and on the stretch of US 183 to the north, according to the TransCAD assignment. This stretch of SH 71 seems unable to handle the additional demand from this site and is impacted fairly severely. Overall, there is no major impact to the south and east, and little to the north, since US 183 seems adequate for handling the extra volume. The most severe impact is to the west all the way to IH 35.

4.4.3 Austin-Bergstrom International Airport

Air cargo operations began at Austin-Bergstrom International Airport in 1997 and have grown strongly since that date, often at a greater rate than passenger throughput. Locating the inland port within the existing airport space would make connectivity between air and land transport very simple. The airport is bound by SH 71, US 183, Burleson Road, and FM 973, all of which are major highways and arterials that would be able to move the traffic generated from the port. There is a Union Pacific (UP) rail line adjacent to the airport that ends just on the other side of US 183; however, it is in poor condition and would need to be rebuilt to meet current carload weights and service levels. In addition, FM 973 is on the proposed alignment of the TTC, so there would be the possibility of a ramp off the future highway very close to the airport. This location will be referred to as A2.

4.4.3.1 Testing of Bergstrom Location

The Austin-Bergstrom location has six lengths of highway of interest that are nearby and likely to be affected. The six selected groups of links are listed in Table 4.4, along with the results of DYNASMART-P and TransCAD, the average speeds on each highway in this alternative, and those speeds in the no-build alternative. Unless otherwise stated, all lengths of highway tested are analyzed to a distance of approximately two miles.

Table 4.4 Traffic Impact Due to an Inland Port at the Bergstrom Location (A2)

Highway Section	Average Speed A2 (mph)	Average Speed Base (mph)	Decrease due to inland port
DYNASMART-P			
SH 71 between US 183 and SH 130	50 (freeflow)	50 (freeflow)	0%
SH 71 between IH 35 and US 183	40.4	44.2	8.6%
US 183 North of SH 71	45.0	50 (freeflow)	10%
US 183 South of SH 71	50 (freeflow)	50 (freeflow)	0%
SH 130 North of SH 71	38.7	39.5	2.0%
SH 130 South of SH 71	49.0	49.1	0.2%
TransCAD			
SH 71 between US 183 and SH 130	39.4	39.2	-0.5%
SH 71 between IH 35 and US 183	33.6	39.4	14.7%
US 183 North of SH 71	35.8	37.7	5.0%
US 183 South of SH 71	45.7	45.3	-0.9%
SH 130 North of SH 71	40.3	44.3	9.0%
SH 130 South of SH 71	45.1	46.5	3.0%

4.4.3.2 Impact of Bergstrom Location

The result of the assignment shows that there is a very slight increase in the average speeds on SH 71 between US 183 and SH 130, which is consistent throughout the study. Even with the additional flow, this stretch of SH 71 has sufficient capacity to handle it without reducing speed. Both of the main routes north, US 183 and SH 130, showed a noticeable reduction in average speeds. The stretch of SH 71 closer to downtown, from IH 35 to US 183, resulted in a very substantial speed reduction. Throughout this trial, that stretch of SH 71 appears inadequate for supporting the extra volume caused by an inland port on the south side of Austin.

4.4.4 Goodnight Ranch

This 714-acre property lies the farthest south and west of any of the possible locations considered. It is closer to IH 35 on the west and proposed SH 45 in the south than SH 71 or the future SH 130. This should give an idea of the effect of a site that connects to SH 130 TTC by first using IH 35 or SH 45 and would most likely connect to downtown Austin by IH 35. A proposed extension of Slaughter Lane would divide the property but possibly also improve its connectivity to the city. Unlike most of the other possible locations, the Goodnight Ranch property is located in the middle of residential areas, which may have a substantial traffic impact. This location will be referred to as A3.

4.4.4.1 Testing of Goodnight Location

The Goodnight Ranch location has five lengths of highway of interest that are nearby and likely to be affected. The five selected groups of links are listed in Table 4.5, along with the results of

DYNASMART-P and TransCAD, the average speeds on each highway in this alternative, and those speeds in the no-build alternative. Unless otherwise stated, all lengths of highway tested are analyzed to a distance of approximately two miles.

Table 4.5 Traffic Impact Due to an Inland Port at the Goodnight Location (A3)

Highway Section	Average Speed A3 (mph)	Average Speed Base (mph)	Decrease Due to Inland Port
DYNASMART-P			
New Slaughter Ln. alignment from site to IH 35	40.6	45.9	11.5%
IH 35 from SH 71 to Slaughter Ln	52.7	54.4	3.1%
IH 35 access lanes from SH 71 to Slaughter Ln.	39.5	41.7	5.3%
SH 71 West of IH 35	43.8	48.6	9.9%
SH 71 between IH 35 and US 183	43.6	50 (freeflow)	12.8%
TransCAD			
New Slaughter Ln. alignment from site to IH 35	30.5	35.9	15.0%
IH 35 from SH 71 to Slaughter Ln.	38.4	36.1	-6.4%
IH 35 access lanes from SH 71 to Slaughter Ln.	32.3	31.6	-2.2%
SH 71 West of IH 35	29.7	33.9	4.7%
SH 71 between IH 35 and US 183	34.0	39.4	13.7%

4.4.4.2 Impact of Goodnight Location

The result of the assignment shows that there is a slight increase in the average speeds on IH 35 from the location of Goodnight Ranch up to SH 71, as well as its access roads, due to the number of smaller state highways on a north/south alignment near that location that help distribute the flow. Slaughter Lane is very negatively impacted, as it is very near the location of A3 and does not have the capacity for the extra demand. As in the other alternative assignments, SH 71 from IH 35 to US 183 proves insufficient in handling additional demand. Overall, the impact on the Goodnight Ranch location is fairly intense, as there is a noticeable affect on major highway speeds as well as a large amount of flow diverting to smaller highways and arterials.

4.4.5 Interport North

This property consists of 652 acres north of SH 71 and east of the future SH 130 alignment with frontage on both roadways. This location would allow for good connectivity both to SH 130 and toward downtown Austin. Additionally, it is also only half a mile east of the Austin-Bergstrom Airport, making air connectivity easy. Because the property is located on the east side of the future SH 130, truck traffic into Interport North would probably be heading in the opposite

direction of most other traffic, improving the traffic situation. This location will be referred to as A4.

4.4.5.1 Testing of Interport North Location

As with most of the locations near an interchange, the Interport North location has four lengths of highway of interest that are nearby and likely to be affected. The four selected groups of links are listed in Table 4.6, along with the results of DYNASMART-P and TransCAD, the average speeds on each highway in this alternative, and those speeds in the no-build alternative. The length of FM 973 north of SH 71 was chosen as an alternative to SH 130, since it is nearby and parallel.

Table 4.6 Traffic Impact Due to an Inland Port at the Interport North Location (A4)

Highway Section	Average Speed A4 (mph)	Average Speed Base (mph)	Decrease Due to Inland Port
DYNASMART-P			
SH 130 North of SH 71	42.0	49.1	14.5%
SH 130 South of SH 71	39.5	40.9	3.4%
SH 71 between US 183 and SH 130	50 (freeflow)	50 (freeflow)	0%
FM 973 North of SH 71	38.5	43.3	4.8%
TransCAD			
SH 130 North of SH 71	40.2	44.3	9.3%
SH 130 South of SH 71	45.1	46.5	3.0%
SH 71 between US 183 and SH 130	39.4	39.2	-.5%
FM 973 North of SH 71	29.7	36.0	17.5%

Figures 4.3a and 4.3b show one of the links in the FM 973 north of SH 71 section under base 2025 demand (4.3a) and under the added demand caused by the inland port at Interport North (4.3b). By the end of the two-hour a.m. peak, the added demand caused this link to bottom out at a user speed of 10 mph.

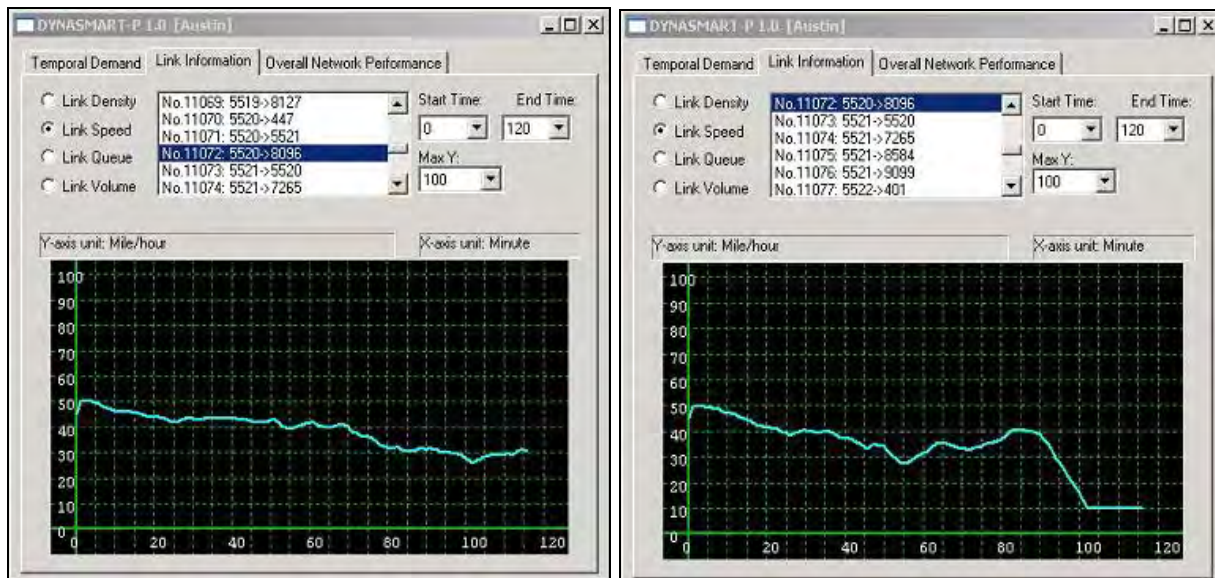


Figure 4.3. Link Speed on an FM 973 Link Before (a) and After (b) A4 Added Demand

4.4.5.2 Impact of Interport North Location

For the A4 assignment, the largest impacts are seen to the north, which is the fastest route to many of the population centers of Austin due to avoiding the north/south travel on the highways closer to downtown. FM 973 sees a very large impact, since it takes a lot of the flow from SH 130, which is parallel to it but does not have the capacity to handle it. This is another example of the smaller highways seeing the largest effects of the inland ports.

4.4.6 Interport South/Carr Family Partnership

The Carr Family Partnership is a 508-acre site bounded by the proposed SH 130 on the west side and SH 71 on the north side. This site has the same connectivity as the Interport North site, located directly across SH 71 from it, but it has the added advantage of being connected to Interport South, a 250-acre site, which would allow both to be used as a 758-acre inland port. There is a possibility that all three sites could be combined into a 1,410-acre site, divided by SH 71. The combination of Interport South and the Carr Family Partnership will be referred to as A5.

4.4.6.1 Testing of Interport South Location

As with most of the locations near an interchange, the Interport South location has four lengths of highway of interest that are nearby and likely to be affected. The four selected groups of links are listed in Table 4.7, along with the results of DYNASMART-P and TransCAD, the average speeds on each highway in this alternative, and those speeds in the no-build alternative. The length of FM 973 north of SH 71 was chosen as an alternative to SH 130, since it is nearby and parallel. Since this location is quite similar to the Interport North location, very similar results are expected.

Table 4.7 Traffic Impact Due to an Inland Port at the Interport South Location (A5)

Highway Section	Average Speed A5 (mph)	Average Speed Base (mph)	Decrease Due to Inland Port
DYNASMART-P			
SH 130 North of SH 71	39.2	39.5	.8%
SH 130 South of SH 71	46.3	49.1	5.7%
SH 71 between US 183 and SH 130	50 (freeflow)	50 (freeflow)	0%
FM 973 North of SH 71	40.6	43.3	6.2%
TransCAD			
SH 130 North of SH 71	40.0	44.3	9.7%
SH 130 South of SH 71	44.9	46.5	3.4%
SH 71 between US 183 and SH 130	38.0	39.2	3.1%
FM 973 North of SH 71	30.2	36.0	16.1%

4.4.6.2 Impact of Interport South Location

The largest impacts are seen to the north, although there is an indication of a slight impact for traffic south and west of Interport South. This is because the fastest route to the majority of the population centers is to get back on SH 130 and travel north to another exit. There is probably some inefficiency in this location if many trucks are leaving SH 130 to use the facility and reentering to travel farther. As in the A4 case, the largest impact is seen on FM 973, which takes much of the flow from SH 130, which is parallel to it but does not have the capacity to handle it. This is another example of the smaller highways seeing the largest effects of the inland ports.

4.4.7 Intersection of FM 969 and SH 130

The land at the intersection of FM 969 and SH 130 serves as a good indicator of locating the inland port on SH 130 but between the two major highways, US 290 and SH 71, where the other sites are located. This site is closer by distance to downtown Austin than the other two intersections and is located on FM 969, which gives reasonable connectivity. It also has average possibility for connectivity to rail, not extremely close, but not as far as the Interport locations. This location will be referred to as A6. As opposed to the previous sites, alternatives 6 and 7 are not specifically planned sites at this time. They are completely hypothetical alternatives, and the site borders simply follow the surrounding streets and rivers.

4.4.7.1 Testing the FM 969 Location

The FM 969 location has five lengths of highway of interest that are nearby and likely to be affected. The five selected groups of links are listed in Table 4.8, along with the results of DYNASMART-P and TransCAD, the average speeds on each highway in this alternative, and those speeds in the no-build alternative. The two lengths of FM 973 north and south of FM 969 were chosen as an alternative to the TTC, since they are nearby and parallel.

Table 4.8 Traffic Impact Due to an Inland Port at the FM 969 Location (A6)

Highway Section	Average Speed A6 (mph)	Average Speed Base (mph)	Decrease Due to Inland Port
DYNASMART-P			
FM 969 West of SH 130	42.9	46.4	7.5%
SH 130 North of FM 969	42.7	45.7	6.6%
SH 130 South of FM 969	43.4	46.0	5.6%
FM 973 North of FM 969	40.7	46.3	12.1%
FM 973 South of FM 969	42.8	43.3	1.2%
TransCAD			
FM 969 West of SH 130	34.4	35.7	3.6%
SH 130 North of FM 969	36.4	44.4	18.0%
SH 130 South of FM 969	41.0	44.0	6.8%
FM 973 North of FM 969	27.9	36.0	22.5%
FM 973 South of FM 969	28.9	36.0	19.7%

4.4.7.2 Impact of FM 969 Location

The result of the assignment shows that, of all the tested locations, A6 affects the major highways the most, with the majority of the traffic traveling north and south from the inland port along either FM 969 or SH 130. Because these two highways are parallel, they both take a portion of the flow and end up with very similar average speeds, but neither length of highway is sufficient for the addition of the port. Location A6 could be classified as having a very high traffic impact on surrounding highways.

4.4.8 Intersection of SH 290 and SH 130

The land at the intersection of US 290 and SH 130 is not currently split up and zoned for easy development of an inland port, as the previous sites are, but being farther away from the city allows flexibility in the size and location of the port. This location would give good connectivity to downtown via US 290 as well as north or south on SH 130. With rail less than a mile from the location, it would be relatively easy to get a rail connection. This location would also avoid highway-related traffic more than some of the previously mentioned locations. It will be called A7.

4.4.8.1 Testing the SH 290 Location

As with most of the locations near an interchange, the SH 290 location has four lengths of highway of interest that are nearby and likely to be affected. The four selected groups of links are listed in Table 4.9, along with the results of DYNASMART-P and TransCAD, the average speeds on each highway in this alternative, and those speeds under the no-build alternative. FM 734 travels northwest from the location and was expected to act as a highly used route from the port to Round Rock. All lengths of highway tested for this location were analyzed to a distance of approximately two miles.

Table 4.9 Traffic Impact Due to an Inland Port at the SH 290 Location (A7)

Highway Section	Average Speed A7 (mph)	Average Speed Base (mph)	Decrease Due to Inland Port
DYNASMART-P			
US 290 West of SH 130	50 (freeflow)	50 (freeflow)	0%
SH 130 North of US 290	46.9	50 (freeflow)	6.2%
SH 130 South of US 290	43.8	50 (freeflow)	12.4%
FM 734 West of SH 130	50 (freeflow)	50 (freeflow)	0%
TransCAD			
US 290 West of SH 130	40.1	39.2	-2.3%
SH 130 North of US 290	36.6	43.8	16.4%
SH 130 South of US 290	41.9	46.3	9.5%
FM 734 West of SH 130	41.9	41.5	-1.0%

4.4.8.2 Impact of US 290 Location

In the no-build scenario, the average speeds at the US 290/SH 130 intersection are all very close to freeflow in the DYNASMART-P model, as this is not an area of extreme projected growth for 2025. The result of the assignment shows that very little of the flow from the inland port is headed west, either by US 290 or FM 734. The majority of the flow heads south to catch another major highway west or north toward Round Rock. For this reason, the lengths of the TTC both north and south of US 290 are very significantly impacted by the addition of the port. Location A7 could be classified as having a medium traffic impact on surrounding highways.

