FUNDING AND PERSONNEL ALLOCATION METHODS USED BY A STATE TRANSPORTATION AGENCY

by

PB99-145096

Felipe Zambrano
Assistant Research Scientist
Texas Transportation Institute

David Finklea
Research Assistant
Texas Department of Transportation

Sung-Ho Chang
Graduate Research Assistant
Texas Transportation Institute

Alberto Castaño-Pardo
Research Assistant
Texas Transportation Institute

Tom Scullion
Associate Research Engineer
Texas Transportation Institute

and

Dock Burke
Research Economist
Texas Transportation Institute

Report 1822-S
Project Number 0-1822
Research Project Title: Optimum Resource Allocation: Phase II

Sponsored by the
Texas Department of Transportation
In Cooperation with
U.S. Department of Transportation
Federal Highway Administration

June 1998
Revised: October 1998

TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77

Technical Report Documentation Page

1. Report No.	2. G	3. Recipient's Catalog No.
FHWA/TX-99/1822-S	PB99-145096	

4. Title and Subtitle	5. Report Date
FUNDING AND PERSONNEL ALLOCATION METHODS USED BY A STATE TRANSPORTATION AGENCY	June 1998 Revised: October 1998
	6. Performing Organization Code
7. Author(s) Felipe Zambrano, David Finklea, Sung-Ho Chang, Alberto Castaño-Pardo, Tom Scullion, and Dock Burke	8. Performing Organization Report No. Report 1822-S
9. Performing Organization Name and Address Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135	10. Work Unit No. (TRAIS) 11. Contract or Grant No. Project No. 0-1822
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Transfer Office P. O. Box 5080 Austin, Texas 78763-5080	13. Type of Report and Period Covered Project Summary: September 1996 - March 1998 14. Sponsoring Agency Code

15. Supplementary Notes

Research performed in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.

Research Project Title: Optimum Resource Allocation: Phase II

16. Abstract

Too often, attempts to improve efficiencies in an organization's operations are offset by unexpected, concomitant changes in related activities of the organization. In a state transportation agency, implementation of changes in maintenance, construction, operations, planning, and finance need to be accomplished with as "global" a view as possible so that negative, induced impacts do not arise. To better anticipate how changes in overall agency performance are related to particular efforts to improve efficiency, this research study was undertaken to examine several aspects of TxDOT's endeavors to produce an optimum resource allocation to implement its agency's policies, plans, and programs. Ideally, a comprehensive analytical approach would encompass each and every activity/function in which the DOT could achieve an improved level of efficiency. However, limitations of time/budget for the research project necessitated that the scope be truncated to a manageable level. Specifically, four particular aspects of TxDOT activities were identified for inclusion in the analysis: program efficiencies in construction and maintenance; interactions between budgeting and planning; centralized and decentralized functions and responsibilities; and outsourcing and in-house activities.

In conducting the analysis, attention was focused upon some of the critical interactions that occur in geographical (district level as compared to headquarters level), chronological, and functional dimensions. A set of analytical procedures illuminate the relationships between and among the four modular parts of the study. Although the goal of the study was to produce the results for an "optimum allocation of resources," the procedures developed are better suited for use in decision making to improve the process of overall resource allocation in TxDOT rather than to describe a specific mathematical or static "optimum."

17. Key Words	18. Distribution Statement
Pavement Management, Optimization, Mobility, Maintenance, Budgeting, Planning, Outsourcing, Contracting Out, Staffing Levels, Resource Allocation, Labor Pool, Non-Highway	No restrictions. This document is available to the public through NTIS: National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161

19. Security Classif.(of this report)	20. Security Classif.(of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	228	

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

DISCLAIMER

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

ACKNOWLEDGMENTS

The authors are indebted to the Texas Department of Transportation (TxDOT) and the U.S. Department of Transportation, Federal Highway Administration (FHWA), for providing guidance and funding for this research. The authors are especially indebted to Mr. Luis Ramirez, P.E., Laredo District Engineer; Mr. Artie V. Elliott, P.E., Finance Division; Mr. James M. Bass, Finance Division; Mr. Joe S. Graff, P.E., Maintenance Division; Ms. Jeanne Huston, Human Resources Division; Mr. James E. Johnson, P.E., Design Division; Mr. Kenneth Renouard, Design Division; and Mr. Bryan Stampley, P.E., Design Division, for their support and guidance throughout the completion of the project. The Texas Transportation Institute staff who assisted with this project included Ms. Angelica De Luna, Mr. Dong-Hun Kang, and Mr. Yong Wang.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

Page

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

Page

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (Continued)

IMPLEMENTATION RECOMMENDATIONS

This study addresses six resource allocation issues within the Texas Department of Transportation (TxDOT). Each of those issues analyzed has its own set of recommendations for implementation that need to be reviewed by TxDOT. Much of the subject matter of this study is grounded on existing TxDOT policies and procedures such that indicated departures from those norms will need to be closely evaluated by TxDOT personnel.

1. **Highway and Non-Highway Programs.** Projections show that available resources from the State Highway Fund will be insufficient to match TEA-21 requirements and continue supporting existing highway and non-highway state-funded programs. To achieve the needed levels of state matching funds for the multiyear TEA-21 requirements, Texas will require additional, sustained funding from current levels. The research team recommends further study to analyze the feasibility of implementing the following alternatives which will not require new revenues:

    - support the operations of the Texas Department of Public Safety from a funding source aside from the Texas Highway Fund,
    - aggregate or reduce the number of state-funded UTP categories and provide more flexibility and transferability of funds among categories, in order to challenge the limited availability of resources from the State Highway Fund, and
    - establish a State Infrastructure Bank (SIB) with the flexibility to finance non-highway (aviation, public transportation, and Gulf Intracoastal Waterway) projects using state funds.

2. **Preservation Program.** To implement the recommendations for improving the Pavement Management Information System (PMIS), the researchers recommend that the Texas Department of Transportation (TxDOT) re-establish a Pavement Management Steering Committee, similar to the committee in place in the early 1990s. This committee should:

    - review and prioritize the action items recommended for improving the existing PMIS system,
    - develop an implementation plan for PMIS Phase 2 implementation at the district level integrating a pavement layer database, initially on the National Highway System and then on the rest of the network, and
    - implement a prototype map-based reporting system.

3. **Mobility Program.** Researchers recommend that TxDOT continue using the current political allocation concept for selecting mobility projects within Unified Transportation Program (UTP) categories 4C, 4D, and 4E at the district level. These decisions are dependent upon political factors due to the involvement and influence that MPOs and local government officials have in the decision-making process. It seems that trying to establish an allocation scheme based on analytical factors for those UTP categories is likely to fail. With respect to the statewide selection of mobility projects, MicroBENCOST is an existing tool that TxDOT may consider using to replace the existing method based on the Cost-Effectiveness Index. Mathematical optimization models guarantee an optimal selection of mobility projects, but they are much more complex than the existing system and may not be effective to develop, implement, and maintain.

4. **Decentralization.** Consideration and further study should be given before further duties (especially non-highway-related responsibilities) are transferred to districts.

5. **Staffing Levels.** The proposed labor pool concept can be properly designed and developed in coordination with the Human Resources Division, especially if the proposed TxDOT job classification system, which will decrease the number of job classifications from 1,700 to 800, is implemented. The labor pool database will keep track of personnel competencies; this information can assist design, construction, and maintenance district personnel during short-term peak workloads and emergency situations. A more detailed study about the feasibility of implementing public-private partnerships that require changes in legislation, similar to those at the Virginia Department of Transportation, should be investigated.

6. **Outsourcing.** The sourcing methodology presented in this report is designed to enable TxDOT to validate its current decision process for allocating work to non-TxDOT sources. Also, the procedure can be used by TxDOT to evaluate future legislative mandates for changes in the outsourcing program. Therefore, this methodology is proposed to aid TxDOT in further enhancing its operations, quality of service, and organizational efficiency. If adopted, researchers recommend that the complete methodology be implemented, not just portions defining critical issues to the outsourcing of job functions.

Critical to the success of the implementation of this methodology is the definition of a *champion*. A *champion* is a person, or small group of advocates in the organization, who recognizes the needs and benefits of utilizing this methodology to help define core job functions and analyzes the opportunity for outsourcing. The champion must also have the knowledge necessary to decide if the methodology will be good for the agency. This means that the champion must understand the benefits and limitations of the methodology, along with its technical operation. This education can be supplied through training seminars or through comprehension of the report.

CHAPTER 1
HIGHWAY AND NON-HIGHWAY PROGRAMS

Resource allocation procedures used by the Texas Department of Transportation (TxDOT) are largely incremental in nature. The allocation of one year is very much like that of the previous year, with changes made on an incremental basis. In highway resource allocation, growth in traffic and lane miles is frequently the primary input to the allocation formulae. Thus, allocations from year to year change incrementally according to variations in traffic and lane miles. Such a method of allocation does not allow for foreseeable changes in local conditions nor for the impact that the allocation itself may have on local conditions. However, when dynamic and new situations arise that impact upon the agency's mission, allocation approaches based on incremental concepts may need supplemental adjustments to account for the non-incremental aspects of the growth.

In a related matter, the allocation of resources for the support of non-highway mission activities has a set of unique conditions that warrant special treatment in TxDOT's overall responsibility to optimize the use of its resources. Foremost among the characteristics, these other modal activities are typically small budget items that do not present opportunities for significant changes in impacts likely to result from different allocation approaches. Further, most of these programs in public transportation, aviation, waterways, etc., are limited by the legislative and administrative implementation of federal programs, such that the state has very little flexibility itself to alter the way in which funding and other resources are allocated.

That does not mean that allocation procedures for non-highway portions of TxDOT programs are not important. To be sure, it matters a great deal whether public transportation funding is targeted for capital expenditures as opposed to operating expenditures. However, given that federal procedures dictate the essential guidelines for expenditures, TxDOT can do little to change or alter its role under current law. Similarly for the Gulf Intracoastal Waterway, TxDOT's maritime transportation responsibilities are limited by law, and the funding needed to support these responsibilities is similarly limited. Since major improvements in outcomes due to different allocation methods are not likely to be present in TxDOT's non-highway activities, the focus of the research project's work has been upon highway items such as construction (mobility program) and maintenance (preservation program).

TXDOT NON-HIGHWAY RESPONSIBILITIES

The Texas Legislature established the Texas Highway Department (THD) in 1917 with the purpose of administering federal funds for construction and maintenance activities. However, during the last two decades, adding other non-highway responsibilities, as chronologically follows, has increased those initial responsibilities:

- In 1975, the Texas Legislature merged THD with the Texas Mass Transportation Commission to create the Texas State Department of Highways and Public Transportation (SDHPT). Currently, the Texas public transit system consists of seven metropolitan transit authorities, 22 municipal and 41 rural transit systems, as well as other providers of transportation for elderly and disabled persons. In addition, SDHPT was also assigned the responsibility of providing state sponsorship of the Gulf Intracoastal Waterway (GIWW), of which the Texas portion comprises 676.8 kilometers (423 miles) in length. The main responsibility was to identify and acquire right-of-way as disposal sites for materials dredged from the GIWW by the U.S. Army Corps of Engineers (1). Other responsibilities included coordination with federal, state, and local agencies for evaluation, planning, maintenance, preservation, enhancement, and improvement of the GIWW (2).

- In 1976, the Governor's Office of Traffic Safety was transferred to the SDHPT with the purpose of reducing the numbers of automobile accidents and the related deaths and injuries. The actual Texas Traffic Safety Program emphasizes 12 distinct program areas that include alcohol and other drug countermeasures, public information and education, occupant safety, and school bus safety (1).

- In 1991, the Texas Legislature merged the responsibilities of several Texas transportation agencies, such as SDHPT, Department of Aviation, and Texas Motor Vehicle Commission, to form the current Texas Department of Transportation (TxDOT). TxDOT's mission was defined as providing for a safe, effective, and efficient transportation system for the movement of people and goods. Aviation responsibilities included promoting, developing, and maintaining 265 general aviation airports, out of the 307 airports that comprise the Texas airport system. Motor vehicle responsibilities included licensing and regulating new and used motor vehicle dealerships, manufacturers, converters, and leasing companies, as well as the Texas Lemon Law for administering consumer complaints (1).

- In 1995, motor carrier regulations from the Texas Railroad Commission were transferred to TxDOT. These regulations include providing required credentials to motor carriers, such as insurance filings, operating registrations, oversize/overweight permits, temporary registrations, vehicle storage facility licenses, operating registrations to international motor carriers, and performance bonds for transportation brokers, besides assessing administrative penalties for violations of motor carrier laws and rules (1).

- Finally, in 1997 the 75th Texas Legislature consolidated the responsibilities of the Automobile Theft Prevention Authority (ATPA) and the Texas Turnpike Authority (TTA) within TxDOT.

  - The Legislature mandated that ATPA be provided management and administrative services by or through TxDOT. ATPA was established in the Governor's Office in 1991 to respond to the growing concern about economic losses due to auto theft, but it was transferred to TxDOT through an interagency agreement in 1993. Under the conditions of the agreement, the Governor's Office reimbursed TxDOT for providing payroll and administrative support services to APTA that allowed ATPA to operate largely as an autonomous entity with little oversight from TxDOT. In 1995, the Legislature decided to establish ATPA within TxDOT. Nevertheless, ATPA was allowed to contract for legal, fiscal, administrative, and personnel services with agencies other than TxDOT, and to employ and compensate staff, thereby creating confusion regarding TxDOT's oversight responsibilities (3). Confusion of ATPA's administrative structure within TxDOT was clarified by the legislature in 1997.

  - TTA was consolidated as a division within TxDOT with full authority to study, design, construct, operate, and expand a turnpike project as a part of the state highway system. TTA was established with the passage of the Turnpike Act in 1953. It had statewide jurisdiction, and its headquarters were designated in Dallas, TX. In 1991, the 72nd Texas Legislature expressed its intentions that TTA be consolidated within TxDOT on September 1, 1997, and required the Sunset Advisory Commission to study the feasibility of different consolidation alternatives (4). Two legislative actions in 1991 facilitated the consolidation of TTA within TxDOT: The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 that allowed federal funds to be spent on toll projects, and an amendment of the Texas Constitution that allowed TxDOT to expend state funds on toll projects, as long as the funds from the State Highway Fund were repaid (3). In 1997, the Texas Sunset Advisory Commission recommended consolidation of TTA within TxDOT and transfer bonding authority for toll projects to the Texas Public Finance Authority. This recommendation was enacted by the Legislature in 1997 (5).

TXDOT UNIFIED TRANSPORTATION PROGRAM

In the early 1970s, the combination of a decrease in revenues and increased demands and costs for highway improvements created a financial crisis for the Texas Highway Department. In 1975, McKinsey and Company (consultant firm) was hired to analyze the financial crisis and recommend an approach for solving it. The final McKinsey report recommended the development of a 20-Year Project Development and Control Plan (PDCP), which was developed by the Texas State Department of Highways and Public Transportation in 1977 as a response to Senate Resolution 589, enacted by the 65th Texas Legislature (6).

The PDCP was the first long-range systematic project planning effort to prioritize projects that contribute the most to the overall transportation system. It classified highway maintenance and construction plans and priorities into the following eight categories: (1) Interstate Highway System-Construction, (2) Interstate Highway System-Rehabilitation, (3) Primary, Secondary, and State System-Construction, (4) Primary, Secondary, and State System-Rehabilitation, (5) Farm-to-Market and Ranch-to-Market Road Systems, (6) Urban System, (7) Safety and Betterment Projects, and (8) Miscellaneous Projects.

Most of the projects in categories 2, 4, 7, and 8 were related primarily to upgrading, rehabilitating, or improving existing facilities, while projects in categories 1, 3, 5, and 6 addressed system completion and capacity needs. Interstate highway construction projects were selected on a statewide basis according to the 1981 Highway Act. Interstate Rehabilitation funds were allocated to the districts statewide, based on pavement conditions. State construction funds were allocated statewide, based on route characteristics such as capacity, continuity, geometrics, serviceability, and mobility. Urban system funds were allocated on the basis of population. Safety and betterment programs and state rehabilitation programs were allocated on a formula based on the number of lane miles, vehicle miles traveled, and a cost index in each highway district.