4.5 Inland Port Selection Model for the Austin Case Study

When applying the inland port selection (IPS) add-in program for TransCAD developed in El Paso, there are seven possible selection criteria that can be applied: land area availability, existing modal capabilities, economic impacts, environmental impacts, traffic impacts, cost of construction, and accessibility of the TTC (the distance from the port to the TTC). The sites, as they were entered into the IPS program, are shown in Figure 4.4.

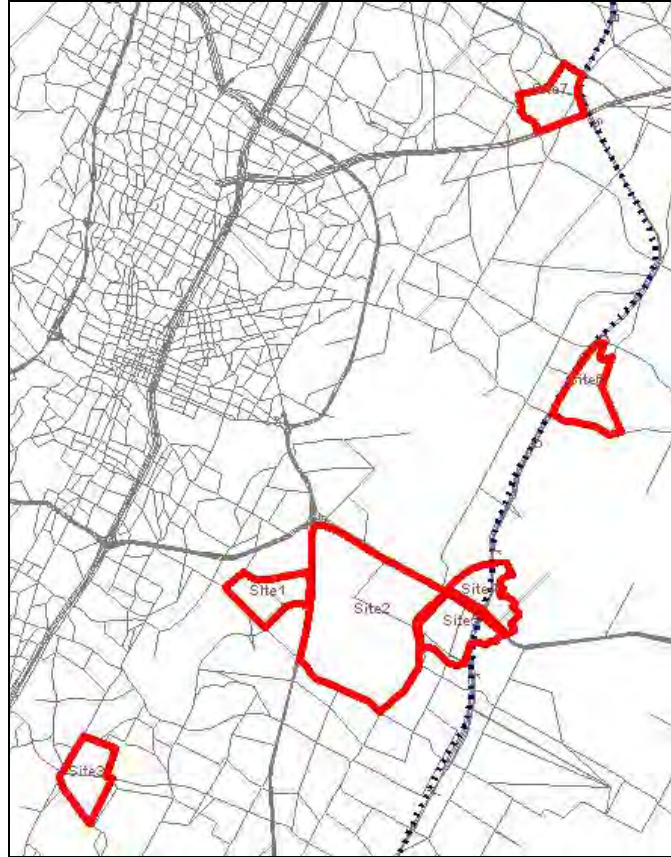


Figure 4.4. Site Locations Entered into the IPS Add-in

4.5.1 Hard Requirements

One of the first steps in choosing an optimal site location is eliminating any sites that do not adhere to a certain hard requirement. A hard requirement is defined as a requirement that will not be weighted in the final decision process but will be used for immediate disqualification of a possible location. The purpose of this type of requirement is eliminating options when it is immediately apparent that they are unacceptable, making the eventual model more efficient and streamlined. All other requirements are considered soft requirements, which are weighted according to the defined criteria weights and determine the best location for a site. While these soft requirements do not simplify the model, they are the criteria that define which location is most suitable for the given situation.

The two hard requirements that are considered in the inland port selection add-in are area of the site and length from the center of the site to the assumed position of SH 130. Whether to include one or both of these is entirely the choice of the modeler and is dependent on many factors. Area should be used as a hard requirement only when it is known that the inland port needs to be greater than a given area to be effective or if there is zoning that restricts how large the port can be. For length, there is no practical reason why a port could be too close to the freeway or toll road unless there are right-of-way restrictions. On the other hand, it may be very useful to put a hard requirement on the maximum length from the possible locations to SH 130 if the modeler is trying to maintain easy access to the highway.

For the Austin case study, no hard requirements were used for several reasons. It was desired that as many possible locations as possible be left in the model. For testing purposes, it was best that the sites be as varied as possible, with large ranges in distance from SH 130 and area of the site. For this reason, hard requirements were not desirable, as they would eliminate any outliers and make a more homogenous sample. In practical use, this may be considered a positive result. However, in our case study, extra modeling time was not an issue.

4.5.2 Running the Add-in and Results

From a closer examination of the seven possible criteria, the cost of construction for each inland port alternative was deemed beyond the scope of this study and was not used in the IPS model. However, due to the close proximity of most of the examined port locations and the assumption that the facilities would all generate the same amount of demand, the economic and environmental impacts on the area will not vary much from one site to the other. For this reason, both of these decision criteria were dropped in the analysis. Since the distance to SH 130 is already taken into account by the traffic impact, that variable was also left out, although being an automatic component of the add-in, it could easily be left in if desired. Land area and accessibility of SH 130 are both determined internally by the add-in. Existing modal capability and traffic impacts are included subjectively. Modal capability is determined from the background information on each site and traffic impacts are determined from the TransCAD and DYNASMART-P simulations, as described in the previous sections.

The land area is calculated automatically in the add-in, leaving only modal capacity and traffic impacts for subjective judgment. Table 4.10 shows the values that these criteria were given, based on the background modal proximity and connectivity from Table 4.2 and the results of the traffic impact study in Section 4.4. Existing modal connectivity was a mixture of three areas: proximity to an airport, proximity to rail, and connectivity to major highways. For the add-in decision-making purposes, low is given a value of 0.335, average is 0.5, high is 0.667, and very high is 0.954.

Table 4.10 Size, Connectivity, and Traffic Impact of Hypothetical Sites

Alt	Name	Size (sq. mi.)	Existing Modal Connectivity	Traffic Impact	Final Rank
1	Former Lockheed Tract	1.54	High	Low	2
2	Austin-Bergstrom Airport	6.48	Very High	Average	1
3	Goodnight Ranch	1.30	Low	High	7
4	Interport North	1.05	Average	Average	4
5	Carr Partnership /Interport South	1.11	Average	Average	3
6	FM 969 and SH 130	1.27	Average	Very High	6
7	US 290 and SH 130	1.02	Low	Low	5

Site size and connectivity are set as benefits for this model, while traffic impacts and distance from SH 130 are costs. The objective entropy weights given to the three variables by the add-in are as follows: 0.300 for site size, 0.403 for existing modal connectivity, and 0.296 for traffic impact.

The results of the IPS add-in program in finding the ideal solution are shown in Table 4.10. The Austin-Bergstrom site ranked highest due to its size, high connectivity, and only average traffic impact. The Interport sites ranked in the middle due to being average in most ways. In reality, one should also look into the relative ease with which each site could be converted to an inland port, together with the zoning and utility work that has already been done on the site. The Goodnight Ranch site ranked last, due to its lack of connectivity as well as the high traffic impacts caused by the strain on the nearby, lower-capacity highways.

4.6 Experiences from the Austin Case Study

The Austin case study shows that it is best to choose as many feasible sites as possible when deciding the optimal location for an inland port serving a city on the TTC. Trying to make the sites diverse in terms of location, size, connectivity, and distance from the city and SH 130 alignment also helps. This study chose seven hypothetical sites, while trying to make them as realistic and feasible as possible. The feasibility considerations could naturally lead to very homogenous alternatives in cities where adequate space is harder to come by, but this problem should be avoided whenever possible.

The Goodnight Ranch alternative, A3, was a good case in point of why it is better to locate a distributing inland port as near as possible to highways that can handle additional flow. A site like Goodnight Ranch, surrounded by small highways and arterials, will have a very large (and negative) impact on those streets. Sites located near higher capacity highways are better equipped to handle the trucks that the inland port will draw.

For many of the alternatives in this study, DYNASMART-P and TransCAD gave somewhat different results. This is largely because the two programs are designed for two different

purposes. While TransCAD gives a quick, static solution to the network assignment, DYNASMART-P gives more complete data, varying with time across the selected period. This dynamic approach has more potential and the possibility to see traffic spikes within a peak period; however, TransCAD is a more straightforward approach when the results are going to be averaged over a stretch of highway and a length of time, as in this case study.

Although the traffic impacts were determined only in the area near each possible location for comparison of locations, there are actually two distinct traffic impacts related to the implementation of an inland port. The more noticeable and localized impacts are the negative impacts due to the additional truck traffic using the inland port. The more widespread traffic impact, which is the main goal of inland ports, is the overall improvement of traffic conditions on the entire network, due to replacing heavy trucks with lighter trucks and distributing the trips from a highly connected location. This widespread traffic impact would not be as useful for determining differences between possible port locations but would be helpful in establishing the true total impact on a network.

The model was also evaluated in the San Antonio metropolitan area, where there were substantial differences to the focus examined in the Austin area. This difference of focus is the subject of the next chapter. It is of particular interest because it provides an opportunity to extend the testing of the beta version of the model.

Chapter 5. The San Antonio Case Study

5.1 Introduction

The location of a multi-modal inland port in the San Antonio region is a likely scenario given that a major section of the Trans-Texas Corridor (TTC) is planned near the San Antonio metropolitan area. The TTC has been envisioned to complement IH 35, a major section of which is in the San Antonio area. The city is located midway between the U.S.–Mexico border and other major metropolitan areas in Texas. San Antonio is directly connected to the border, with a confluence of major interstate freeways as well as major rail corridors. This case study presents some of the candidate locations for a prospective multi-modal inland port in the vicinity of San Antonio.

5.2 Location of Candidate Sites for an Inter-modal Inland Port

The candidate sites for a multi-modal inland port were identified based on pre-existing knowledge of availability of land space, proximity to the major highways, proximity to TTC corridor alignment, existing rail lines, and proximity to airports. As illustrated in Figure 5.1, the candidate sites for the inland port in the San Antonio area are as follows:

- KellyUSA
- Brooks City-Base
- Stinson Municipal Airport
- Union Pacific Rail Yard (Downtown San Antonio adjacent to IH 37 and IH 35)
- San Antonio International Airport.

KellyUSA is located in the southwestern part of San Antonio and lies near the western corner of IH 35 and US 90. Kelly Air Force Base was officially closed in July 2001. The infrastructure was leased to the Greater Kelly Development Authority (GKDA). GKDA began the transformation of the base into a multi-use airport and rail facility to serve as an industrial/business park. Almost 1,928 acres of land have been turned over to GKDA for re-use, which includes 11.8 million square feet of buildings and a multi-purpose runway. To better manage the existing and future infrastructure, KellyUSA is being master planned and incorporated into the city's plans for future development. With the completion of multiple phases of development, KellyUSA is expected to provide an economic impact on San Antonio that is estimated to exceed \$4.3 billion (Greater Kelly Development Authority 2005).

Union Pacific Rail Yard Downtown San Antonio is located close to downtown San Antonio and is adjacent to IH 37 and IH 35. The rail yard is close to major business centers in downtown San Antonio. The Union Pacific rail lines in San Antonio directly connect with Mexico's main rail networks, providing shippers with direct rail access to cities like Monterrey, Mexico City, etc. The inter-modal rail yard is equipped with facilities for loading and unloading containers. Plans are underway to expand and enhance the capacity of the facility (San Antonio Texas Foreign Investment and Business Guide 2005).

San Antonio International Airport is located in north central San Antonio, approximately 8 miles from the downtown central business district. The airport is easily accessible from IH 410 and US 281. The airport covers 2,600 acres, is the primary airport serving the metropolitan area, and consists of two major terminals serving the public. The cargo warehouse capacity of 164,280 feet of space is available within two Foreign Trade Zones (City of San Antonio 2005). The close-up view of all the aforementioned candidate sites is shown in Figure 5.2.

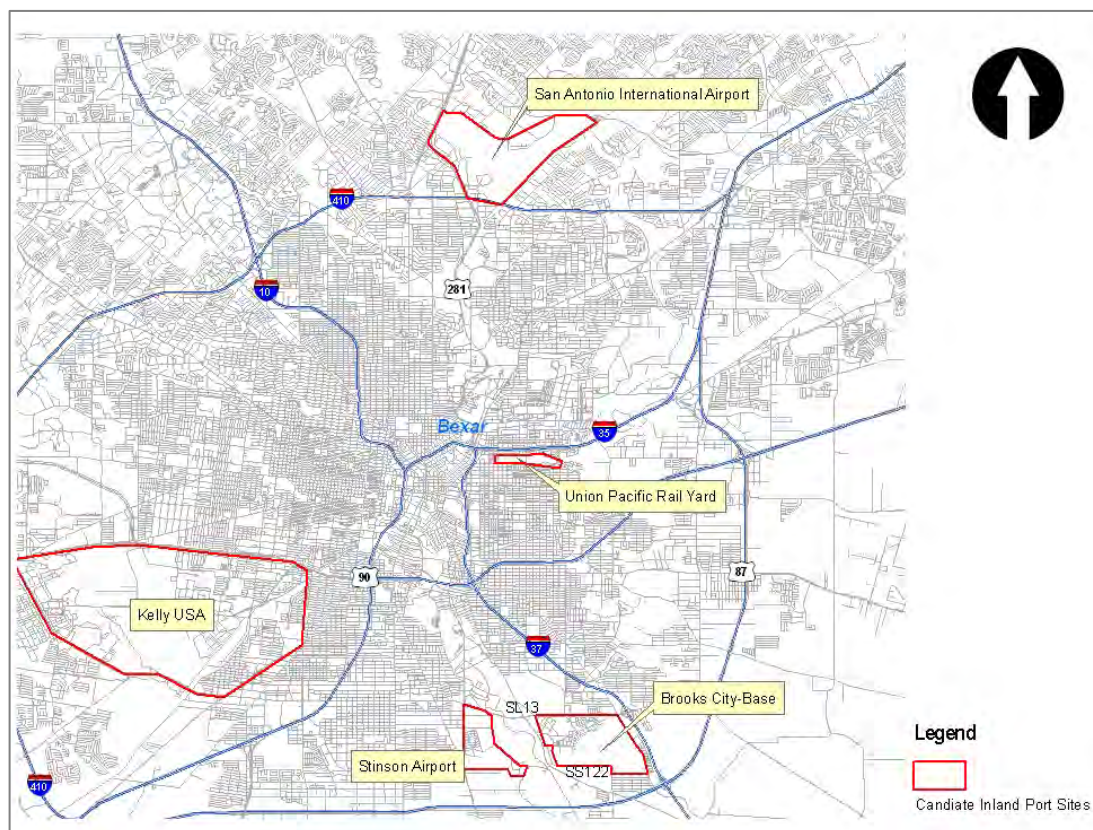


Figure 5.2. Close-up Views of Candidate Sites for Inter-Modal Inland Port

Table 5.1 presents the characteristics of the candidate inland ports.

Table 5.1 Characteristics of Candidate Inland Port Sites

Candidate Sites	Size (Acres)	Residential Location	Airport Proximity	Rail Proximity	Connectivity to Highways	TSZ
KellyUSA	1928	No	Inside	Runs Through	IH 35, US 90, SH 13, IH 410	299
Brooks City-Base	1310	No	Close	Adjacent	SH 13, US 281, IH 410, SH 122	683
Stinson Municipal Airport	NA	No	Inside	Adjacent	SH 13, SH 122, IH 410, SH 536	578
Union Pacific Rail Yard	NA	Yes	No	Runs Through	IH 35, IH 37	621
San Antonio International Airport	2600	Yes	Inside	Adjacent	IH 410, US 281	557

Note: TSZ = Traffic Zone Number in DYNASMART-P simulation model.

Researchers analyzed traffic impact due to construction of candidate port sites by comparing before and after impacts on average speed of traffic on the roadway links surrounding the site. Table 5.2 presents roadway links analyzed for individual sites.