In 1984, the PDCP was renamed as the Project Development Plan (PDP), and the scope was reduced to a 10-year program. The PDP served as the department's framework for the construction program, providing for systematic planning, development, and control of construction projects based on the same funding categories used in the PDCP. The PDP, with a decrease in time horizon, was designed to be a more responsive and dynamic process for scheduling and managing projects with improved accountability (7). The name of the PDP was changed in 1997 and became the actual Unified Transportation Program (UTP).

The UTP includes 33 funding categories that use different types of formulas for allocations to the Metropolitan Planning Organizations (MPOs) and districts and for prioritizing statewide projects (8). Most of the funding categories described in the UTP were established with the passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). These categories are federally funded and include the Interstate Construction, Interstate Maintenance, National Highway System (NHS), Surface Transportation Program (STP), Congestion Mitigation and Air Quality Improvement, and Bridges programs. Even though ISTEA establishes the funding levels for these categories, TxDOT has the flexibility for establishing the allocation or project selection formulas, except for the Interstate Construction and some of the STP programs (e.g., safety, enhancements, and metropolitan mobility and rehabilitation).

The allocation formulas used for interstate maintenance, NHS rehabilitation, and STP rehabilitation in urban and rural areas are usually based on equivalent single axle loads (ESALs) per lane mile, lane miles, and pavement condition. NHS mobility (added capacity) projects are selected statewide on a cost-effectiveness index (CEI), and STP metropolitan, urban, and rural mobility projects are based on population parameters. On- and off-state highway system bridges are evaluated using the Texas Eligible Bridge Selection System (TEBSS).

State-funded allocation categories include state preventive maintenance, rehabilitation and expansion of farm-to-market roads, traffic control devices, rehabilitation of traffic management systems, discretionary programs, urban street programs, and miscellaneous programs. The allocation formulas used for state preventive maintenance and rehabilitation of highways are based on ESALs per lane mile, lane miles, and pavement condition. Selection of projects for farm-to-market expansion are prioritized on cost per vehicle mile; urban streets programs are based on population; traffic control devices are based on lane miles and population; and discretionary programs are based on vehicle miles and registered vehicles.

FUNDING LEGISLATIVE CONSTRAINTS

Since the creation of the SDHPT in 1975, funds that were constitutionally dedicated for highway purposes from the State Highway Fund have been competing against other transportation modes and programs. A TxDOT summary of estimated allocations for Fiscal Year 1998 is illustrated in Table 1.1 (9). From Table 1.1, it can be seen that the highway system accounts for approximately 90.5 percent of the total estimated allocation in Fiscal Year (FY) 1998, while 2 percent is for non-highway transportation modes and 7.5 percent for support services and administrative management.

TxDOT is multimodal and committed to other non-highway modes of transportation. Comparing the total highway and non-highway allocated dollars from Table 1.1 does not reflect the percentage of needs (by mode) actually being addressed. TxDOT's multimodal commitment is clearly shown in Table 1.2 by comparing the percentage of total highway and non-highway needs funded during FY 1998.

Table 1.2 shows that estimated allocations during FY 1998 met 29.72 and 29.63 percent of highway and non-highway needs, respectively, even though constitutional restrictions prevent TxDOT from increasing non-highway current funding allocations. However, the bottom line is that both highway and non-highway infrastructure will continue to deteriorate since only approximately 31 percent of the total state transportation needs are met with current funding levels.

Table 1.1. TxDOT's Estimated Allocations for Fiscal Year 1998 (9)

Classification	Strategy	Allocation per Strategy		Method of Financing (Percentage)				Allocation per Classification	
		Amount	Percentage	GR	SHF 6	FF	Other	Amount	Percentage
Highway System	Plan / Design / Manage Highway Projects	$361,526,794	10.27%	0.06%	66.58%	33.22%	0.14%[1]	$3,186,962,545	90.55%
	Right-Of-Way Acquisition	$142,000,000	4.03%	-----	95.64%	4.36%	-----		
	Highway Construction	$1,871,990,558	53.19%	-----	48.54%	51.46%	-----		
	Contracted Routine and Preventive Maintenance	$425,739,494	12.10%	-----	100.00%	-----	-----		
	Routine Maintenance	$376,500,000	10.70%	-----	99.87%	0.13%	-----		
	Ferry System	$9,205,699	0.26%	-----	100.00%	-----	-----		
Non-Highway System	Aviation Services	$33,166,282	0.94%	-----	60.80%	39.20%	-----	$71,206,905	2.02%
	Public Transportation	$37,668,912	1.07%	46.90%	20.81%	32.29%	-----		
	Gulf Waterway	$371,711	0.01%	-----	100.00%	-----	-----		
Support Services	Registration and Titling	$41,280,912	1.17%	2.82%	96.32%	0.11%	0.75%[2]	$103,819,856	2.95%
	Vehicle Dealer Regulation	$2,665,601	0.08%	-----	100.00%	-----	-----		
	Research	$18,000,000	0.51%	-----	36.38%	63.62%	-----		
	Traffic Safety	$12,430,831	0.35%	-----	13.24%	86.76%	-----		
	Travel Information	$17,972,469	0.51%	-----	100.00%	-----	-----		
	Advertising / Junkyards	$487,801	0.01%	-----	-----	-----	100.00%[3]		
	Auto Theft Prevention	$10,982,242	0.31%	100.00%	-----	-----	-----		
Administrative Management	Central Administration	$32,179,497	0.91%	-----	99.79%	0.21%	-----	$157,425,827	4.47%
	Information Resources	$28,861,264	0.82%	-----	100.00%	-----	-----		
	Other Support Services	$38,435,300	1.09%	-----	100.00%	-----	-----		
	Regional Administration	$57,949,766	1.65%	-----	100.00%	-----	-----		
TOTAL		$3,519,415,133	99.98%*	0.85%	66.78%	32.33%	0.04%	$3,519,415,133	99.99%*

* = Error due to rounding
GR = General Revenue Fund,
SHF 6 = State Highway Fund No. 006,
FF = Federal Funds, and
Other = (1) General Revenue Fund – Dedicated – TxDOT Turnpike Authority Account No. 5038,
(2) Appropriated Receipts, and
(3) General Revenue Fund – Dedicated – Texas Highway Beautification Account No. 071.

Table 1.2. Estimated Percentage of Total Needs Funded during Fiscal Year 1998 (9, 10)

Budget Strategy	Current Funding Level	Optimal* Funding Level	Percentage of Total Needs Funded
Highway System	$3,186,962,545	$10,723,151,53	29.72%
Aviation Services	$33,166,282	$134,572,497	24.65%
Public Transportation	$37,668,912	$102,348,291	36.80%
Gulf Waterway	$371,711	$3,427,368	10.85%
Support Services	$103,819,856	$300,781,063	34.52%
Administrative Management	$157,425,827	$184,368,746	85.39%
TOTAL	$3,519,415,133	$11,448,649,50	30.74%

* = Estimated annual funding required to satisfy 100 percent of the state transportation needs for the period 1997-2006

The Texas Constitution and the Transportation Code limit the use of state transportation funds that have been constitutionally dedicated to the highway system to support non-highway transportation programs, such as public transit, aviation, rail, and the GIWW. Resources are constitutionally dedicated for the sole purposes of:

- Improving the highway system (planning, design, construction, and maintenance activities);
- Mitigating environmental effects that directly result from construction or maintenance activities of the state highway system; and
- Policing the highway system by the Department of Public Safety.

In 1929, the Texas Legislature established the Texas Highway Patrol in Texas Highway Department (THD). In 1935, the DPS was formed as a separate agency from THD by merging two of its components, the License and Weight Inspection Division and the Texas Highway Patrol. Direct appropriations from the State Highway Fund to DPS were $51.6 million per year in 1986 (10). Resources allocated for the benefit of the Texas Department of Public Safety (DPS) from the State Highway Fund now account for approximately $320 million during Fiscal Year 1998. Current appropriations finance 97% of the DPS Capitol Security Strategy, 99% of the Central Administration Strategy, and 100% of the Texas Rangers and Physical Plant (9).

In terms of transferability of resources among budget strategies, TxDOT is allowed to transfer funds among right-of-way acquisition, construction, and contracted routine and preventive maintenance strategies. Funds from other budget strategies can be transferred into the total allocated to right-of-way acquisition, construction, and contracted routine and preventive maintenance, but no funds can be transferred out of those strategies without approval of the Legislative Board. In addition, the allocation of funds for public transportation is further restricted in the budget by setting the amounts that must be allocated to rural transportation providers and urban public transportation providers. TxDOT is, therefore, very restricted in allocating funds among the various modes of transportation. In each budget strategy, however, there is some flexibility that the department can use at its discretion for allocating funds. It is an objective of the research study to suggest methods for allocating these funds in such a way that the benefits to Texans are maximized. One of the major difficulties in allocating funds across different types of transportation projects is to find a method for obtaining comparable benefits. In chapter 3, user benefits are used for allocating funds among a number of possible mobility projects. This was possible because benefits can be computed in a consistent manner, not only for different types of mobility improvements, but also across safety, mobility, or rehabilitation projects.

STATE INFRASTRUCTURE BANK

In 1997, the 75th Texas Legislature passed Senate Bill 370 that allowed TxDOT to establish and administer a State Infrastructure Bank (SIB), in compliance with federal guidelines described in the National Highway System (NHS) Designation Act of 1995. The SIB is an innovative financing scheme that operates mainly as a revolving loan fund and consists of at least two separate subaccounts: a highway subaccount and a transit subaccount. The initial federal program allowed a maximum of 10 participating states into a pilot program to transfer up to 10 percent of apportioned federal highway and transit funds into their respective subaccounts (11). However, those federal funds need to be transferred gradually into the SIB during a nine-year period, as is shown in Table 1.3.

The law also required the states to match those funds with non-federal funding sources. In the case of the state of Texas, rules governing the highway subaccount have been established. Even though the operation of federal transit subaccounts is authorized in the NHS Designation Act of 1995, Texas has not completed its rule-making procedures for the transit portion of the SIB program. To date, TxDOT has received only one inquiry that indicated a need for a transit SIB, and that issue was resolved legislatively.

Table 1.3. Yearly Percentages of Allowed Federal Funds to be Transferred into a SIB

Year	Percentage
1	15%
2	53%
3	16%
4	5%
5	3%
6	3%
7	2%
8	2%
9	1%

Note: As of November 1, 1998, TxDOT will have drawn all allowable federal funds to the SIB without further legislation
Source: TxDOT's Finance Division

The SIB's purpose is to maximize the availability of funding, through private and local participation, for improving the state transportation system in a cost-effective, safe, and timely manner. Table 1.4 provides a list of current transportation projects in different districts that have been submitted to the Texas Transportation Commission to be funded from the SIB.

Table 1.4. Transportation Projects to be Funded from the State Infrastructure Bank

District	Construction/Rehabilitation Project	Cost
Dallas	George Bush Turnpike	$135,000,000
Laredo	Laredo International Toll Bridge IV	$27,000,000
Houston	US 59	$2,700,000
	SH 35 Utility Relocation	$600,000
Austin	US 183 and SH 71	$4,000,000*
Corpus Christi	US 77 Railroad Overpass	$1,500,000*
Childress	Off-System Bridge	$46,712
	Three Off-System Bridges	$46,625*
Tyler	Right-Of-Way for US 175	$350,000*

* = Pending for approval
Source: TxDOT's Finance Division

In 1998, the U.S. Congress enacted the Transportation Equity Act for the 21st Century (TEA-21). This Act establishes a new pilot program in four states for SIBs under different guidelines from those established by the NHS Designation Act of 1995. It provides more flexibility to the states for using funds in the SIBs since the 10 percent limit on capitalization with eligible program categories was removed, and no separate highway and transit subaccounts were required. Separate subaccounts for interstate and rail projects are required. Unfortunately, this new pilot program benefits only the participating states of California, Florida, Missouri, and

Rhode Island. The state of Texas must continue operating its SIB under the original guidelines established in the NHS Designation Act of 1995.

THE TRANSPORTATION CONSTRUCTION PROGRAM AND THE UTP

Table 1.5 shows the different budget strategies for Fiscal Year 1998 for the Texas highway system.

Table 1.5. Estimated Allocations for Strategies Related to the Texas Highway System (9)

Budget Strategy	Estimated	Percentage
Planning / Design / Management	$361,526,795	11.34%
Right-Of-Way Acquisition	$142,000,001	4.46%
Highway Construction	$1,871,990,559	58.74%
Contracted Routine and Preventive Maintenance	$425,739,495	13.36%
Routine Maintenance	$376,500,001	11.81%
Ferry System	$9,205,700	0.29%
TOTAL	$3,186,962,545	100.00%

From Table 1.5, it can be seen that TxDOT allocated approximately 59 percent of the total funds for the highway system during Fiscal Year 1998 to the Transportation Construction Program (closely related to the Construction Strategy), which addresses various needs of the Texas highway system. The Transportation Construction Program is composed of the following programs and is summarized in Figure 1.1 (12):

1. *Preservation Programs* – these programs include three separate programs:
    - Rehabilitation,
    - Preventive Maintenance, and
    - Bridge Rehabilitation and Replacement.

2. *Site Specific Safety Programs* – programs included are:
    - Hazard Elimination,
    - Railroad Grade Crossings, and
    - Substandard Railroad Underpasses.

3. *Mobility Programs* – the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 defines mobility targets as:
   - Interstate – addresses incomplete sections of the interstate system,
   - Metropolitan – cities greater than 200,000 population,
   - Urban – cities between 200,000 and 5,000 population, and
   - Rural – cities less than 5,000 and rural population.

4. *Specific System Programs* – these programs target the following system needs:
   - State Farm-to-Market and Market Road System,
   - State Park Road System, and
   - Texas Turnpike Authority Toll Roads.

5. *Special Transportation Programs* – these programs are identified in the ISTEA of 1991 and target project needs in the three following programs:
   - National Highway System (NHS) Program – project types eligible for this program are: traffic management, wetlands, car/van pools, bicycle lanes, and walkways.
   - Surface Transportation Program – project types eligible for this program include: car pool, bicycle lanes, walkways, wetlands, transit, and transportation enhancement.
   - Congestion Mitigation and Air Quality Program – eligible project types are: high occupancy vehicle lanes, and other projects that may improve air quality in non-attainment areas.

6. *Federal Demonstration Projects* – these projects have been specifically identified for development with federal funds in the ISTEA of 1991 and annual federal appropriation legislation by the U.S. Congress and include:
   - Urban and Rural Access Projects,
   - High Priority NHS Corridor Projects,
   - Priority Intermodal Projects,
   - Innovative Projects,

- Intelligent Transportation System Projects, and
- Railroad Relocation Projects.

7. *Strategic Priority Projects* – these projects are selected by the Texas Transportation Commission throughout the state.