Table 5.2 Roadway Links around Candidate Inland Port Sites

Candidate Sites	Roadway Links	Length (miles)
KellyUSA	US 90 between IH 35 and SH 13	7.05
	IH 35 between US 90 and SH 13	2.71
	SH 13 between IH 35 and US 90	7.36
Brooks City Base	SH 13 between US 281 and SH 122	2.03
	SH 122 between SH 13 and IH 410	2.95
	US 281 between IH 410 and SH 13	1.76
	IH 410 between SH 122 and US 281	0.76
Stinson Municipal Airport	SH 13 between SH 536 and SH 122	1.22
	SH 122 between SH 13 and IH 410	2.95
	SH 536 between IH 410 and SH 13	2.33
	IH 410 between SH 122 and SH 536	3.07
Union Pacific Rail Yard	IH 37 between IH 35 and US 90	3.09
	IH 35 between IH 37 and Coliseum Road	2.43
San Antonio International Airport	IH 410 between US 281 and US 81	4.81
	US 281 between IH 410 and Bitters Road	3.21

5.3 Assumptions

The toll feasibility study completed by Wilbur Smith Associates (Wilbur Smith 2005) was used to estimate truck traffic along the TTC corridor in the 2025 study year. The average annual daily traffic (AADT) was estimated to be 32,620 trucks, of which one-third (10,873) is assumed to be diverted to the San Antonio area and two-thirds to continue along the corridor. It was assumed that the diverted trucks (10,873) were equally distributed from the inland port to the rest of the TSZs. The AADT traffic was converted to vehicles per hour using the following relationship:

$$DDHV = AADT \times K \times D,$$

where $DDHV$ is directional design hour volume (vph), $AADT$ is annual average daily traffic (vpd), K is the proportion of daily traffic occurring during the peak hour (0.12), and D is the proportion of peak-hour traffic traveling in the peak direction (0.55). Hence,

$$DDHV = 10,873 \times 0.12 \times 0.55 = 718 \text{ vph}$$

As such, 718 vph is assumed to be generated from the inland port during the peak hour in the peak direction, which will be equally distributed to other TSZs in the “build” alternative. However, for the no-build alternative, the additional truck volumes will be added on to the TSZs assuming that the trucks do not originate from one particular location. By comparing the results based on these two assumptions, researchers can quantify the traffic impact around the inland port site. In addition, an annual 3 percent increase in overall traffic volume was assumed through the design year of 2025 for all TSZs.

5.4 Mesoscopic Simulation Using DYNASMART-P

The network analysis and evaluation tool chosen for both the Austin and San Antonio case studies was the DYNASMART-P simulation model. For the purposes of this case study, a single O–D matrix for the peak two-hour morning period was used for each of the six alternative cases. The first case is the no-build base case with no inland port, which uses an unmodified 2025 O–D matrix. The other five cases represent the inland port being located in one of the aforementioned five candidate sites. The modification to these O–D matrices included adding the 100 percent dispersed demand from the port alternative TSZ to all other TSZs in the regional network.

In order to adjust the traffic movement during peak hours (this case study uses a 7 to 9 a.m. peak hour period), application of a k-factor for the two-hour a.m. peak was required. It is generally accepted that for most urban areas, this single peak hour factor is approximately 0.10. In other words, 10 percent of the trips made in the network take place in a single peak hour. The Capital Area Metropolitan Planning Organization (CAMPO) study showed that the 7 to 9 a.m. k-factor is approximately 0.17. This value was used for all six of the O–D matrices after the added demand was applied. It was determined that the average speed on the link would be used as the performance measure to quantify the traffic impact for the case studies.

5.5 No-Build Alternative

A no-build alternative was analyzed using 2025 as the future design year. No inland ports were added under this scenario. However, additional truck traffic was assumed to be distributed equally to all traffic zones from the TTC without an inland port being built. The no-build alternative does take into account the increase in traffic over the future years, including an increase in truck traffic due to the TTC. Additional truck demands were not assumed to originate from a specific port area in this alternative. Table 5.3 presents traffic impact (analyzed using DYNASMART-P) on roadway links surrounding the candidate ports.

Table 5.3 Average Speed of Highway Sections in No-build Alternative

Candidate Sites	Roadway Links	Average Speed (mph) No Build
KellyUSA	US 90 between IH 35 and SH 13	60.68
	IH 35 between US 90 and SH 13	65.12
	SH 13 between IH 35 and US 90	47.20
Brooks City-Base	SH 13 between US 281 and SH 122	47.99
	SH 122 between SH 13 and IH 410	47.46
	US 281 between IH 410 and SH 13	65.00 (FF)
	IH 410 between SH 122 and US 281	48.86
Stinson Municipal Airport	SH 13 between SH 536 and SH 122	48.22
	SH 122 between SH 13 and IH 410	48.75
	SH 536 between IH 410 and SH 13	47.64
	IH 410 between SH 122 and SH 536	49.47
Union Pacific Rail Yard	IH 37 between IH 35 and US 90	65.00 (FF)
	IH 35 between IH 37 and Coliseum Road	65.05
San Antonio International Airport	IH 410 between US 281 and US 81	41.12
	US 281 between IH 410 and Bitters Road	65.00 (FF)

Note: FF is freeflow speed

5.6 Build Alternatives

KellyUSA is primarily served by US 90 on the north side, IH 35 on the east side, and SH 13 on the south side. Among these three routes, SH 13 is the closest. KellyUSA is also located in the area with least residential population, which also makes the site advantageous over other candidate sites. Table 5.4 presents results from DYNASMART-P simulation regarding the impact on average speeds due to additional trucks generated from the inland port site at KellyUSA.

Table 5.4 Impact on Average Speed: Highway Sections around KellyUSA

Candidate Sites	Roadway Links	Average Speed (mph)	Average Speed (mph)—No Build	Difference (%)
KellyUSA	US 90 between IH 35 and SH 13	57.63 (FF)	60.68	-5.02
	IH 35 between US 90 and SH 13	65.00 (FF)	65.12	-0.18
	SH 13 between IH 35 and US 90	42.76	47.20	-10.38

The difference in average speed between the no-build alternative and the KellyUSA alternative for SH 13 is highest among the subject roadway sections analyzed. SH 13 is the nearest highway section compared to other highway sections. The results indicate that it may be beneficial for trucks to use US 90 and IH 35, as opposed to SH 13, to accomplish access and egress to and from the KellyUSA site.

Brooks City-Base is also located in a lesser populated area (compared to most other alternatives) and is flanked by US 281 on the east side, IH 410 on the south side, SH 122 on the west side and SH 13 on the north side. The Union Pacific rail line runs parallel to SH 122 on the periphery of the site. Table 5.5 presents results from DYNASMART-P simulation regarding the impact on average speeds due to additional trucks generated from the inland port site Brooks City-Base.

The simulation results show that there is no impact on average speed on US 281 and minimal impact on other nearby roadways as well. Stinson Municipal Airport is also located in only a moderately populated area and is surrounded by SH 122 on the east side, IH 410 on the south side, SH 536 on the west side and SH 13 on the north side. The Union Pacific rail line runs parallel to SH 122 on the periphery of the site. Table 5.6 presents results from DYNASMART-P simulation regarding the impact on average speeds due to additional trucks generated from the inland port site at Stinson Municipal Airport.

Table 5.5 Impact on Average Speed: Highway Sections around Brooks City-Base

Candidate Sites	Roadway Links	Average Speed (mph)	Average Speed (mph)—No Build	Difference (%)
Brooks City-Base	SH 13 between US 281 and SH 122	47.73	47.99	- 0.54
	SH 122 between SH 13 and IH 410	47.21	47.46	-0.52
	US 281 between IH 410 and SH 13	65.00 (FF)	65.00 (FF)	0.00
	IH 410 between SH 122 and US 281	48.81	48.86	-0.10
Stinson Municipal Airport	SH 13 between SH 536 and SH 122	48.54	48.22	+0.66
	SH 122 between SH 13 and IH 410	48.50	48.75	-0.51
	SH 536 between IH 410 and SH 13	47.69	47.64	+0.10
	IH 410 between SH 122 and SH 536	49.41	49.47	-0.12

Table 5.6 Impact on Average Speed: Highway Sections around Stinson Airport

Candidate Sites	Roadway Links	Average Speed (mph)	Average Speed (mph)—No Build	Difference (%)
Brooks City Base	SH 13 between US 281 and SH 122	47.81	47.99	-0.37
	SH 122 between SH 13 and IH 410	47.65	47.46	+0.40
	US 281 between IH 410 and SH 13	65.00	65.00 (FF)	0.00
	IH 410 between SH 122 and US 281	48.71	48.86	-0.31
Stinson Municipal Airport	SH 13 between SH 536 and SH 122	48.50	48.22	+0.58
	SH 122 between SH 13 and IH 410	47.59	48.75	-2.38
	SH 536 between IH 410 and SH 13	47.74	47.64	+0.20
	IH 410 between SH 122 and SH 536	49.38	49.47	-0.18

The simulation results show that there is minimal impact on average speed of the surrounding roadways.

The Union Pacific rail yard lies in the heart of downtown San Antonio. Hence, trucks exiting and entering the site will impact the lower-level roads surrounding the yard close to the highways. The rail yard is served by IH 35 on the north side and IH 37 on the west side. Table 5.7 presents results from DYNASMART-P simulation regarding the impact on average speeds due to additional trucks generated from the inland port site at Union Pacific rail yard. The

DYNASMART-P simulation showed that there is a 12 percent reduction in average speed on the section of IH 35 close to the rail yard.

Table 5.7 Impact on Average Speed: Highway Sections around Union Pacific Rail Yard

Candidate Sites	Roadway Links	Average Speed (mph)	Average Speed (mph)—No Build	Difference (%)
Union Pacific Rail Yard	IH 37 between IH 35 and US 90	56.97	65.00	-12.35
	IH 35 between IH 37 and Coliseum Road	65.00	65.05	-0.07

San Antonio International Airport lies in a densely populated area of the north central part of San Antonio. The airport is served by IH 410 on the south side and US 281 on the west side. The airport is surrounded by retail businesses and residential neighborhoods. The DYNASMART-P simulation showed that there is minimal reduction in average speed on the section of US 281 and IH 410 adjacent to the facility. However, considering the available free space (or lack thereof) near the airport, construction of an inland port might be difficult at this location. Table 5.8 presents results from DYNASMART-P simulation regarding the impact on average speeds due to additional trucks generated from the inland port site at San Antonio International Airport.

Table 5.8 Impact on Average Speed along Highway Sections around SA Airport

Candidate Sites	Roadway Links	Average Speed (mph)	Average Speed (mph)—No Build	Difference (%)
San Antonio International Airport	IH 410 between US 281 and US 81	40.95	41.12	-0.41
	US 281 between IH 410 and Bitters Road	65.00	65.00	0.00

5.7 Summary

The San Antonio case study consisted of five hypothetical sites for a multi-modal inland port associated with the TTC. Researchers selected the sites for the study based on their location, size, and proximity to major highways, airports, and railway lines. The year 2025 was used and traffic projections were estimated to be 3 percent annually, including truck traffic along the TTC. A no-build case was developed in which it was assumed that the inland port would not be constructed. However, additional truck traffic is created in the road network and distributed equally among individual traffic zones from the TTC. Additional alternatives were created assuming the inland port would be constructed at the candidate sites and truck traffic would be generated from the site.

The difference between no-build and build alternatives is that in the no-build alternative, additional truck traffic due to TTC is distributed from various locations. In build alternative scenarios, the inland port site will generate additional trucks from each respective candidate site. Hence, build alternatives concentrate additional truck traffic on roadways around the inland port site. This may increase congestion around the port and significantly impact the traffic movement.

Out of many traffic performance measures, average speed was chosen to determine the impact of the additional truck traffic around the site for the purposes of the case study analyses.

Considering the proximity of the Union Pacific rail yard and San Antonio International Airport to the dense residential neighborhoods and land availability, these sites may not be suitable for construction of an inland port. Analysis of the Union Pacific rail yard site also showed significant reduction in average speeds on nearby sections of IH 37.

KellyUSA, Brooks City-Base, and Stinson Airport appear to be more suitable sites for an inland port. However, further comparative economic analysis is necessary to determine their relative suitability. From a traffic operations performance perspective, no significant reduction in average speeds was found for these three sites. However, the difference in speed reductions between the five location scenarios can be used to weigh the sites against each other in terms of suitability. This difference, along with environmental and connectivity differences, allows for the use of the inland port location selection model. Otherwise, proper criteria for selection would be unclear.

The two case studies—Austin and San Antonio—examined the impact of inland port traffic on the metropolitan highway networks as one of the major determinants in site selection. Traffic levels are derived from the variety of economic activities that each site can be expected to generate. The team decided that the determination of precise inland port traffic could not be incorporated at this stage in the evaluation process, but that the economic impacts—which largely determine the magnitude of such traffic volumes—should be calculated once the model had been run. The subject of economic impacts and their measurement is addressed in the next chapter.

Chapter 6. Economic Impacts

6.1 Background and Purpose

The purpose of Study 0-4702 was to assess the effects of the placement of the Trans-Texas Corridor (TTC) inland port facilities on the various communities by-passed by the corridor. The model developed in the course of the study has been shown to forecast a range of traffic flow impacts under a variety of TTC35 and inland port locations. Construction of the TTC will, of course, have consequences beyond its direct effects on the transportation system. It will have an effect on the local and regional economics of the areas in which it is constructed. This chapter will address methods of assessing these effects. It will survey several methodologies that could be used to estimate the economic impacts and benefits of locating inland port nodes on the TTC also linking the TTC to existing inland ports.

For those readers who wish to follow up on economic impact methodologies, an annotated bibliography of the research that the study team found is attached in Appendix D.

The placement of large transportation infrastructure projects can have dramatic local, regional, and even national economic effects. Indeed, one of the key goals of inland ports is often to “accelerate economic growth and create employment opportunities” (Prozzi et al. 2002). Therefore, an analysis of the economic impacts under competing scenarios can play an important part in the planning of the TTC. These effects are caused by a variety of factors, from the spatial dimensions that affect transportation between the port and freight end destinations, to job creation, property value appreciation, and the subsequent stimulus that these effects have on the surrounding community. In evaluating the economic impact of TTC/inland port location selection, the costs and benefits to major stakeholders should be evaluated. Among these are producers of the goods and services that will utilize the port and surrounding transportation arteries, residents of the area where the transportation activity will be shifted, developers and investors, and participants in the transportation, property, labor, and product markets.

Figure 6.1 offers an illustration of the relationship between the construction of transportation infrastructure and the numerous stakeholders in each project. These stakeholders can include labor, land, and financial markets. Local and regional businesses as well as residents of the area in which the project is being developed are also affected.

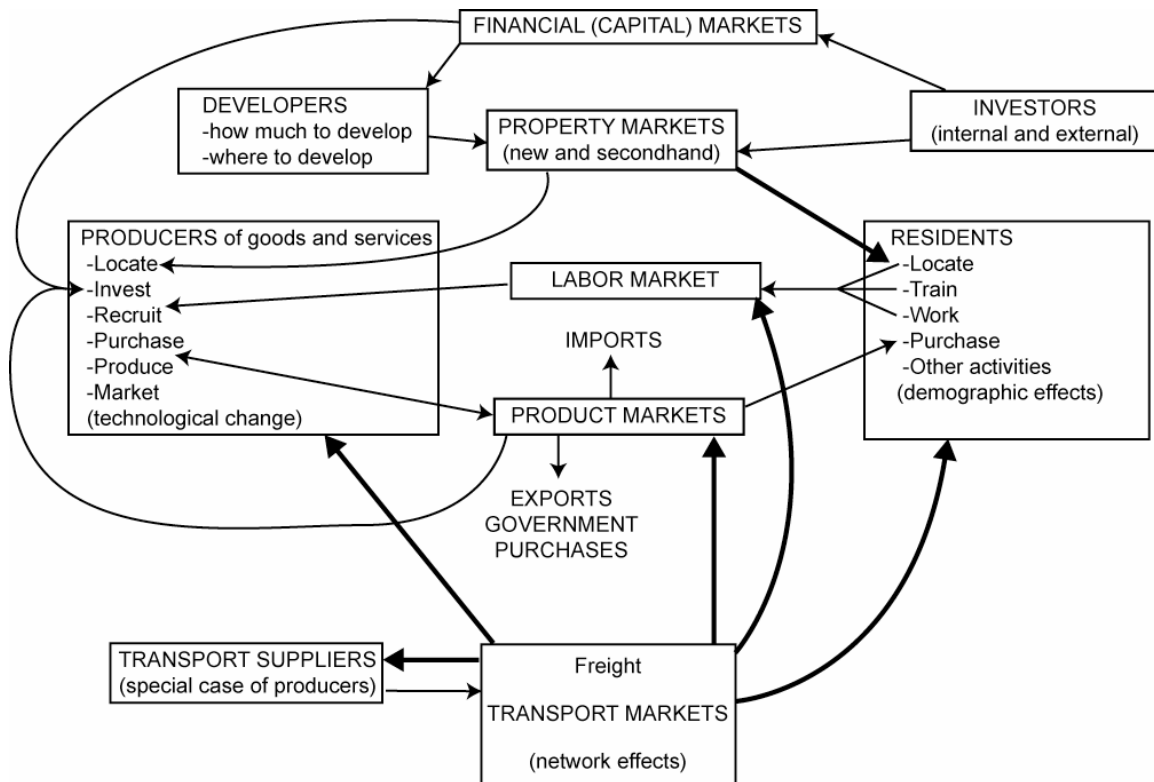


Figure 6.1. Stakeholders and Beneficiaries of Inland Port Construction (SACTRA 1999)

As Figure 6.1 implies, estimating the economic effects of transportation projects can be both complicated and contentious. Transport projects are often justified based on improving economic efficiency and are frequently components of economic development policies. While there are clear benefits from the development of transportation infrastructure, studies have shown that transportation investment is not a sufficient condition for economic growth. That is, in economically depressed areas there are factors beyond limited transportation capability that have hindered growth. While it is important to keep these caveats in mind when assessing the costs and benefits of developing transportation corridors that include extensive intermodal capabilities, in the U.S., which has an extensive and well-developed transportation system, transportation investment is more often aimed at alleviating congestion. Traditionally, estimates of demand for congestion alleviation projects are more reliable than other types of projects, and thus the direct transportation impacts are more easily estimable.

Calculating the impact of inland port/transportation corridor construction on labor and property markets can be more challenging. Transportation is argued to have several economic benefits, chief among these is the gain in efficiency that comes from improvements in transportation infrastructure and user costs. These improvements affect economies through their effects on businesses, labor markets, and property markets. Businesses benefit from lower transportation costs, which in turn reduces distribution and warehousing costs. Studies have shown that businesses are often able to consolidate supply chains as well, and this also reduces inventory and transportation costs. Labor costs remain the single largest cost for most businesses and improved transportation often links commercial areas to new labor markets. Expanded

transportation capacity is often argued to benefit workers by providing additional job opportunities while increasing the supply of labor and reducing average wage costs.

Inland port facilities offer specific economic benefits through their role as logistics hubs and distribution centers. Inland ports can benefit producers by providing more efficient supply chains. Inland ports can reduce the number of “intermediate links” in a supply chain, reducing costs and congestion. The overall “length of haul” can also be reduced, thus lowering transportation costs. This reduction in intermediary costs can be significant. For example, typically raw materials pass from suppliers, to manufacturers, to warehouses, and finally to retailers/suppliers. Between each node, transportation costs and transit time add to the costs of the product. Additionally, at nodes in the process, there may be inventory and “stock-out” costs. An inland port can consolidate key nodes in this process, reducing inventory costs and time. This benefits both producers, who have a simplified supply chain, and consumers, who will benefit from lower costs. Workers are affected by the same reduction in transportation costs that businesses enjoy. These costs can include the direct costs of commuting to work—the cost of fuel, depreciation to the value of a vehicle etc.—as well as the opportunity cost of time spent in transit. Additionally, workers can benefit from increased employment opportunities, as more jobs are accessible to them (Prozzi et al. 2002).

An additional economic advantage of an inland port located adjacent to a toll road is the possibility of increasing truck size and weight. On privately funded corridors such as the TTC, there is the possibility that transportation companies will be allowed to use vehicles that exceed current federal size and weight limits, providing a more efficient means of transporting goods. This would be an advantage for shippers, due to fewer trips, and to the corridor operator, since higher tolls would be charged. However, when the trucks leave the corridor and enter directly onto an urban street network, they would be restricted by lower weight and size limits. In these cases, inland ports located directly beside the TTC can supply the service of consolidating or transloading the cargo into multiple loads, so improving efficiency and possibly capturing more value for the inland port operator. The Florida turnpike system offers transportation companies the opportunity to make up and break down longer combination vehicles using open service areas adjacent to the toll road kiosks/entry points.

In the case of the Columbus Inland Port, the increased economic activity has been estimated to produce “25,000 additional jobs over a 15 year period,” contributing as much as \$73 million in annual income to the area.

The development of infrastructure, such an inland port and/or a transportation corridor can also generate growth in the size of labor markets. This is because labor is a locationally specific input to economic activity. That is, much of the labor will have to be physically present checking inventories, assessing weight, inspecting containers, etc. The facilities’ greatest effect on labor markets is to facilities located in same general geographic area as the facilities. Indeed, inland ports “tend to be labor intensive because of the value-added services provided at the ports.” These services include manufacturing, intermediary components for traded products, component assembly, packaging labeling, transportation, storage, distribution, or providing auxiliary services such as finance, accounting, marketing, legal advice, and customs brokerage (SACTRA 1999).

Increased transportation infrastructure often leads to increased property values because of improved accessibility. This improved accessibility makes investment in land more attractive because its utility has increased. Housing markets are known to display close relationships with transport improvements. Indeed, housing prices and land values may rise speculatively in anticipation of transport improvements. If transport is improved, the value of land at a particular location will rise because there is incentive both for individuals to move outward seeking cheaper land and for more land to be converted to urban use at the margin (SACTRA 1999).

Finally, increased economic activity brings larger tax revenues. Near Fort Worth, Texas, *tenants* at Alliance Texas paid \$45.7 million in taxes to two counties, four cities, and two school districts in the year 2000 alone. This was an increase over past years, and with growth at Alliance, it is expected to continue (Prozzi et al. 2002).

Detractors argue that these benefits can be negated in several ways. Some studies have argued that certain projects have a negative net present value due to the effects of induced traffic—demand increasing in response to supply, thus eliminating any benefit (SACTRA 1999). Transportation projects can also lead to environmental degradation, which can take the form of increased pollution or urban sprawl. Although difficult to model, where possible, the costs of these factors should be taken into account in economic analyses.

6.2 Types of Economic Impacts

The impacts from transportation projects can be divided into three broad categories. These are direct user benefits, direct economic benefits, and indirect and induced economic benefits (Weisbrod and Weisbrod 1997), which are identified in Table 6.1.

Table 6.1 Types of Economic Benefits (Weisbrod and Weisbrod 1997)

Direct User Benefits	Direct Economic Benefits	Indirect and Induced Impacts
<ul style="list-style-type: none"> • Ease of access • Comfort • Safety • Travel Time Savings • Reduced Travel Costs 	<ul style="list-style-type: none"> • Reduced costs for goods and services • Increased access to markets • Increased employment opportunities 	<ul style="list-style-type: none"> • Growth of markets for service providers • Changes to population patterns • Changes to business location patterns • Changes to land use, and resulting land value patterns • Changes to government costs and revenues • Changes to the environment

Direct user benefits are the easiest to identify. They are the benefits that are conferred to the people who use the system. They include improved comfort, safety, shorter transit times, and lower travel costs (TRB-477 1997).

Indirect economic benefits are the benefits that businesses and residents enjoy. For businesses, the benefits may take the form of improvements in efficiency. These improvements include improved labor market access and a lower cost of basic input factors. In turn, these

improvements lead to lower product cost, higher product quality, or better product availability. For residents who use the system, reduced cost of goods and services as well as better access to labor markets and leisure opportunities are some of the indirect benefits that can occur. Indirect economic effects can also include the growth of suppliers to directly affected businesses as well as growth in service providers to workers. Additionally, businesses and residents alike may be affected by changes to “population and business location patterns, land use, and resulting land value patterns, which may also affect government costs and revenues.” Changes such as these “ultimately affect income, wealth, the environment, and quality of life” (Weisbrod and Weisbrod 1997). For example, increases in trade due to NAFTA have seen growth because of

“...value-added trade related activities. These activities translated into an increase in employment of government officials, such as U.S. Customs and the Immigration and Naturalization Service (INS)*, and increased employment in the private sector. Increased private sector employment relates to the growth of manufacturing, transportation, storage, distribution, and other trade related services. Inland port development is thus motivated in some instances because of potential economic development benefits, which has occurred at traditional border ports of entry” (Prozzi et al. 2002).

6.3 Research Methodologies

Before any methodology can be employed to estimate the impacts of transportation investment, researchers must identify the relationships and variables that they seek to evaluate.

A number of methods are used to estimate these impacts. Common methodologies include input-output (I-O) models, economic forecasting and simulation models, and multiple regression and econometric models. Additionally, case studies are commonly compiled. Each model type has strengths and weaknesses with regard to effects that can be analyzed, the degree of expertise on the part of the analyst and the type and degree of specificity of data that is required. Importantly, these factors influence the amount of time and money that it takes to develop each type of model. Table 6.2 shows a selection of relevant popular methods.

* Both of these agencies have been absorbed into Customs and Border Protection (CBP), which is a part of the Department of Homeland Security (DHS).

Table 6.2 Common Methods of Estimating Economic Impacts (TCRP Report 25)

Benefit-Cost Analysis	Input-Output Models	Economic Forecasting and Simulation Models	Multiple Regression and Econometric Models
Used to assess the overall value of an investment. Can incorporate a large number of impacts into the analysis.	Measures effects of transportation investment, often in terms of employment and income. A widely accepted method.	Used for predictive studies. They can measure “employment, output, sales, and productivity by industry sector.”	Common types include hedonistic price modeling and logit models. Used to estimate the effects of a set of independent variables on price or a non-continuous dependent variable

6.3.1 Benefit-Cost Analysis (BCA)

This approach—also termed cost-benefit analysis—includes those techniques that attempt to set out and then evaluate the full benefits of a project to help decide whether it should be undertaken. This approach is straightforward, although some issues are often overlooked by users, and there may well be complexities when valuing certain social costs.

The main difference between BCA and ordinary investment appraisal techniques is an emphasis on social costs and the use of values net of taxes and transfers. Typically, the project impact is disaggregated into a variety of cost (net) components, which are then allocated over the life cycle of the project. Costs are then discounted back to present value using a discount rate, which approximates to cost of capital to produce a net present value, internal rate of return and, if necessary, a cost benefit ratio (Luskin, 1999).

6.3.2 Input-Output Models

Input-output (I-O) models are used to “enumerate inter-industry production and linkages that occur as a consequence of increased demand and consumption within a particular sector, such as transit.” Researchers can use the amount that a new transit system costs to “construct, operate and maintain” as inputs to an I-O model. “The model estimates the dollar value of direct, indirect and induced production that results from the spending. In this kind of analysis, the input to the model is the dollar value of the...travel time savings, safety benefits and changes in operating costs...for industries that will benefit from [the investment].” I-O models measure transfer impacts, usually in terms of employment and income. They also provide inter-industry outputs by sector (Cervero and Aschauer 1998). “I-O modeling is a widely accepted methodology for tracking the economic impacts of major investments within a regional economy’s industry sectors.” However, I-O models are complicated and their focus on industrial interaction can ignore other important economic costs and benefits. Additionally, their development is time-intensive (Cervero and Aschauer 1998).

6.3.3 Economic Forecasting and Simulation Models

Forecasting and simulation models can aid in the analysis of business cost, competitiveness, and changes in the business environment, in addition to inter-industry production and consumption.

They “come much closer than I-O models to capturing the full range of potential benefits from transportation investments.” Systems of simultaneous regression equations and stochastic simulation are common methods of designing forecasting and simulation models. “Variables such as demand levels, capital supplies, service levels, and prices simultaneously influence each other.” Forecasting and simulation models attempt to capture these relationships and generate forecasts. They are capable of forecasting “employment, output, sales, and productivity by industry sector, and personal income.” Economic forecasting and simulation models “forecast both construction period impacts and long-term, permanent impacts,” but they are expensive (Cervero and Aschauer 1998).

6.3.4 Multiple Regression and Econometric Models

Because of the easy availability of time-series data on land values and property sales, multiple regression models are a popular way of exploring causal relationships between infrastructure projects and their benefits. “Regression models allow researchers to distinguish, within a certain degree of probability, the amount of economic changes in a study area attributable to” transportation investment. Regression allows the effects of transit’s presence to be separated out from the influences of other factors, like location, topography, neighborhood quality, etc. (Aschauer 2001) A special type of regression involves logistic regression (logit) models. These are used when the dependent variable is not continuous. (Cervero and Aschauer 1998)

6.3.5 Recent TxDOT Recent Sponsored Research on Economic Impacts

TxDOT, through its Research Technology and Implementation (RTI) Office, sponsors a wide variety of transportation studies to strengthen Departmental efficiency and resolve critical problems facing staff. This program recently included various economic subjects, including the broad topic of how transportation affects the state economy. One such study, taking a macro view of the topic, is a joint TTI/CTR study entitled “Transportation and the Texas Economy” and is now under final RTI review and is to be published later this year (Burke, D., Luskin, D., and Rosa, D., 2006). This study will identify current, accurate, and objective economic measures that will assist the development of programs consistent with the Department mission and current strategic plan.

The study team will compile, using current state and U.S. data, an economic profile of the transportation system and its relevance to the state of Texas, evaluating such data as transportation outlays and gross state product, freight transportation outlays by mode, the same for passenger transportation by mode, employment in transportation, outlays for transportation equipment and capacity, and finally, government expenditures in transportation services and facilities. A summary of the results from this undertaking will be published in a pocket guide, which could be useful to those evaluating the economic impacts of inland ports.

TxDOT study 0-5025, entitled “Promoting Local Participation on Transportation Improvement Projects”, addresses many of the key elements identified in this chapter. The study, due in late 2006, will develop examples of economic and other benefits from major transportation projects, identify estimation methods to quantify economic benefits, and provide existing and innovative funding sources for local entities. The project is scheduled to develop a guidebook to use when choosing a method to estimate project benefits (Luskin, D., Hallett, I., and Walton, C.M., 2006) and identify examples of a benefit prospectus to encourage local participation (Bochner B.,

Luskin D., Hallett I., and Walton C.M., 2007). It is recommended that both the final report and the various products of this study—particularly the guide—be used to sharpen the specific benefits associated with each prospective inland port location.

6.4 Conclusion

The act of constructing the TTC will itself have a major impact on the surrounding economy. The Perryman Group completed a study that relied on Input-Output and econometric models to estimate that construction of the TTC will contribute \$10.1 billion to Texas' annual gross state product as well as 176,936 person-years of employment. The model also used cost-per-mile estimates to estimate the direct economic effects. Indirect and induced effects estimates were calculated using a proprietary Texas Multi Regional Impact Assessment System. The impact of construction will include direct benefits, as well as indirect and induced impacts (The Perryman Group, 2002).

Typically, the benefits generated by inland ports or large distribution centers of the type likely to be built near the TTC will be in two categories. The first relates to the type and size of the inland port, including terminal design and the company profiles of those located within the port. The category also generates the economic activity that drives the demand (and routes) for trucks. The second category relates to the macro-economic impacts created by the port, centering on company activities within the port. This category produces the economic and financial data that are used by a wide variety of individuals, particularly developers, chambers of commerce members, and local politicians to discuss, promote, or question specific private investments. Such data include job creation, salary levels, and taxes of various types, together with rebates or incentives that may be offered to companies to relocate to the new site. The recommendations of the team will be given in the next and final chapter. The subject of economic impacts, however, can be summarized as follows. Locational modeling should ultimately incorporate economic impacts of the first type, since they generate the traffic impacts so critical to transportation efficiencies in the metropolitan area. Once the ranking of sites is determined, then the second category can be broadly established for community use. However, it should be recognized that, in all likelihood, the macro-impacts will be identical between all the favored locations and can therefore play no part in selecting reasons why one is preferable to another.

Chapter 7. Summary and Conclusions

7.1 Introduction

The study proposal contained a number of key tasks—principally, the development of a location model and the measurement of traffic impacts in a tested user-friendly planning format—that were successfully addressed during the course of the work. Two tasks, however, could not be easily incorporated into the work—one for reasons beyond the scope of the team, the other because of data issues.

The first was a result of the delay in the selection of the TTC 35 consortium (Cintra-Zachary) that stretched virtually until the end of the project, or at least well past the time when all modeling aspects could be changed within the study period. This was unfortunate, because it meant that the team never had an opportunity to incorporate the consortium’s ideas into the model development, although Cintra-Zachary did have an opportunity to review the completed Austin case study and offered constructive feedback to the team.

The second prevented the model from explicitly considering the macro-economic impacts associated with site location within the structure of the model. Insufficient disaggregated economic data exists at the Texas metropolitan level to permit site discrimination at the micro-level—that is, where sites are so close to each other (sometimes just a few miles) that no economic differentials exist. Accordingly, the data available cannot contribute to a site selection model in the way the proposal described. A compromise was therefore reached. Once the model had selected the best sites based on the multiple attributes described in Chapter 3, a broad measure of macro-economic impacts, covering tax, employment, and multiplier effects would then be estimated to show the overall impact of the facility on the local economy. The team recognizes that such an action is required because these data play critical roles in determining whether planning permission is granted by local governments, and in some cases, whether incentive packages are offered to inland port or distribution center developers or operators.