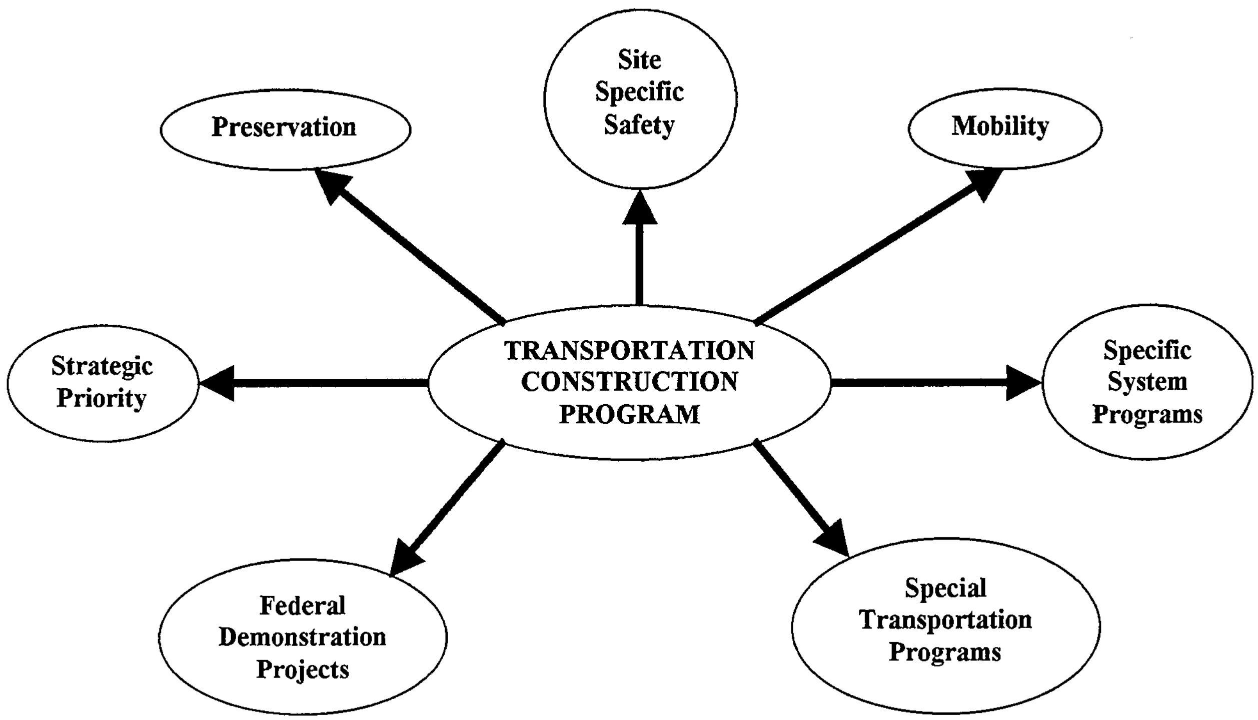

Figure 1.1. Programs Supported by the Transportation Construction Strategy

The distribution of transportation funds for the above construction programs to TxDOT districts, projects, and programs is currently accomplished, as described in the UTP, using a combination of statewide competition indices and formula allocations based on characteristics such as population, traffic, lane miles, and condition of the roads. Table 1.6 shows the estimated allocations for the different UTP categories in the construction program for Fiscal Years 1998 to 2001. Dollar amounts shown in Table 1.6 were estimated before the passage of TEA-21. The 2000 UTP will program all TEA-21 projected federal dollars from Fiscal Year 1998 through Fiscal Year 2003.

Table 1.6. Estimated Allocations for UTP Categories in the Transportation Construction Program for FY 1998-2001

UTP Category Number and Name	FY 1998	FY 1999	FY 2000	FY 2001	TOTAL	Percentage
1 — Interstate Construction	$ 59,676,200	$ 0	$ 0	$ 0	$ 59,676,200	0.79%
2 — Interstate Maintenance	$ 126,608,000	$ 136,082,000	$ 150,906,000	$ 150,781,000	$ 564,377,000	7.49%
3A — National Highway System (NHS) Mobility	$ 190,113,176	$ 317,265,590	$ 255,632,129	$ 293,728,049	$ 1,056,738,944	14.03%
3B — NHS Texas Trunk System	$ 62,820,275	$ 84,374,300	$ 103,070,000	$ 86,429,535	$ 336,694,110	4.47%
3C — NHS Rehabilitation	$ 39,637,000	$ 29,093,000	$ 37,924,000	$ 46,595,000	$ 153,249,000	2.03%
3D — NHS Traffic Management Systems	$ 5,449,340	$ 12,397,250	$ 9,970,100	$ 9,946,100	$ 37,762,790	0.50%
3E — NHS Miscellaneous	$ 10,492,721	$ 3,959,676	$ 9,574,000	$ 11,097,071	$ 35,123,468	0.47%
4A — Surface Transportation Program (STP) Safety	$ 36,611,900	$ 36,579,700	$ 29,230,000	$ 29,230,000	$ 131,651,600	1.75%
4B — STP Transportation Enhancement	$ 73,845,994	$ 16,992,963	$ 1,803,520	$ 0	$ 92,642,477	1.23%
4C — STP Metropolitan Mobility/Rehabilitation	$ 159,007,094	$ 156,489,094	$ 155,536,000	$ 154,087,000	$ 625,119,188	8.30%
4D — STP Urban Mobility/Rehabilitation	$ 79,066,000	$ 95,630,000	$ 106,641,000	$ 88,518,000	$ 369,855,000	4.91%
4E — STP Rural Mobility/Rehabilitation	$ 62,148,000	$ 50,552,000	$ 49,131,000	$ 59,917,000	$ 221,748,000	2.94%
4F — STP Rehabilitation in Urban and Rural Areas	$ 85,406,000	$ 127,341,000	$ 127,263,000	$ 129,808,000	$ 469,818,000	6.24%
4G — Railroad Grade Separation	$ 12,200,000	$ 28,591,800	$ 15,294,672	$ 20,271,050	$ 76,357,522	1.01%
5 — Congestion Mitigation & Air Quality Improvement	$ 128,172,000	$ 120,954,000	$ 110,754,000	$ 106,492,000	$ 466,372,000	6.19%
6A — Bridges Replacement/Rehabilitation - On State System	$ 88,690,293	$ 85,612,813	$ 87,239,376	$ 81,743,064	$ 343,285,546	4.56%
6B — Bridges Replacement/Rehabilitation - Off State System	$ 21,886,491	$ 24,333,024	$ 22,616,785	$ 30,509,756	$ 99,346,056	1.32%
7 — State Preventive Maintenance	$ 145,000,000	$ 145,000,000	$ 145,000,000	$ 145,000,000	$ 580,000,000	7.70%
8A — Farm-to-Market Roads Rehabilitation	$ 25,000,000	$ 25,000,000	$ 25,000,000	$ 25,000,000	$ 100,000,000	1.33%
8B — Farm-to-Market Roads Expansions	$ 13,547,145	$ 33,225,205	$ 15,405,294	$ 13,324,309	$ 75,501,953	1.00%
9 — State Park Roads	$ 12,288,000	$ 5,096,026	$ 4,973,400	$ 14,729,400	$ 37,086,826	0.49%
10A – Traffic Control Devices	$ 15,000,000	$ 15,000,000	$ 15,000,000	$ 15,000,000	$ 60,000,000	0.80%
10B – Rehabilitation of Traffic Management Systems	$ 5,000,000	$ 5,000,000	$ 5,000,000	$ 5,000,000	$ 20,000,000	0.27%
11 – State District Discretionary	$ 55,506,457	$ 50,000,000	$ 50,000,000	$ 50,000,000	$ 205,506,457	2.73%
12 – Strategic Priority Program	$ 133,249,684	$ 104,095,200	$ 176,929,000	$ 153,871,897	$ 568,145,781	7.54%
13A – State Funded Mobility	$ 0	$ 0	$ 0	$ 0	$ 0	0%
13B – Hurricane Evacuation Routes	$ 17,560,000	$ 17,960,000	$ 15,243,124	$ 13,750,000	$ 64,513,124	0.86%
13C – NAFTA Discretionary Program	$ 8,000,000	$ 8,000,000	$ 800,000	$ 8,000,000	$ 24,800,000	0.33%
13D – Urban Streets Program	$ 18,000,000	$ 18,000,000	$ 18,000,000	$ 18,000,000	$ 72,000,000	0.96%
14 – State Rehabilitation	$ 67,500,000	$ 67,500,000	$ 67,500,000	$ 67,500,000	$ 270,000,000	3.58%
15 – Federal Demonstration Projects	$ 101,203,129	$ 32,211,000	$ 8,355,180	$ 39,175,000	$ 180,944,309	2.40%
16 – Miscellaneous	$ 16,122,300	$ 14,717,900	$ 13,491,300	$ 9,824,400	$ 54,155,900	0.72%
17 – State Principal Arterial Street System	$ 18,979,258	$ 23,261,000	$ 27,790,989	$ 11,596,116	$ 81,627,363	1.08%
TOTAL	$1,893,786,457	$1,890,314,541	$1,861,073,869	$1,888,923,747	$ 7,534,098,614	100.00%

Source: TxDOT's Transportation Planning and Programming Division

This study will address only the allocation criteria for the selection of projects in the preservation program (rehabilitation and preventive maintenance programs) and the mobility program. More detailed analysis for both programs is given in chapters 2 and 3, respectively.