7.2 Further Work on the Location Model for Planning Use

Given more time, this work could be expanded in several significant ways. Comparisons could be made between site alternatives not only for average speeds, but also for peaks in the speeds and volumes of each link, using DYNASMART-P simulations and so creating a more accurate depiction of traffic behavior on the network.

It would also be helpful to test the IPS add-in completely by conducting further work to consider as many of the seven criteria as possible. This would involve additional work, including a study of varying construction costs, finding the environmental effects of each alternative due to traffic (to find possible variances), and studying each individual area to find economic impacts attendant on future growth.

In addition, if truck traffic studies are desired for the future, either for the state or for private developers, more truck-specific data should be collected regularly. Currently, auto studies are generally completed with a high degree of accuracy, due to the detail of volume and origin-destination data for autos, but truck data are lacking. Incorporating truck traffic volumes by time of day and origin–destination tables similar to the tables currently existing for total traffic would result in studies such as this one being completed much more accurately.

Aside from the truck-specific volumes and origin-destination data that could be collected, it may also be useful to determine the two different traffic impacts separately. For widespread traffic impacts, such as the lowering of congestion and travel times in the network, TransCAD would be the preferred package for analysis. For the more localized impacts on the area near a planned inland port, a simulation model such as DYNASMART-P would be much more accurate. The two resulting impacts of an inland port that is in the preferred location could be compared to determine whether the inland port creates an overall travel time cost or benefit. The hope would be that the inland port implementation would cause a travel time benefit, but even if not, it may still be worthwhile due to economic, safety, and road condition benefits.

7.3 Final Thoughts

A multi-modal transportation corridor like the TTC possesses a number of benefits that offer planners a new transportation system solution to meet future needs of the Texas economy and its residents. Predictably, the corridor has been largely approached from the engineering or supply side part of the transportation equation. A somewhat overlooked aspect—and perhaps the most difficult area—is the benefit from the demand side, in all the different forms associated with potential corridor modes. A key reason for promoting a multi-modal corridor a decade ago in study 0-1246 was that total modal benefits exceeded any benefit associated with highways alone.

In this regard, the TTC is multi-modal only in concept at this stage in its development. The TTC 35 master plan will almost certainly rely on highway use to generate the revenues to finance the project—at least in the early years. Other modes—rail, truck-only, utilities, and so forth (water transmission is currently not permitted)—may well use the corridor and contribute to its economic success, but it will take time to incorporate TTC alignments into their existing networks to where it would make commercial sense. The proposal assumed that the TTC 35 could incorporate development at or around a limited number of metropolitan ramps (termed “nodes”) to facilitate freight transfers in a more efficient manner than that currently possible. The team strongly believes that the benefits (value-added services) offered at such sites would strengthen the revenue stream of the TTC 35 operator and constitute a legitimate source, since such sites would have no purpose if the TTC were located elsewhere or not built at all.

This much is known: Large distribution centers are now a fundamental part of the logistics business. Sometimes, they can be grouped into centers like inland ports that can then act as economic engines to springboard or stimulate local growth. If the TTC 35 consortium is precluded from developing such sites as part of its master plan then it is highly likely they will be provided by other private sector groups. At the October 2005 lunch of the Austin Realtors, the economic impacts of SH 130 (TTC 35) were predicted to create the biggest economic change in the city in around 40 years—since the construction of IH 35. If the model developed as the main product of this study is not ultimately used by the TTC 35 consortium, it should find a useful home in the TxDOT Austin District office or at CAMPO, evaluating the wide variety of sites that will be promoted by the private sector. Moreover, this is likely to be repeated in other metropolitan areas like San Antonio, as the TTC 35 offers supply chain improvements to the shipping and freight sectors.

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Appendix A: Inland Port Classification User's Guide

Introduction

This document consists of a description of the current GIS-based Inland Port Selection software. This software facilitates the task of finding the best inland port location according to given criteria. For this document, accessibility to the Trans-Texas Corridor (TTC) is specifically emphasized.

Software Overview

In order to use the Inland Port Selection application, a commercial license of the TransCAD GIS software is required. To properly execute the program, a GIS map containing nodes and links layers must be present among the layers of the map.

Running the Inland port selection (IPS) program

Open the TransCAD program (refer to the installation guide for an explanation on the installation process for the program). Ensure that the required files are in the *saved* map file you will be working on.

Starting GISDK


- Choose **Tools-Add-Ins** to display the Add-Ins dialog box.
- Select the GIS Developer's Kit in the Add-Ins list.
- Select OK.

The GISDK Toolbox shown in Figure A1 is displayed on the screen, meaning that you are ready to use GISDK.




Figure A1. GISDK Toolbox

Compiling the IPS Add-In

- Make TransCAD the current application.
- Click on the compile button  in the previously opened GISDK Toolbox to display the Compile File dialog box.
- From the Inland Port Selection Program folder, choose the file named IPS and click on the Open button.

GISDK will compile the selected file. The compiler will proceed to check the syntax of the statements in the file. If any errors are found, they will be displayed as a list in an error file.

Running the Inland Port Selection Add-In

- Click on the test button  in the GISDK Toolbox to display the Test an Add-In dialog box.
- In the Type of Add-In radio list, select the Macro option.
- Type in “IPS” in the Name text box, as shown in Figure A2.

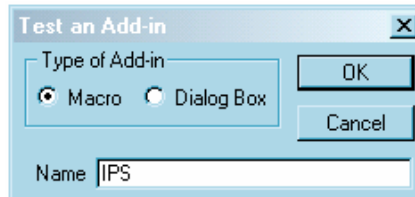


Figure A2. Test an Add-In Dialog Box

- Click OK. TransCAD will display a dialog box called Inland Port Selection (Main Toolbox). Figure A3 displays a graphical representation of this toolbox and the numbering that will be used for organization of the sections of this guide.

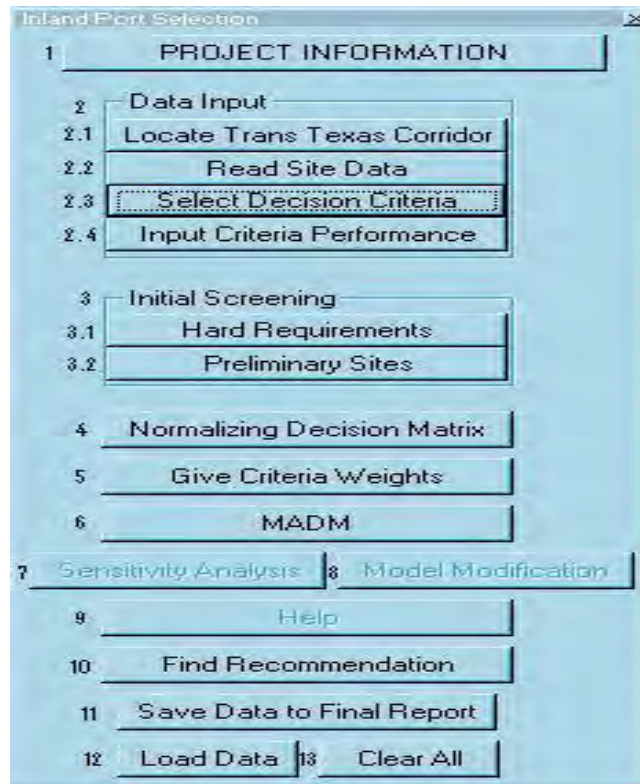


Figure A3. IPS Program Toolbox

Inland Port Selection Dialog Box

A brief description of the basic components of the dialog toolbox will be given. Each section related to one component/button of the dialog box will be given the same number, as shown in Figure A3.

1. Project Information

This button provides an area where the user can input the general information of the project. First, a layer information edit box will appear *requiring* the user to enter the name of the node layer and highway layer that are at use. This will ensure the proper running of the program.

Once done, several edit boxes are provided in which the rest of the project's information can be entered.

2. Data Input

This section consists of the following criteria buttons:

- **2.1 Locate Trans Texas Corridor**

When the user clicks on this button, a dialog box called Outline Trans Texas Corridor will appear on the screen (refer to Figure A3). The “Draw” button (shown in Figure A4) allows the user to draw the TTC on the screen by connecting points on the TransCAD map. Once this is done, clicking “OK” closes this dialog box.

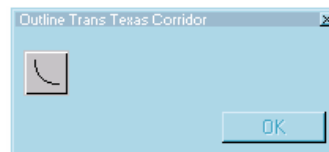


Figure A4. Outline Trans Texas Corridor Dialog Box

- **2.2 Read Sites Data**

This dialog box (Figure A5) allows the user to input the number of candidate sites that will be considered. The maximum number for this option is 10 candidate sites. Once the user has entered the number of sites, a second dialog box will appear. The button in this dialog box allows the user to create the sites in the TransCAD window. Creation of these sites consists of forming the shape as a series of points and double clicking on the closing point.

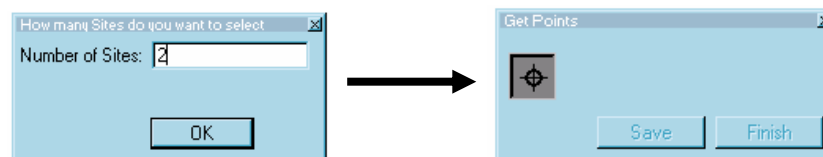


Figure A5. Number of Sites to be Selected and Site Creation Tool

The program will allow the user to create the number of sites entered in the previous dialog box. Once all the sites have been created, clicking Finish will close this dialog box.

Figure A6 displays how the utilization of this option will look on the screen.

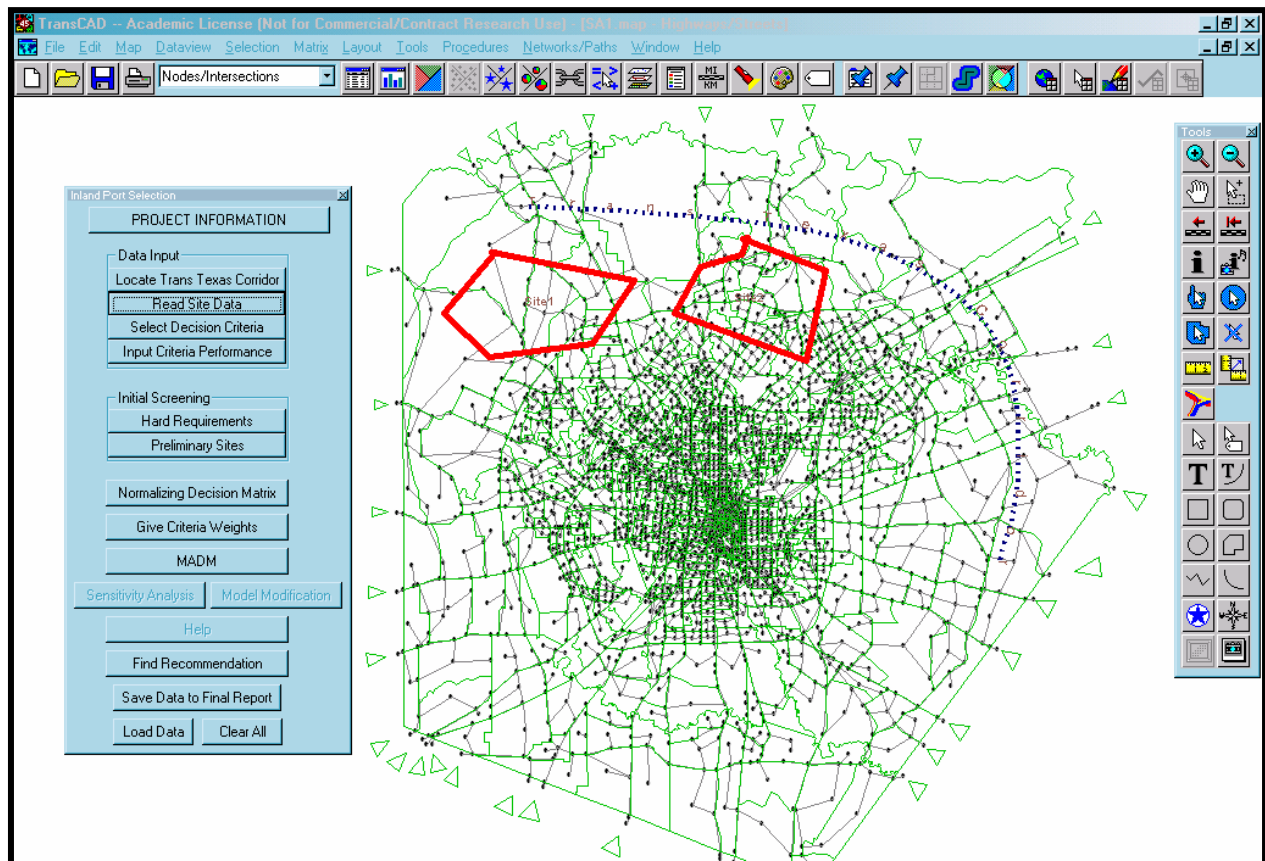
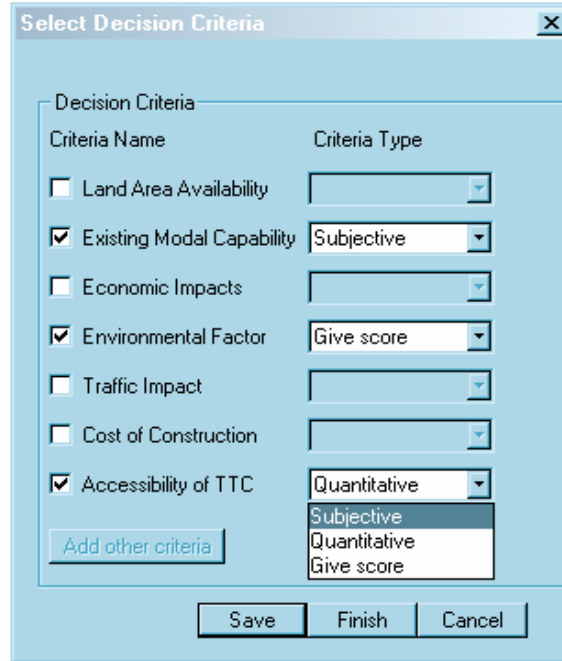


Figure A6. Graphical Representation of Candidate Site Creation

- ### 2.3 Select Decision Criteria

The user has the option to select among the given criteria from this dialog box. Once a criterion is selected, the corresponding criteria type list (see Figure A7) will be enabled, giving the user three options on how to input the data—Subjective, Quantitative, and Give Score.



The dialog box is titled "Select Decision Criteria" and contains a table with two columns: "Criteria Name" and "Criteria Type". The table lists seven criteria, each with a checkbox and a dropdown menu. The "Existing Modal Capability" and "Accessibility of TTC" criteria are checked. The "Accessibility of TTC" dropdown menu is open, showing three options: "Quantitative", "Subjective", and "Give score". Below the table is an "Add other criteria" button. At the bottom of the dialog box are three buttons: "Save", "Finish", and "Cancel".

Criteria Name	Criteria Type
<input type="checkbox"/> Land Area Availability	
<input checked="" type="checkbox"/> Existing Modal Capability	Subjective
<input type="checkbox"/> Economic Impacts	
<input checked="" type="checkbox"/> Environmental Factor	Give score
<input type="checkbox"/> Traffic Impact	
<input type="checkbox"/> Cost of Construction	
<input checked="" type="checkbox"/> Accessibility of TTC	Quantitative

Buttons: Add other criteria, Save, Finish, Cancel

Figure A7. Select Decision Criteria Dialog Box

- **2.4 Input Criteria Performance**

This dialog box displays the criteria that were selected by the user in the Select Decision Criteria dialog box shown in Figure A7. This dialog box allows the user to input the criteria performance according to the type selected. If the criterion is given a Subjective type, the user may choose among the following categories: very low, low, average, high, and very high. If a criterion is given a Quantitative or Give Score criterion type, the user has the freedom to enter this data according to his or her needs and discretion. Figure A8 shows this dialog box.

For the special case of Accessibility of TTC if the user chooses the quantitative criterion type, the Shortest Path tool will appear on the screen. When selecting this tool, the user must double click on the section of TTC where the tool is to calculate the shortest path. The shortest path will be drawn on the map and the distance will be displayed in the text box.