TEA-21 IMPACT ON TXDOT PROGRAMS

With the enactment of TEA-21, the state of Texas is expected to receive an annual average of approximately $1.9 billion in federal funds during the next six years (see Table 1.7), which represents an annual increase of approximately $700 million to the ISTEA funding level of the Transportation Construction Program.

Table 1.7. Estimated Total Annual Federal Funding to the State of Texas (in billions)

	FISCAL YEAR					
	1998	**1999**	**2000**	**2001**	**2002**	**2003**
Allocation	$1.62	$1.85	$1.89	$1.96	$2.00	$2.03

Source: TxDOT's Legislative Affairs Office

Table 1.8 provides a depiction of the main federal funding categories within the Transportation Construction Program with their respective expected annual federal funding levels.

Table 1.8. Estimated Annual Allocations to the Transportation Construction Program

Federal Funding Category	Annual Funding Level
Interstate Maintenance	$279,956,000
National Highway System (NHS)	$345,534,000
Surface Transportation Program	$419,281,000
Bridge Program	$127,064,000
Congestion Mitigation/Air Quality	$74,560,000
Minimum Guarantee	$527,007,000
Congressional High Priority	$82,198,000
Recreational Trails	$2,083,000
Metropolitan Planning	$12,880,000
TOTAL	$1,870,563,000

Source: TxDOT's Transportation Planning and Programming Division

Although TEA-21 increased the availability of funds for transportation projects by approximately $700 million, it will increase the Texas federal match requirements with state dollars. It is estimated that an additional $180 million per year in state match will be required in order to use effectively the total estimated federal funds. Additional state matching requirements are likely to affect several existing state-funded budget Strategies and programs within the Transportation Construction Program. In 1996, projection of future state funds indicated that by year 2001, adequate funds would not be available for 100 percent state-funded projects. In addition, future projects indicated that by year 2004, Texas would be unable to match federal-aid requirements for highway construction, resulting in the loss of four federal dollars for each state dollar not available for matching (10). Table 1.9 provides a list of potential budget Strategies and UTP categories within the Transportation Construction Program that may be affected by the state match requirement, since they are financed almost entirely with state funds from the State Highway Fund.

Table 1.9. State-Funded Budget Strategies and UTP Categories

Budget Strategy	UTP Category
• Right-Of-Way Acquisition • Contracted Routine and Preventive Maintenance • Routine Maintenance • Ferry System • Gulf Intracoastal Waterway • Registration and Titling • Vehicle Dealer Regulation • Travel Information	• 7 – State Preventive Maintenance • 8A – Farm-to-Market Roads Rehabilitation • 8B – Farm-to-Market Roads Expansion • 9 – State Park Roads • 10A – Traffic Control Devises • 10B – Rehabilitation of Traffic Management Systems • 11 – State District Discretionary • 12 – Strategic Priority Program • 13A – State Funded Mobility • 13B – Hurricane Evacuation Routes • 13C – NAFTA Discretionary Program • 14 – State Rehabilitation • 16 – Miscellaneous • 17 – State Principal Arterial Street System

RECOMMENDATIONS

The aging and deterioration of the Texas transportation infrastructure, along with an increase in heavy truck traffic, inflation, and construction costs, will challenge the limited availability of funds within the State Highway Fund. In addition, TEA-21 federal match requirements with state funds are expected to reduce available funding for state highway and non-highway programs. Without additional revenues, such as an increase in motor fuel taxes, currently projected state funds will be inadequate for the state of Texas to fully participate in the

TEA-21 programs over the next six years. This critical issue should be given top priority. The following is a set of recommendations that may help TxDOT continue addressing highway and non-highway transportation needs without requiring new revenues.

1. TxDOT should study the feasibility of supporting DPS operations from another funding source than the Texas Highway Fund. A five-cent per gallon of motor fuel tax increase was approved by the 72nd Texas Legislature in 1991. This was expected to generate approximately $400 million annually in additional revenue for the State Highway Fund. In 1998, DPS received $320 million from the Texas Highway Fund. Consequently, only $80 million of the increased motor fuel taxes approved in 1991 are presently available for highway infrastructure needs. Since 1984, appropriations to the DPS from the State Highway Fund have increased approximately 927 percent (9).

2. TxDOT should analyze the feasibility of aggregating or reducing the number of categories in the UTP. By providing more flexibility and transferability of funds among fewer numbers of categories, especially for state-funded categories listed in Table 1.8, TxDOT may be able to confront the limited availability of resources from the State Highway Fund.

3. TxDOT should analyze the establishment of a State Infrastructure Bank (SIB), with the flexibility to finance non-highway projects. The Ohio Department of Transportation (ODOT) has implemented such an approach by establishing a SIB that provides funding for multimodal projects (highways, public transit, aviation, and rail) and intermodal transportation facilities and projects. The SIB consists of a highway and transit infrastructure bank fund, an aviation infrastructure bank fund, a rail infrastructure bank fund, and an infrastructure bank obligations fund. This program was capitalized in 1996 with $30 million authorization from the Ohio State Legislature and approximately $60 million in Federal Title 23 Highway Funds. The aviation and rail infrastructure banks were appropriated from state funds with $1 million each. Water-related projects are financed by the Ohio Water Development Authority, which has the authority to issue bonds in a manner similar to the SIB.

REFERENCES

1. *Strategic Plan 1997-2001.* Texas Department of Transportation, Austin, Texas, June 1996.

2. *Self-Evaluation Report to the Sunset Advisory Commission.* Texas State Department of Highways and Public Transportation, Austin, Texas, September 1989.

3. *Texas Department of Transportation, Texas Turnpike Authority, and Automobile Theft Prevention Authority: Staff Report.* Texas Sunset Advisory Commission, Austin, Texas, 1996.

4. *House Bill No. 9.* 72nd Legislature – First Called Session. Austin, Texas, August 26, 1991.

5. *Report to the 75th Legislature.* Texas Sunset Advisory Commission, Austin, Texas, 1997.

6. *Highway Programming Issues and Practices: Proceedings of Two Conferences. Final Report.* Federal Highway Administration, Washington, D.C., May 1983, pp. 47-53.

7. *Strategic Mobility Plan.* State Department of Highways and Public Transportation, Austin, Texas, August 1984.

8. *Unified Transportation Program.* Texas Department of Transportation, Austin, Texas, September 26, 1996.

9. *Legislative Appropriations Request for Fiscal Years 2000 and 2001.* Texas Department of Transportation, Austin, Texas, August 28, 1998.

10. *How Can TxDOT Keep Texas Moving? An Internal Assessment of Transportation Needs for 1997-2006.* Management Services Office, Texas Department of Transportation, Austin, Texas, July 1996.

11. *National Highway System Designation Act of 1995.* Public Law 104-59. 104th Congress. Washington, D.C., November 8, 1995.

12. *TxDOT Project Selection Process.* Texas Department of Transportation, Austin, Texas, 1996.

CHAPTER 2
PRESERVATION PROGRAM

INTRODUCTION

The objective of the preservation programs is to protect the highway capital investment, and it is composed of three main programs: (1) rehabilitation program, (2) preventive maintenance program, and (3) bridge rehabilitation and replacement program. Table 2.1 shows the Unified Transportation Program funding categories used to financially support the Preservation Program (1).