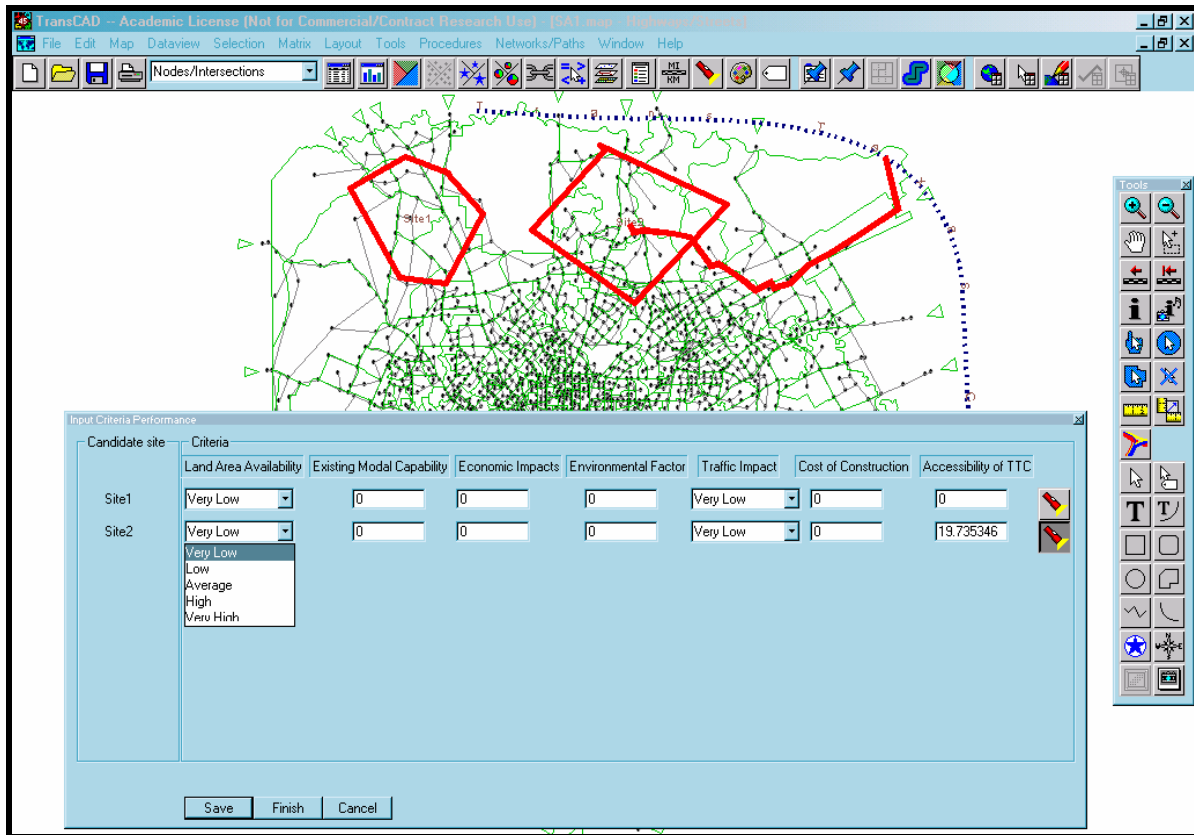


Figure A8. Input Criteria Performance Dialog Box

3. Initial Screening

This section consists of the following criteria buttons:

- **3.1 Hard Requirements**

This option allows the user to filter candidate sites according to “hard requirements” (see Figure A9) that can be assigned to the sites.

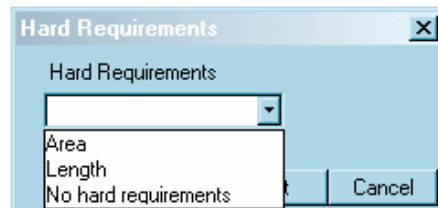


Figure A9. Hard Requirement Dialog Box

Area:

Selecting Area displays a dialog box with the areas of all the sites. Once the hard requirement has been input, selecting Next will display another dialog box that gives the option of entering a value for site area and choosing a “greater than” or “less than” sign, filtering candidate sites that are above or below that value.

Length:

Selecting Length displays a dialog box that shows the shortest distance from the sites to the TTC, from the Input Criteria Performance step. Selecting Next displays another dialog box that gives the option of entering a value for length to the TTC and choosing a “greater than” or “less than” sign to filter candidate sites that do not comply.

- **3.2 Preliminary Sites**

After all the filtrations have taken place, this option lets the user know which candidate sites remain. The other sites are removed.

4. Normalizing Decision Matrix

The criteria selected in the previous steps will be displayed in a Normalizing Decision Matrix, as seen in Figure A10. The user will need to define the normalization type with benefit or cost. The program will use a method to calculate the normalization for the corresponding criterion.

Criteria Name	Normalization Type
Land Area Availability	Benefit
Existing Modal Capability	Cost
Economic Impacts	Benefit
Environmental Factor	Benefit
Traffic Impact	Benefit
Cost of Construction	Benefit
Accessibility of TTC	Benefit

Save Next Cancel

Figure A10. Normalizing Decision Matrix Dialog Box

5. Given Criteria Weights

The program allows the user to select the type of method (see Figure A11) he or she wants to use in order to assign weights to the criteria.

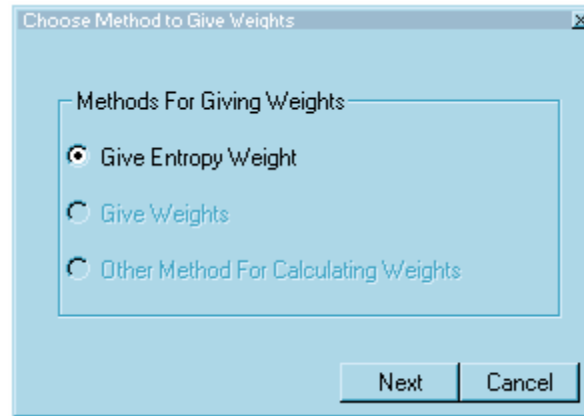


Figure A11. Given Criteria Weights Dialog Box

6. Multiple Attribute Decision Making (MADM)

The program allows the user to find the best site according to relative closeness to the ideal solution. Figure A12 displays the type of MADM methods that are available to the user.

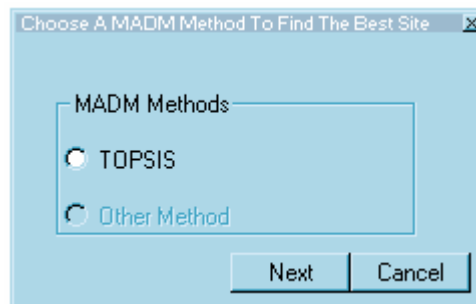


Figure A12. MADM Dialog Box

7. Sensitivity Analysis

This element of the model will be available in future developments.

8. Model Modification

This element of the model will be available in future developments.

9. Help

This element of the model will be available in future developments.

10. Find Recommendation

This option displays the results obtained by applying the described methods. These results are in the form of a final ranking of the suitability of each location.

11. Save Data to Final Report

When finished with steps 1 through 10, the user can click on this button to save all the data entered into a final report that will be exported into a text file. Thus, this button

will give the option of selecting or entering a project file name that will be saved to the specified file.

12. Load Data

This button allows the user to import the saved data and information from individual dialog boxes. This intermediate data should not be mistaken for the data of the final report.

13. Clear All

The user can wipe all the information from the current project in order to allow for the reentering of new data. This will not erase previously saved information.

Appendix B: TxDOT Research Project 0-1326—The Managed Transportation System

A Center for Transportation Research (CTR) team examined alternative systems to the current interstate network. This team was led by Dr. B. Frank McCullough, who worked on IH designs as a Texas Department of Highways engineer in the late 1950s and was therefore aware of the change in rural IH mobility. TxDOT Project 0-1326 was awarded to CTR in 1994 and addressed how the capacity dilemma for IH transport might be approached. Originally termed a *super corridor* by the team, a concept was proposed that blended a variety of approaches to congestion management in urban settings, primarily by capitalizing on the benefits of multi-modality, as well as providing financial mechanisms to sustain its operation and maintenance.

CTR Project 0-1326 found that vehicular traffic moving through rural sections of IH 35 in Central Texas had been growing at a dramatic rate since 1985. Some rural sections exhibited traffic growth rates as high as 10 percent per annum between 1970 and 1993. As traffic grows, so does travel time—with the inevitable consequence of increased congestion. Examining Figure B1 shows that a trip from San Antonio to Dallas on IH 35 that took approximately 4.5 hours in 1972 would require 8 hours by 2006, if no capacity were added and traffic grew at 8 percent.

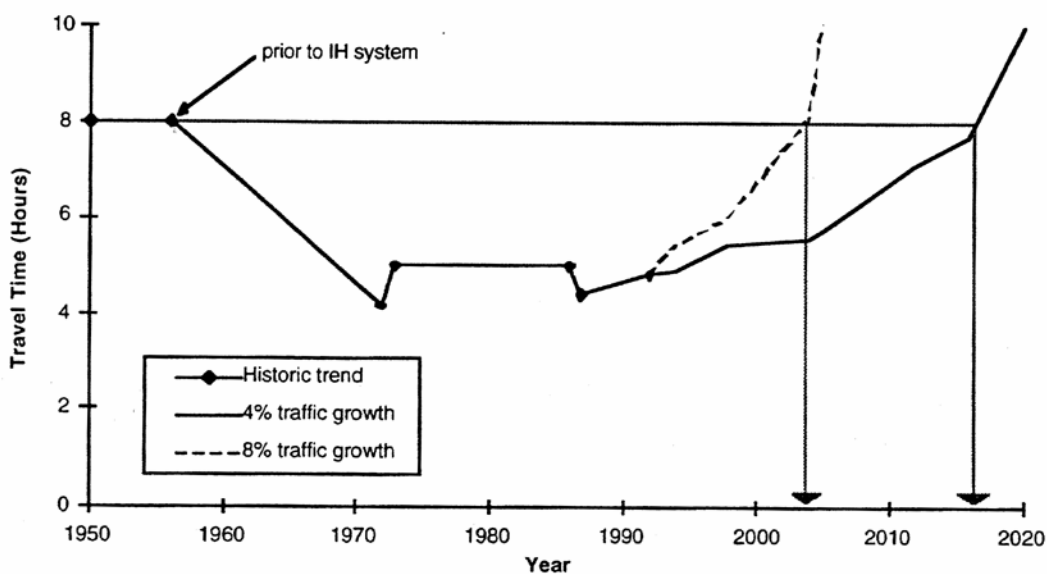


Figure B1. Travel Time for a San Antonio-to-Dallas Trip along IH 35

The primary objective of Project 0-1326 was to examine alternatives to the “build-out” philosophy typically adopted by transportation planners facing IH congestion. As the team evaluated alternative designs, it was decided to include rail and other commodities transmitted over land. A key recommendation was that congested sections of the IH network (like Central Texas on IH 35) could be relieved by building a complementary multi-modal loop. This was first

termed a *super corridor* or *managed transportation system* (MTS) and was considered a feasible solution to the growing congestion on certain IH rural sections. Figure B2 gives one example of a cross section of the MTS from Report 1326-1 and shows the key features of the system—separate truck lanes, high-speed car lanes, service areas, rights-of-way for the transmission of gas, electricity, and fiber optics, and a rail element.

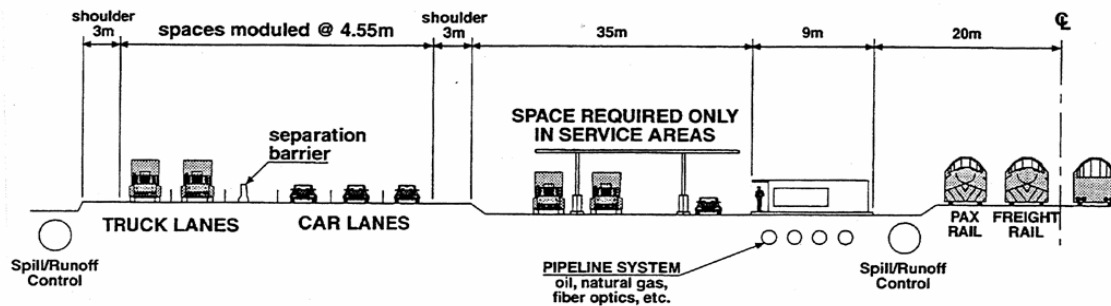


Figure B2. Conceptual Cross Section of the MTS Approach to Capacity

The concept proposed in the MTS reports lay dormant for several years. In part, this was because the MTS did not fit into historic TxDOT planning and also required changes in state legislation. Furthermore, when the MTS idea was first developed Union Pacific (UP) was addressing operational problems following its merger with Southern Pacific, and it was simply not the time to meet with UP and discuss the MTS multimodal corridor program.

The MTS was, in essence, a relatively short multimodal bypass of congested IH sections like Austin, which tied into the IH system. As an example, an MTS for Central Texas would have linked into the Union Pacific line around Round Rock and back into the right-of-way near San Antonio, and would have provided only two directional rail lines shared with higher speed passenger travel of the type provided by Amtrak on the Washington D.C to New York corridor. The current Union Pacific MOPAC right-of-way would have been used for low-speed heavy commuter rail, for other public transit systems, and for rail freight deliveries to UP customers in the emerging Central Texas Metroplex.

The governor's office reviewed the 0-1326 reports and it may therefore have formed the basis of certain TTC characteristics. State Highway 130, when completed, will follow the route recommended by the 1326 team, though the rail element was not part of the original design and was retrofitted into the highway alignment.

Appendix C: Multiple Criteria Decision Making and Inland Port Selection Decision Model

The commonly used approach for selection is based on the weights assigned to several criteria and measured scores of each candidate with respect to different criteria, termed the Simple Additive Weighting (SAW) MCDM approach because of its consideration of multiple criteria. However, it is important to realize that the SAW approach is just one of a number of MCDM models as shown in Appendix C.

A strong assumption underlying SAW is that the DM accepts the performance tradeoffs of the criteria among the different candidates. In some applications, certain criteria are given absolute thresholds which must be met and, which, if violated, disqualify the candidate site. Therefore, SAW may not necessarily be the most suitable approach for all applications including inland port site selection. Furthermore, the assignment of criteria weights could be more accurately captured by applying a pair-wise comparison of the criteria. Instead of assigning weight to all criteria at once, the pair-wise comparison approach asks the DM to select two criteria and compare their relative importance. This approach is prevalent as it allows the DM to carefully and accurately report their preference toward the criteria.

Decision support for multiple criteria problems has advanced significantly in the last 20 years and is now a recognized research approach (Shim, Warkentin, et al. 2002). MCDM techniques are used in a wide variety of applications (Gillians, Raymaekers, et al. 2005); in transportation, MCDM has been widely used in recent years to study freight research problems. As an example, freight transportation, multi-criteria shortest-path problems have always been hard to solve. Skriver incorporated MCDM theory into this problem (Skriver and Andersen 2000) and, by implementing and testing different algorithms, made a theoretical argument on the performance of all the existing algorithms to rank them by performance. Some other topics relating to freight transportation have also proved to have close interaction with MCDM. A report by Davis (Davis et al. 1999) described how MCDM might be used in conjunction with transportation system modeling techniques to select among alternative transportation corridor improvement options. In addition, freight shipping company performance evaluation, strategic alliance selection in linear shipping, and street maintenance resource allocation evaluation can all utilize MCDM to perform a concrete and effective solving process (Ding et al. 2004).

In addition, the traditional TOPSIS method does not consider ambiguity in the measurement of qualitative attributes. Some of the evaluation data of inland port location under different qualitative criteria are often expressed linguistically, making the application of fuzzy set theory (Facchinetti and Ricci 2003) advantageous in reflecting the vagueness of the human cognitive process when utilizing TOPSIS to evaluate inland port location-selection problems. Chen (Chen et al. 1992) and Chu (Chu 2002) proposed using fuzzy numbers in the TOPSIS analysis which significantly enhanced the capability to represent a decision maker's preference. However, a reasonable method for assigning criteria weights is still lacking.

Deng proposed a simple and reasonable method to calculate criteria weights using weighted Euclidean distances (Deng et al. 1998). This method is applicable to inland port location-

selection problems, because reliable subjective weights cannot be obtained. In other words, when the problem involves a group of Decision Makers (DMs) with various interests, a consensus on the criteria weights may not always be achieved. The foundation of this method is Shannon's entropy concept (Weaver 1947), which is a measure of uncertainty in the information formulated using probability theory. It indicates that a broad distribution represents more uncertainty than a sharply peaked one. Although there are many other methods for giving criteria weights (Fan et al. 2001), the entropy method has three distinct features. The first is particularly applicable when reliable subjective weights are difficult to obtain. The second can resolve the problems that are encountered when criteria may not be completely independent, because they are all linked and affected to some extent by the operation of the alternatives when using an objective weighting process.

In this Appendix, the proposed modified fuzzy TOPSIS is discussed in detail. First, the following notations are defined:

I	: Set of alternatives
J	: Set of criteria
X	: Decision matrix, $X = \{x_{ij} \mid \forall i \in I, j \in J\}$
x_{ij}	: Numerical outcome of the i th alternative with respect to the j th criterion
x_j^*	: $\max_i x_{ij}$, the maximal x_{ij} value across all alternatives
x_j^{\min}	: $\min_i x_{ij}$, the minimal x_{ij} value across all alternatives
R	: Normalized decision matrix, $R = \{r_{ij} \mid \forall i \in I, j \in J\}$, $R = \Theta X$, Θ : normalization operator
r_{ij}	: Normalized numerical outcome of the i th alternative with respect to the j th criterion
W	: Criteria weight vector, $W = \{w_j \mid \forall j \in J\}$
w_j	: Weight of criterion j
V	: Weighted normalized decision matrix, $V = W \cdot R = \{v_{ij} \mid \forall i \in I, j \in J\}$
v_{ij}	: Weighted normalized numerical outcome of the i th alternative with respect to the j th criterion

Next, the proposed modified fuzzy TOPSIS entails the following steps:

Step 1: Transform Fuzzy Numbers into Crisp Numbers (optional)

The transformation of fuzzy numbers into crisp numbers is needed when linguistic terms (e.g., very poor, poor, good, very good, etc.) are used to capture subjective assessment of a certain criterion. Using linguistic terms to capture a decision-maker's response has advantages, as it is the natural way opinions are expressed. However, the linguistic terms need to be converted to commensurable units in order to work with other attributes (note that TOPSIS is a type of compensatory multi-attribute model). The proposed method is a numerical approximation that

converts linguistic terms to their corresponding fuzzy numbers. Similar to the method proposed by Chen (Chen and Hwang 1992), the scale system contains five conversion scales, depending on the number of linguistic terms and different verbal terms. This step consists of the following two sub-steps:

In the proposed method, each verbal term is represented by a triangular fuzzy membership function, as shown in Figure C1. There are fuzzy numbers associated with each membership function. The membership function assigns to each fuzzy number a grade of membership Y . This membership grade ranges from $[0, 1]$. Meanwhile ordinate U_Y is the membership value for the vertical axis. The fuzzy max shown in Equation (1) and fuzzy min shown in Equation (2) are defined in a manner such that absolute locations of fuzzy numbers can be automatically incorporated in the comparison process. They are defined as the two dashed lines in Figure C1.

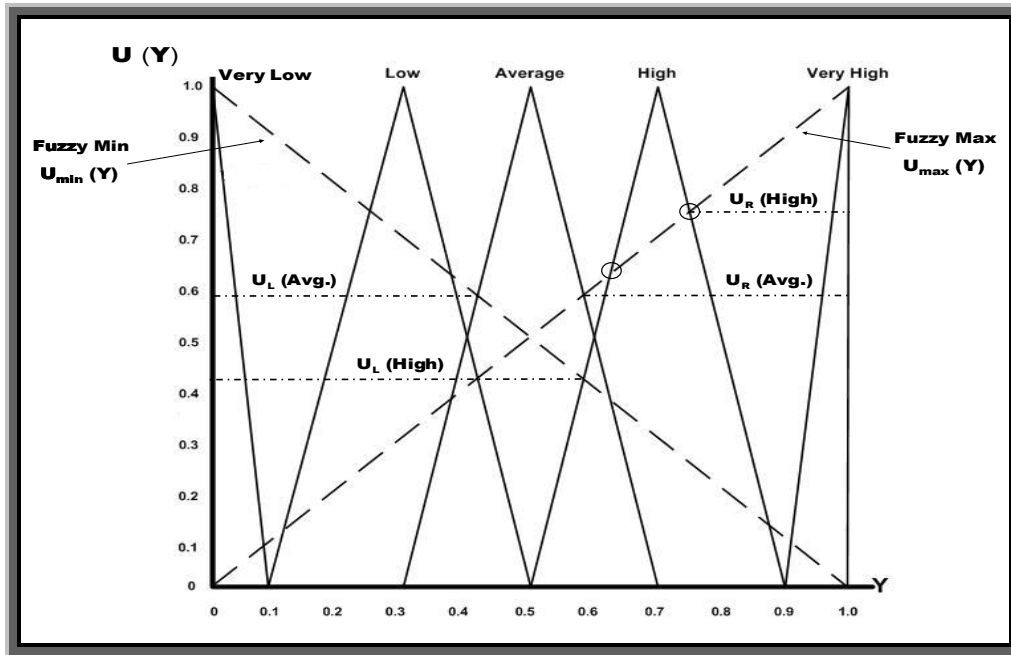


Figure C1. Conversion of Linguistic Terms to Fuzzy Number for Qualitative Attributes

The membership functions are shown as follows:

$$U_{\max}(Y) = \begin{cases} Y, & 0 \leq Y \leq 1 \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

$$U_{\min}(Y) = \begin{cases} 1 - Y, & 0 \leq Y \leq 1 \\ 0, & \text{otherwise} \end{cases} \quad (2)$$

Then, the right utility score of each fuzzy number M is defined as:

$$U_R(M) = \text{Max} [U_M(Y) \cap U_{\max}(Y)]. \quad (3)$$

The $U_R(M)$ score is a unique, crisp, real number in $[0, 1]$. It is the maximum membership value of the intersection of fuzzy number M and the fuzzy max. For example, the line of fuzzy max has two intersecting points with the membership function of the fuzzy number *High*, as shown in Figure C1. The membership values of these two points are 0.63 and 0.75; therefore, the maximum membership value of these two points is 0.75, which is $U_R(High)$ as shown in Figure C1. The left score of M can be determined using:

$$U_L(M) = \text{Max}[U_M(Y) \cap U_{\min}(Y)] \quad (4)$$

Again, $U_L(M)$ is a crisp number in $[0,1]$.

Given the left and right scores, the total score of a fuzzy number M is defined as:

$$U_T(M) = \frac{[U_R(M) + 1 - U_L(M)]}{2}. \quad (5)$$

The results are summarized in Table C1.

Table C1. Linguistic Term Converted to Crisp Score

	Very Low	Low	Average	High	Very High
Crisp Score	0.0455	0.335	0.5	0.667	0.954

Step 2: Construct Normalized Decision Matrix

The original decision matrix usually contains incommensurable attribute units; thus, the normalized decision matrix R ensures that all the values in the normalized matrix are between zero and one. The normalization also ensures that both benefit (the larger the more preferable) and cost (the smaller the more preferable) attributes are converted to the same direction (the larger the more preferable). Namely, for the benefit criterion j , we consider the normalization of x_{ij} as Equation (6).

$$r_{ij} = \frac{x_{ij} - x_j^{\min}}{x_j^* - x_j^{\min}} \quad (6)$$

For the cost criterion j , the normalization of x_{ij} is expressed as:

$$r_{ij} = \frac{x_j^* - x_{ij}}{x_j^* - x_j^{\min}} \quad (7)$$

The normalized decision matrix can therefore be expressed as:

$$R = \begin{bmatrix} r_{11} & r_{12} & r_{13} & \dots & r_{1m} \\ r_{21} & r_{22} & r_{23} & \dots & r_{2m} \\ r_{31} & r_{32} & r_{33} & \dots & r_{3m} \\ \dots & \dots & \dots & r_{ij} & \dots \\ r_{n1} & r_{n2} & r_{n3} & \dots & r_{nm} \end{bmatrix} \quad (8)$$

Step 3: Calculate Criteria Weights

The criteria weights represent decision makers' attitudes toward the importance of each criterion. In the inland port site-selection context, reliable criteria weights may not be easy to obtain because either a diversified group of decision makers are involved or the decision makers have a wide range and inconsistent perception toward inland port selection. To remediate this issue, we introduce the entropy measures (Shannon, C.E. and Weaver 1949) that are designed to construct reliable criteria weights.

To this end, we consider that the amount of decision information contained in Equation (8) can be measured by the entropy value e_j as:

$$e_j = -k \sum_{i=1}^{|I|} r_{ij} \ln r_{ij} \quad (9)$$

where $k = 1/\ln |I|$ is a constant that guarantees $0 \leq e_j \leq 1$. The entropy value e_j represents the amount of information contained in the R matrix. The e_j reaches its maximal value if all r_{ij} are equal over the same alternative. This implies that a decision maker provides the minimal information in his or her attribute/preference toward different alternatives under criterion j and the criterion j is deemed of limited importance.

The degree of divergence (d_i) of the average intrinsic information contained by each criterion j can be calculated as:

$$d_j = 1 - e_j. \quad (10)$$

The weight for each criterion i is thus given by:

$$w_j = \frac{d_j}{\sum_{k=1}^m d_k} \quad (11)$$

It is also easy to verify that $\sum_{j=1}^m w_j = 1$.

In the group decision-making context, Equation (10) is modified to be $d_j^n = 1 - e_j^n$ (where e_j^n is the entropy value for decision maker n), and the overall synthesized criteria weights can be expressed as $w_j = \frac{\bar{d}_j}{\sum_{k=1}^{|J|} \bar{d}_k}$, where $\bar{d}_j = \sum_{n=1}^n d_j^n / n$.

Step 4: Construct Weighted, Normalized Decision Matrix

The matrix in this step is obtained by taking the product of criteria weight W and the normalized decision matrix R .

$$V = \begin{bmatrix} v_{11} & v_{12} & v_{13} & \dots & v_{1m} \\ v_{21} & v_{22} & v_{23} & \dots & v_{2m} \\ v_{31} & v_{32} & v_{33} & \dots & v_{3m} \\ \dots & \dots & \dots & v_{ij} & \dots \\ v_{n1} & v_{n2} & v_{n3} & \dots & v_{nm} \end{bmatrix} = W \cdot R = \begin{bmatrix} W_1 r_{11} & W_2 r_{12} & W_3 r_{13} & \dots & W_m r_{1m} \\ W_1 r_{21} & W_2 r_{22} & W_3 r_{23} & \dots & W_m r_{2m} \\ W_1 r_{31} & W_2 r_{32} & W_3 r_{33} & \dots & W_m r_{3m} \\ \dots & \dots & \dots & W_j r_{ij} & \dots \\ W_1 r_{n1} & W_2 r_{n2} & W_3 r_{n3} & \dots & W_m r_{nm} \end{bmatrix}$$

Step 5: Define Ideal and Negative Site

The ideal site (A^*) is defined as a hypothetical site that possesses all the superior possible performance with respect to all criteria. Namely, the ideal solution is comprised of all the highest scores of every column in the weighted normalized matrix V . The ideal site (A^*) can be expressed as:

$$A^* = \left\{ (\max_i v_{ij} \mid j \in J) \mid i = 1, 2, \dots, |I| \right\} = \{v_1^*, v_2^*, \dots, v_j^*, \dots, v_n^*\} \quad (12)$$

On the other hand, the negative site (A^-) is defined as a hypothetical site that possesses all the inferior possible performance with respect to all criteria. That is, the negative solutions comprise all the lowest scores of every column in the weighted normalized matrix V .

$$A^- = \left\{ (\min_i v_{ij} \mid j \in J) \mid i = 1, 2, \dots, |I| \right\} = \{v_1^-, v_2^-, \dots, v_j^-, \dots, v_n^-\} \quad (13)$$

Step 6: Calculate Separation Measures

The separation measures estimate the distance of each candidate to either the ideal site or the negative site. The separation measure of each candidate site from the ideal site can be expressed as:

$$S_{i*} = \sqrt{\sum_{j=1}^m (v_{ij} - v_j^*)^2}, i = 1, 2, \dots, |I| \quad (14)$$

Similarly, the separation measure of each candidate site from the negative site is:

$$S_{i-} = \sqrt{\sum_{j=1}^m (v_{ij} - v_j^-)^2}, i = 1, 2, \dots, |I| \quad (15)$$

Step 7: Calculation of Relative Closeness to the Ideal Solution

This method considers the distances to both the ideal and negative sites simultaneously by taking the relative closeness to the ideal solution. The relative closeness of alternative i with respect to the A^* is defined as:

$$C_{i*} = \frac{S_{i-}}{(S_{i*} + S_{i-})}, \quad 0 < C_{i*} < 1, i = 1, 2, \dots, |I| \quad (16)$$

Obviously, for an alternative site i that is closer to A^+ than to A^- as C_{i*} approaches 1, Equation (16) suggests that the evaluation grade of A_i increases with C_{i*} . The relative closeness C_{i*} can be regarded herein as the evaluation value of alternative location A_i . Therefore, the larger C_{i*} is the higher priority/preference that the alternative site i receives from decision makers.

Appendix D: Annotated Bibliography

CTR Inland Port Work

1. Harrison, Robert and Leitner, Sara Jean. The Identification and Classification of Inland Ports. Research Report 4083-1. Center for Transportation Research. Bureau of Engineering Research. The University of Texas at Austin. August 2001.

The report provides a working definition of inland ports and explores their importance in relieving congestion at hub facilities. It also discusses the integral role these facilities can play in maximizing efficiency and providing shippers and end users with considerable cost savings. The report also discusses ways that transportation planners can include inland ports in their long-range transportation plans.

Abstract: This report presents a formal definition for inland ports and creates a classification methodology to promote familiarity with inland port operations and aid transportation planners interested in supporting inland port operations. Inland ports are sites away from traditional borders where international trade is processed and value-added services are provided. As the private sector becomes more focused on globalization and efficient supply chains, inland ports may become more important. Transportation planners need to recognize that inland ports may also promote the development of more efficient multi-modal corridors. The classification methodology builds on the management product life cycle concept to create an inland port development life cycle. The stages of the development life cycle can assist planners in understanding what actions can be taken to best promote positive transportation impact by inland ports.

2. Prozzi, Jolanda; Henk, Russell; McCray, John; Harrison, Robert. Inland Ports: Planning Successful Developments. Research Report 4083-2. Center for Transportation Research. Bureau of Engineering Research. The University of Texas at Austin. October 2002.

The report examines the intricate planning that is necessary for inland ports to succeed. It also explores the interaction and collaboration between key stakeholders in the community and state Departments of Transportation (DOTs) throughout the planning process and operational phases of inland port development cycles. The report also reviews the myriad variables and factors that need to be taken into account when analyzing a potential site for an inland port facility.

Abstract: The consideration of multi-modal inland ports to enhance trade corridor performance and improve the efficiency of global supply chains is starting to emerge in the transportation community. Ultimately, it is believed that inland ports have the capability to create local employment, enhance corridor efficiencies and thus trade competitiveness, and reduce both public and private costs. The objective of 4083-1 was to create a classification methodology to better understand how different inland ports can support efficient supply chains and enhance corridor performance. The first year study recognized the importance of inland ports as

international trade processing locations. In addition to this function, inland ports relieve congested traditional ports of entry, facilitate value-added services, and enhance local and regional development. The objectives of 4083-2 are to demonstrate the role and benefits of inland ports, provide a brief overview of TxDOT highway planning and programming process, highlight the critical investments required and the level of TxDOT support that can be expected as the inland ports develop, consider the impacts of trade and trade truck flows on the locations of inland port developments, and finally, to propose an evaluation framework that allows TxDOT planners to review potential inland port investment requests from a transportation planning perspective. Given the multi-modal components of inland port developments, it is foreseen that the finds of this study can be used to inform transportation planners considering the location of multi-modal terminals on the proposed Trans Texas Corridors.

3. Harrison, Robert; McCray, John; Henk, Russell; Prozzi, Jolanda. Inland Port Transportation Evaluation Guide. Research Report 4083-P4. Center for Transportation Research. The University of Texas at Austin. October 2002.

This report provides an overview of the role that the Texas Department of Transportation (TxDOT) could play in addressing the transportation needs of an inland port facility site. The report outlined TxDOT's project development process to help inland port proponents gain a better understanding of TxDOT's procedures when considering new projects. With increased understanding of the process, proponents can be proactive in anticipating TxDOT's questions, concerns, and needs. They should continually be preparing and updating data and supplying supporting documentation to ensure that their submission will be expedited.

Abstract: None provided.

4. Harrison, Robert; Prozzi, Jolanda; McCray, John; Henk, Russell. Project Summary Report 4083-S. Impact of Inland Ports on Trade Flows and Transportation in Texas: A Summary. Center for Transportation Research. The University of Texas at Austin. October 2002.

This summary report provided a synopsis of CTR's findings from two earlier reports about inland ports. It provided CTR's recommendations for successful planning and integration of inland port facilities. The recommendations made by the CTR researchers included stimulating development of inland ports, assisting in the design and operation of true multi-modal hubs with effective links to regional modal networks, and gauging an inland port's impact on the department's highway network.

Abstract: None provided.