Table 2.1. UTP Categories Related to the Preservation Program

UTP Category Number	UTP Category Name	Expected Allocated Funds (FY 1998-2001)[1]	Percentage[2]
2	Interstate Maintenance	$ 564,377,000	7.48%
3C	National Highway System Rehabilitation	$ 153,249,000	2.03%
4A	Surface Transportation Program (STP): Safety	$ 131,651,600	1.75%
4F	Surface Transportation Program (STP): Urban/Rural Rehabilitation	$ 469,818,000	6.23%
6A	Bridge Replacement/Rehabilitation—On State Highway System	$ 343,285,546	4.55%
6B	Bridge Replacement/Rehabilitation—Off State Highway System	$ 99,346,056	1.32%
7	State Preventive Maintenance	$ 580,000,000	7.69%
8A	Farm-to-Market Roads Rehabilitation	$ 100,000,000	1.33%
9	State Park Roads	$ 37,086,826	0.49%
10A	Traffic Control Devices	$ 60,000,000	0.80%
10B	Rehabilitation of Traffic Management Systems	$ 20,000,000	0.27%
11	State District Discretionary	$ 205,506,457	2.72%
14	State Rehabilitation	$ 270,000,000	3.58%
TOTAL		$ 3,034,320,485	40.22%

Source: TxDOT's Transportation Planning and Programming Division

[1] From Table 1.6

[2] Calculated using the Estimated Grand Total = $7,534,098,614 from Table 1.6

Table 2.1 shows that preservation programs comprised approximately 40 percent of total construction category funds. Most of the UTP categories related to preservation activities are considered district bank balance programs in which TxDOT's central office allocates funds to districts to address local needs. The allocation of funds to districts is based on formulas involving the following main factors:

- traffic, lane miles, and pavement condition (categories 2, 3C, 4F, 7, 8A, and 14),
- lane miles and population (category 10A),
- type of equipment and lane miles covered by equipment (category 10B), and
- traffic and registered vehicles (category 11).

Other UTP categories are project specific in which projects are selected at the central level based on statewide competition indexes (categories 4A, 6A, and 6B), or through recommendations made by another state agency (Texas Parks and Wildlife Department for category 9). This chapter will address only funding allocation and project selection issues related to maintenance and rehabilitation activities of roadways in UTP categories 2, 3C, 4F, 7, 8A, and 14.

A pavement preservation program determines the most cost-effective rehabilitative actions and projects that will keep the highway network at the desired condition levels from year to year. A systematic approach that assists pavement managers with making decisions as to how to best spend the limited available funds to preserve the highway network is called Pavement Management System (PMS). PMS emerged in the early 1970s as a consequence of the existing deterioration of pavements. PMS is a set of tools or methods that can assist decision makers in finding cost-effective strategies for providing, evaluating, and maintaining pavements in a serviceable condition. It uses objective measurements to derive a suggested policy for preserving the highway condition. In addition, PMS provides information on the pavement network condition to assist decision makers to justify funding requests and allocate funds to programs and districts. This chapter describes how the state departments of transportation from California and Texas use their respective PMS in the allocation of funds and selection of projects.

CALIFORNIA DEPARTMENT OF TRANSPORTATION (2, 3, 4)

The California Department of Transportation (CALTRANS) has maintenance and rehabilitation programs to preserve the state highway infrastructure of approximately 79,014.4 lane-km (49,384 lane miles). Approximately 70 percent of the total lane miles are asphalt concrete (AC) pavements, and 30 percent are Portland cement concrete (PCC) pavements. The maintenance program includes routine maintenance and major and preventive maintenance (usually performed by contract) to keep the highway safe and serviceable until rehabilitation is needed. The rehabilitation program improves the facility and provides an additional 10-year service life.

Routine Maintenance

Routine maintenance includes response and routine maintenance activities. Response activities, such as patching and filling potholes and cracks, are considered more urgent than routine maintenance activities (crack sealing, seal coats, thin asphalt overlays, and shoulder maintenance). State forces usually perform these activities if the work cost does not exceed $24,000 per location. The average costs for routine maintenance are $4,500 per lane mile per year.

Contract Maintenance

If the work cost exceeds $24,000 but is less than $125,000, the work is generally performed by contractors and is managed by the HM1-Roadbed Maintenance Program. HM1 contracts include pavement asphalt overlays less than 0.254 m (1 inch) thick, surface sealing, and concrete slab replacements. Depending upon traffic and weather conditions, these treatments may extend the pavement life from two to five years. The cost for contract maintenance ranges from $7,000 to $20,000 per lane mile for both AC and PCC pavements.

The state highway system has been divided into three highway classes based on their functional classifications:

- *Class 1:* Rural principal arterials and their extensions into urban areas,
- *Class 2:* Roads that are not defined as class 1 or 3, primarily minor arterials, and
- *Class 3:* Collectors, low volume roads, and other logical segments added for continuity.

Allocation of maintenance operating funds to districts is based on the following formula:

- 5 percent of district inventory of class 3 roads,
- 40 percent of district inventory minus class 3 roads,
- 30 percent of district three-year average expenditure, and
- 25 percent of district needs based on pavement distressed lane miles.

Preventive Maintenance

The Capital Preventive Maintenance (CAPM) program covers damaged pavements that cannot be corrected by regular maintenance but without extensive enough pavement distress to require a complete rehabilitation. CAPM treatments restore the pavement and extend the pavement service life by five to seven years, if treated in early stages of pavement structural failure. The average cost of CAPM treatments, such as AC overlays and some PCC slab replacements, is approximately $70,000 per lane mile.

Roadway Rehabilitation

The HA22 Rehabilitation Program restores severely damaged pavements to a condition equal to or better than original condition. These deteriorated pavement conditions usually develop after the design life has been exceeded in terms of either age or accumulated traffic loads. Depending upon the pavement type, the cost of rehabilitation projects ranges between $150,000 to $200,000 per lane mile.

Prioritization of Preventive Maintenance and Rehabilitation Projects

Instead of allocating maintenance and rehabilitation funds to districts, those projects are identified and prioritized at the central level (headquarters) with input from districts and a Pavement Management System (PMS). CALTRANS PMS consists of a pavement condition survey that is conducted biennially to determine pavement distress and ride quality on every lane mile of the state highway system. PMS data are then merged with other highway information, such as highway class, traffic volumes, truck traffic percentages, and skid factors, to identify distress locations, evaluate pavement distress, and prepare the District Pavement Inventory

Report. Distress locations are further evaluated to determine candidate project locations, corrective strategies, and costs associated with pavement types.

The district program advisor compiles projects from PMS-generated reports and from input provided by district maintenance supervisors. Then, projects are prioritized and proposed for funding based on ride quality and degree of structural problem. Rehabilitation projects in the HA22 program received the highest priority (1-8), followed by preventive maintenance projects in the HM1 program with priorities 9-10. Routine maintenance projects may receive priorities between 7 and 10, while class 3 road maintenance projects receive the lowest priority (11-14). Table 2.2 shows the priorities assigned to maintenance and rehabilitation projects using ride quality, degree of structural problem, and highway class as prioritization criteria.

Table 2.2. Prioritization Criteria for Maintenance and Rehabilitation Projects

Problem Type		Class of Highway		
Ride Quality	**Structural Problem**	**1**	**2**	**3**
Poor Ride ≥ 45	Major	1	2	11
	Minor	3	4	12
	None	5	6	
Acceptable Ride ≤ 45	Major	7	8	13
	Minor	9	10	14

Rehabilitation	Class 3 Road Maintenance
Routine Maintenance	Preventive Maintenance