Other Work

1. Amlin, J., Levesque, R., and Backus, G. Economic Impact of a Pacific Northwest Port Shutdown. Prepared for Sandia National Laboratories, May 2003.

This analysis uses the Regional Economic Modeling Inc (REMI) Policy Insight Model to obtain expected impacts to the economy from different port closures focusing on Washington, Oregon, and Alaska. Simulated port closures are created and the REMI model used to analyze impacted trade flows.

2. Anderson, William P. Public Roads (64) 2. Measuring Economic Impacts of Federal-Aid Highways Projects. September/October 2000.

This article details the difficulty in trying to assess actual jobs created because of transportation projects. The author states that employment-generation effects travel backward along a chain of “production inputs.” The article details the process and analysis a researcher must undertake to understand the economic spillover effects of transportation projects.

3. Aschauer, D. Public Finance and Management. Output and Employment Effects of Public Capital. Volume 1, Issue 2 2001.

Abstract: This paper develops a two-equation model linking public capital to employment and output growth. The basic innovation is that the relationship between public capital and economic growth is non-linear, which allows an estimate of the growth-maximizing level of public capital (relative to private capital). The model is empirically implemented using a variety of estimation procedures with data for the 48 contiguous United States over the period from 1970 to 1999. Some of the more significant findings of the paper include generally positive effects of public capital on economic growth (both in terms of output and employment); an estimated value of the growth-maximizing public capital stock between 50 and 70 percent of the private capital stock; negative effects on public debt and taxes on economic growth; somewhat higher growth effects from public capital in the 1980s than the 1970s; and somewhat larger growth effects from public capital in the snowbelt than in the sunbelt.

4. Aversa, R., Botter, R.C., Haralambides, H.E., Yoshizaki, H.T.Y. A Mixed Integer Programming Model on the Location of a Hub Port in the East Coast of South America. Maritime Economics & Logistics. March 2005, Volume 7, Number 1, Pages 1-18.

Abstract: This report introduces a mixed integer programming model on the selection of a hub port in the East Coast of South America, among a set of 11 ports that are servicing the regional demand for container transportation. Ports in Brazil, Argentina, and Uruguay are considered, together with several origin/destination ports in the world. The model minimizes total system costs, taking into account both port costs (dues and terminal handling charges) and shipping costs (feeder and mainline). In total, the model consists of 3,883 decision variables and 4,225 constraints. It turns out the port of Santos (Brazil) is the optimal single-hub solution, with the port of Buenos Aires (Argentina) as a close runner up. In addition, the model provides tentative estimates of improvements in demand and costs necessary to bring a certain port up to hub

status. Despite some bold assumptions and limitations—mainly due to data availability—the model offers a straightforward decision tool to all ports in the world aspiring to achieve hub status and all that comes with it. *Maritime Economics & Logistics* (2005) 7, 1–18.

5. Bhatta, Saurav D. and Drennan, Matthew P. The Economic Benefits of Public Investment in Transportation: A Review of Recent Literature. *Journal of Planning Education and Research* (2003).

Abstract: This article reviews the recent literature on the long-term economic benefits of public investments in transportation. It organizes the literature into six groups according to the type of benefit being measured, namely output; productivity; production costs; income, property values, employment, and real wages; rate of return; and noncommercial travel time. The central question addressed by the papers reviewed is whether public investments in transportation yield long-term economic benefits. While the different studies arrive at different numerical answers, most of them do indicate a positive and statistically significant relationship between such investments and economic benefit measures. Transportation planners engaged in the effort to win funding for the best of competing projects would gain by an awareness of that economic benefit literature and by applying the methods to measuring benefits of their projects.

6. Boske, L. B., and Cuttino, J. C. “The Impacts of U.S.–Latin American Trade on the Southwest’s Economy and Transportation System: Case Studies of Coffee and Steel on the U.S.–Brazil Trade Corridor.” Special Project Reports. The University of Texas at Austin (2001).

The authors note the incomplete methods available to adequately measure trade impacts. They develop a more comprehensive approach to capture a more complete picture of measuring economic and transportation impacts related to trade corridors. To achieve this objective, the authors use a case study to identify the economic and transportation impacts over an entire supply chain for specific commodities.

7. Boske, Leigh B., and Cuttino, John C. *Measuring the Economic and Transportation Impacts of Maritime-related Trade*. The University of Texas at Austin (2003).

This study examines what economic impacts are and how they take place so that policy makers can make sound decisions for enhancing or moving goods and services along a trade corridor. The authors note the importance of reviewing economic impact studies—especially port impact studies—supply chain logistics, and transportation corridors to best capture the effects of international trade between the U.S. and Latin America.

8. Brown, Thomas R. and Hatch, Anthony B. *The Value of Rail Intermodal to the U.S. Economy*. Available: <http://www.aar.org/pubcommon/documents/govt/brown.pdf>. September 2002.

This report states that a critical factor in having a robust and growing economy is an efficient freight transportation system. The authors contend that this provides the U.S. with a huge advantage over other countries, but said that changing dynamics will make it necessary for

transportation planners to explore ways of reducing the nation's dependence on highway-based carriage. The authors argue that freight rail, and specifically intermodal rail, can help reduce this dependence while providing a number of spillover benefits, such as reduced highway congestion, increased highway safety, and helping to better preserve the environment. The authors also state that more rail intermodal traffic would result in a reduced need to build more highways.

9. Cantos, Pedro; Gumbau-Albert, Mercedes; Maudos, Joaquin. Transport Infrastructures, Spillover Effects and Regional Growth: Evidence of the Spanish Case. *Transport Reviews*, Vol. 25, No. 1, 25-50, January 2005.

Abstract: The impact of transport infrastructures on the economic growth of both regions and sectors, distinguishing among modes of transport, is analyzed. An attempt is also made to capture the spillover effects associated with transport infrastructures. Two different methodologies are used: the first adopts an accounting approach based on a regression on indices of total factor productivity; the second uses econometric estimates of the production function. Very similar elasticities are obtained with both methodologies for the private sector of the economy, both for the aggregate capital stock of transport infrastructures and for the various types of infrastructure. However, the disaggregated results for sectors of production are not conclusive. The results confirm the existence of very substantial spillover effects associated with transport infrastructures.

10. Cervero, R. and Aschauer, D. *Economic Impact Analysis of Transit Investments: Guidebook for Practitioners*. Transit Cooperative Research Program: Report 35. Washington, DC: National Academy Press, 1998.

This report identifies and describes a broad array of predictive and evaluative methods used to conduct economic impact analysis on transportation investments. Twelve methods are focused on, analyzing three types of economic impact categories: generative impacts, redistributive impacts, and transfer impacts. The report provides a descriptive analysis highlighting the advantages and disadvantages to various methods. It provides guidance on method selection and suggests criteria for evaluating and presenting results from economic impact analysis studies.

11. Economic Development Research Group and Cambridge Systematics, Inc. *Using Empirical Information to Measure the Economic Impact of Highways Investments*. Volume 1: Review of Literature, Data Sources, and Agency Needs. Prepared for Federal Highway Administration. April 2001.

This report documents and reviews existing empirical studies that examine the relationships between highway investment and economic development. The work focuses specifically on work that was performed during the 1990s on rurally located highways. The volume also describes data sources that can be utilized in conducting economic analysis studies and presents guidelines for the conduct of future economic impact assessment studies.

12. Economic Development Research Group and Cambridge Systematics, Inc. *Using Empirical Information to Measure the Economic Impact of Highways Investments*.

This report stated that economic benefits realized by transportation projects would vary depending on the size, location, and scope of the project as well as a number of other variables. The report states that generalizations about highways affecting business locations and growth are not sufficient because they do not distinguish between specific project alternatives. The report attempts to correct for this flaw by using more comprehensive data to parse out the different economic effects that are associated with investments in individual highway projects.

13. Hughes, David W. Choices. Policy Uses of Economic Multiplier and Impact Analysis. *The Magazine of Food, Farm and Resource Issues*. A publication of the American Agricultural Economics Association.

This article explains why the multiplier effects associated with economic development are often vastly overstated. The author examines some of the common fallacies that people often make when calculating the economic benefits of a project. The author also delves into areas where economic impacts are transparent and easily identified.

14. ICF Consulting and HLB Decision-Economics (under subcontract to AECOM). Economic Effects of Transportation: The Freight Story. January 2002.

This study examines the links between freight transportation and the economy. The consultants conclude that the efficient movement of freight can lead to a significant boost to the aggregate economy and also will result in better services being provided to customers. They conclude that this is largely because finding ways to reduce the cost of freight carriage allows production or distribution facilities to serve a wider market area and potentially realize gains from scale efficiencies. Moreover, factors can draw supplies from a larger coverage area and potential realize cost savings and improve the quality of parts and materials coming into the factory.

15. Kapros, S., Panou, K., and Tsamboulas, D.A. Evaluation of Intermodal Freight Villages Using a Multi-criteria Approach. Paper to Transportation Research Board Annual Meeting January 2005.

Abstract: The objective of this paper is to develop an integrated methodological process for evaluating the expected impact of freight villages. The process takes into account the viability of freight villages and the priorities of stakeholders involved. Since the criteria are of different nature and their measurement units are not the same, the use of multi-criteria analysis is proposed. The process required an in-depth analysis of the decision making process for the creation of a new freight village, the operations and the actors involved, and the most recent best practices. The methodology identifies the set of decision criteria, including environmental quality, contribution to local/regional economy, contribution to national economy, attractiveness for private financing, contribution to lane use changes, and complementarity with other policy plans. In addition, it defines the most appropriate corresponding indicators. The identification of stakeholder categories and decision criteria provide added value to the proposed methodological process. The importance that the European transport policies place on freight villages and

terminals development could render the process the main contributor to the development of a pan-European decision tool for assessing such investments, especially if private and public funds are involved. The pilot application is related to the evaluation of investments for a freight village development in northern Greece. Its choice for the methodology application is based on its location at the crossroads of important road and rail axes of trans-European transport networks and the expressed interest from the European Commission and Greek private investors.

16. Lakshmann, T. R. and Anderson, William P. Transportation Infrastructure, Freight Services Sector and Economic Growth: A Synopsis. Center for Transportation Studies. Boston University. Prepared for the U.S. Department of Transportation. Federal Highway Administration. January 2002.

This study examines the links between transportation investments and the performance of the freight sector and other economic sectors. The authors conclude that transportation projects often spur economic growth. Moreover, investments in transportation projects lead to a much greater rate of return than investments that go toward projects in other sectors. The authors conclude that the benefits from transportation infrastructure extend well beyond U.S. borders because domestic transportation is needed to bring export goods to international gateways.

17. Librach, A. Downtown Rail Service: Development Impact Assessment. Capitol Market Research. Austin, Texas 2004.

This report provides an economic analysis of the potential impact that a downtown rail service would bring to Austin, Texas.

18. The Perryman Group. The Net Economic Benefits of the Trans Texas Corridor. January 2002.

This report provides an analysis of the projected economic benefits Texas will receive from the construction of the Trans-Texas Corridor (TTC). The report concludes that the state will reap a number of benefits, including \$20.6 billion in annual total expenditures, \$10.1 billion in annual gross state product, \$6.7 billion in annual personal income, and 176,936 person-years of employment.

19. Shadewald, Jerry K.; Hallmark, Shauna; Souleyette, Reginald R. Visualizing System-Wide Economic Impacts of Transportation Projects. Journal of Urban Planning and Development. December 2001.

Abstract: The economic evaluation of proposed transportation projects has traditionally been a technical process based on collected data and equations. Future needs must be considered to adequately meet the demands of system users to ensure project success. Political pressure forces transportation professionals to begin incorporating the public into every stage of a proposed project, including the economic analysis. This paper describes a streamlined process that brings together existing technologies to produce future needs estimates, perform the economic evaluation of the proposed solution, and display the costs and benefits. This process is performed in a geographic information system environment that enables the efficient storage and

visualization of data, thereby increasing the efficiency of the economic evaluation as well as providing a venue to display results.

- 20.** Schweppe, Ellen. Do Better Roads Mean More Jobs? U.S. Department of Transportation. Federal Highway Administration. May/June 2002.

This study explains why more research has to be conducted to accurately determine the effects of highway projects on an area's economy. The author concludes that the models being used to prove or disprove links between transportation highway projects and economic development often are not comprehensive enough and do not provide a holistic picture for researchers to understand. The author states that the Federal Highway Administration (FHWA) is developing a three-pronged plan to develop more accurate and reliable measures to make up for the current models' flaws and deficiencies.

- 21.** Standing Advisory Committee for Trunk Road Assessment. Report to Secretary of Transport: Transport and the Economy: Full Report. 9 August 1999.

This report provided a background on economic methodology used in economic review of transport's role in the economy.

- 22.** UCLA Extension Public Policy Program. Finance: The Critical Link. Prepared by Amy Ford and Kevin Holliday. Annual Symposium Series on the Transportation–Land Use–Environment Connection. Summary of Proceedings. October 2003.

This report provides a summary of discussions that various transportation and other officials spoke on as part of a symposium held at UCLA. Among the topics discussed at the symposium were the constraints involved in financing transportation projects and private sector views on location decisions, public regulation of land markets, smart growth, and fiscal incentives/disincentives. Another key discussion topic revolved around the movement of goods.

- 23.** The University of Texas at Austin. The Knowledge Economy. Office of Public Affairs. Report released in 2005.

This study updates a study by the Bureau of Business Research titled "Economic Contributions of the University of Texas System: A Study in Three Parts (1994)." The updated study states that The University of Texas at Austin has a \$7.4 billion impact on the Texas economy every year. The report provides an overview of how the University of Texas contributes to the state's economic development.

- 24.** U.S. Department of Transportation. Federal Highway Administration. State Economic Development Highway Programs—Planning—FHWA. Part 1. National Overview.

This study states that businesses are examining how to best take advantage of improved transportation access because of increased investments that allow for new kinds of economic activities to occur. Some of the benefits businesses often realize from improved access include economies of scale, just-in-time production processes, and logistical efficiencies because of

access to broader labor markets, supply markets, and customer markets. This study states that the availability of market access and the value of these associated cost factors are considered in business location and investment decisions. The authors note, however, that the value of accessibility improvements—for improving productivity, helping to attract new business investment in areas of need, and addressing equity concerns for economically distressed areas—are typically beyond the standard engineering evaluation of highway investment needs.

25. Weinstein, B.L. and Clower T. L. The Estimated Value of New Investments Adjacent to DART LRT Stations: 1999-2005. University of North Texas, Denton. September 2005.

This study review the economic impact of Dallas' Light Rail Line from 1999–2005.

26. Weiss, H. Martin and Figura, Roger. A Provisional Typology of Highway Economic Development Projects. U.S. Department of Transportation. Federal Highway Administration. (2003).

Abstract: Past effort to analyze/select promising highway economic development projects for implementation and evaluate implemented projects for effectiveness have not progressed as far as they could partly because not all projects are the same type. Projects that improve local access to employment sites are inherently different from improvement to connectivity between two cities (sometimes called corridor improvements) and will properly merit different analysis and evaluation. This paper focuses on categorizing the different types of projects and discusses the different methods that will be required in analysis, evaluation, and selection.

27. Weiss, H. Martin. Economic Development Highways Initiative: Lessons Learned, and a Framework in the Sky. U.S. Department of Transportation. Federal Highway Administration.

Abstract: In FY 2000, Congress directed the FHWA to conduct the Economic Development Highways Initiative (EDHI). FHWA has substantially completed this assignment. Over 200 state, local, and regional officials, including many elected officials, provided advice to FHWA and the prime contractor (AECOM Consult) during studies conducted under EDHI. A number of subcontractors—including universities—also participated. EDHI was also informed by contemporaneous research sponsored by FHWA and others working outside of the formal structure of EDHI itself. Lessons learned included:

- Respecting the state/local process can result in expectation that is more realistic.
- A meaningful assessment of economic development potential requires a realistic look at the highway improvement process and a hard look at the existing local economy.
- Studies done during an improvement project should be considered, in addition to the textbook cases of before (ex-ante) studies and before/after studies (ex-post).
- A number of methods can be used to estimate the impact of improvements.

- 28.** Wilbur Smith Associates with the Louis Berger Group and AECOM Consulting. US 83 State Economic Development Highways Programs. Texas Corridor Initiative. U.S. Department of Transportation. Federal Highway Administration. July 2003

This report looked at upgrades made to US 83 to identify what, if any, economic and societal benefits were realized. The report categorized benefits based on improved safety, mixed traffic use, and economic development opportunities. The report concluded that increased economic opportunities exist if roadways continued to be improved, which the authors said will lead to a substantial increase in business traffic. In addition, the authors said that distribution centers would be able to better capitalize on an improved transportation network.