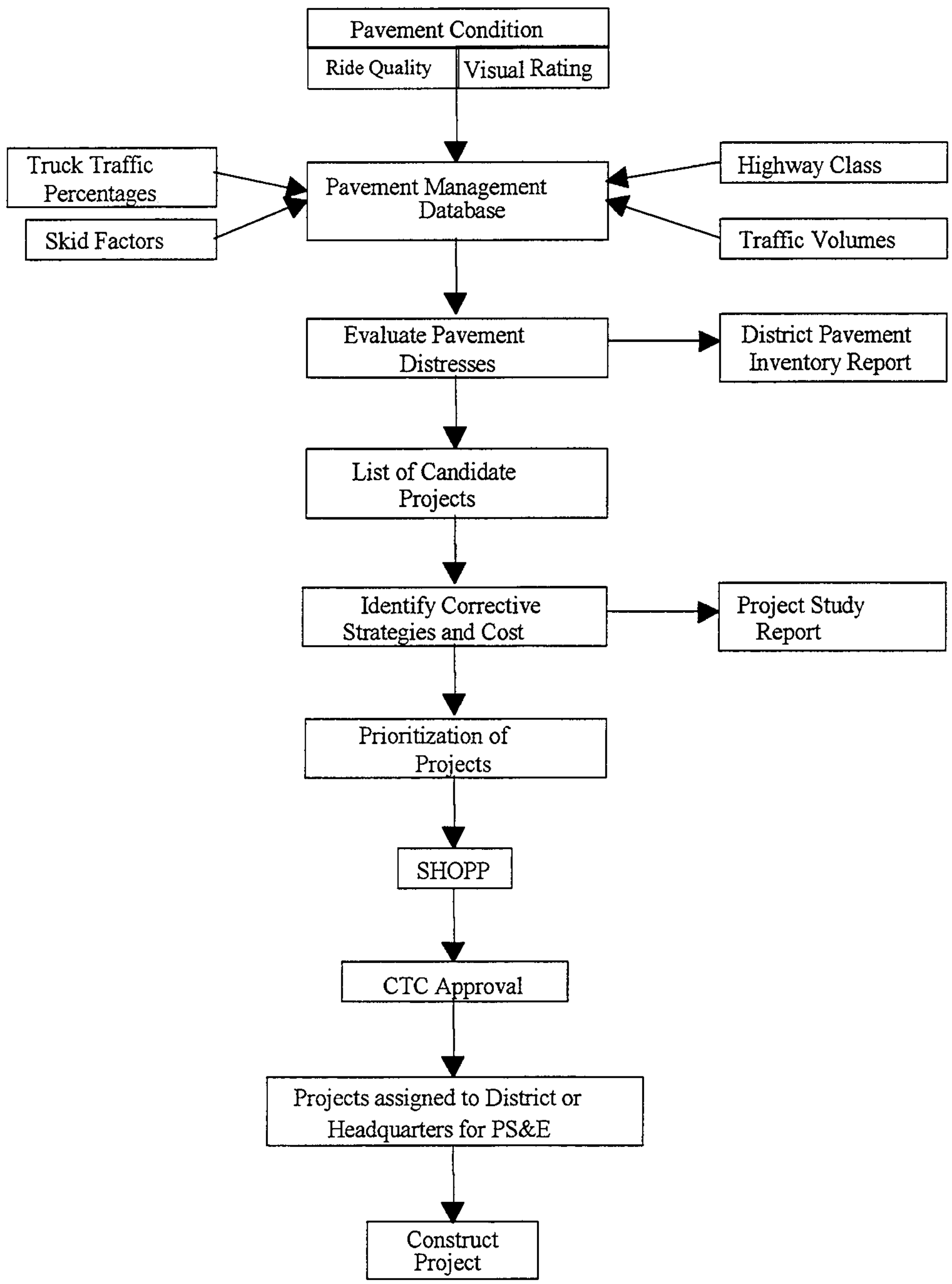

Figure 2.1. Maintenance and Rehabilitation Project Selection Process

TEXAS DEPARTMENT OF TRANSPORTATION

The results presented in the rest of this chapter are based on interviews conducted with district engineers, directors of transportation planning and development, district design engineers, and district pavement engineers from rural, urban, and metropolitan districts. In addition, this study was also coordinated simultaneously with TxDOT Research Project 0-1420: *Continued Development of TxDOT PMIS*, in which a survey that included questions regarding PMIS usage, areas of improvement, and training needs was sent to districts and the Austin Pavement Section of the Design Division.

Background of TxDOT's Pavement Management System

TxDOT is in charge of managing a highway network that consists of approximately 294,400 lane-km (184,000 lane miles) of roads. TxDOT has operated a network level pavement management system, known as the Pavement Evaluation System (PES), since September 1982. In 1989, a Pavement Management Steering Committee was assembled to plan the next steps in improving and expanding PES. That committee recommended a two-phase approach to develop and implement the current pavement management system, known as Pavement Management Information System (PMIS). Phase 1 was to focus primarily on the needs of the Austin-based central level administration, to assist with their need to follow network-level trends in condition, to conduct impact analysis, and to assist with maintenance and rehabilitation fund allocation to districts. The Phase 1 system would be available for district use in documenting pavement conditions and identifying potential maintenance and rehabilitation candidates, but many of the features thought essential to complete implementation at the district level were scheduled for development in a Phase 2 implementation effort. Phase 1 implementation is complete, and PMIS is increasingly being integrated into all levels of decision making within TxDOT. However, development of Phase 2 has been on hold since 1995. Lack of funding at the central level for development of Phase 2 has created the situation in which several districts began to develop PMIS project-level capabilities by themselves, but without much coordination with the central office and among districts.

Pavement Management Information System

The Pavement Management Information System (PMIS) is a tool for planning, programming, and budgeting maintenance and rehabilitation funds. PMIS is defined as an automated system for storing, retrieving, analyzing, and reporting information designed to assist decision makers to make cost-effective decisions concerning the maintenance and rehabilitation of pavements (5). The basic elements are described and summarized below:

- an inventory of pavement sections,
- pavement condition data,
- needs estimate, and
- prioritization of candidate highway sections for funding.

The *network inventory* provides basic information on the type and location of the pavements. Since the entire length of the highway network is impossible to manage as a whole, it is divided into sections. This process is called segmentation, and there are two general concepts in PMIS for making this segmentation. In the first concept, the highway network is divided into Data Collection Sections of uniform size (0.8 km [0.5 mile]). In the second concept, the highway network is broken into Management Sections, which are defined as sections of pavements of variable length and similar structure that the engineer intends to maintain in a uniform manner and which may be considered as candidate projects (5). Minimum data required for each Data Collection or Management Section include: identification, the beginning and ending Reference Marker limits, number of traffic lanes, functional classification, area, pavement type, and traffic levels. *Pavement condition data* provides the capability of collecting and storing visual distress, ride quality, deflection, and skid data. *Needs estimate* identifies the sections needing preventive maintenance and rehabilitation treatments. Within the system, an array of decision trees is used to relate the current condition of the pavements to the required treatment. One of the following general treatment levels is warranted for each highway section: needs nothing (NN), preventive maintenance (PM), light rehabilitation (LRhb), medium rehabilitation (MRhb), or heavy rehabilitation/reconstruction (HRhb). *Prioritization of candidate sections* is a systematic methodology that establishes priorities for the allocation of available funds while the best possible highway network condition is provided. PMIS performs a year-by-year (can rank up to 10 years in the future) ranking procedure based on a cost-effectiveness ratio that is applied sequentially for each year of the analysis period. The effectiveness is defined as the sum of the areas under the distress and ride utility curves generated by any particular treatment. PMIS concepts are described in detail in TTI reports 997-1F and 1989-1, entitled *Pavement Management Information System: Concepts and Data* (6) and *Pavement Management Information System: Concepts, Equations, and Analysis Pavements* (7), respectively.

Pavement Management Levels

PMIS assists decision makers at two levels of management, referred to as network-level and project-level management. The purpose of network-level management is directed at planning and programming of maintenance and rehabilitation activities. This includes amount of funding needed for a given analysis period, identification of sections of the highway network which need maintenance or rehabilitation, and the impact of various funding levels on the pavement condition. Highway sections selected by network-level management are analyzed in detail at the project level. Project-level management is often known as pavement design because it includes the detailed engineering analysis, which determines the most cost-effective design, and the maintenance treatment or rehabilitation strategy to be applied to the specific highway section.

FUNDING ALLOCATION TO DISTRICTS

PMIS provides information on the condition of the state highway network to assist TxDOT's decision makers to establish goals, plan ahead, justify funding requests, and allocate funds to programs and districts. Those who make these types of network-level decisions are generally relatively high within the organization, and they generally have some type of funding authority for the specific funds being managed. In Texas, the state legislature makes the ultimate decisions about the overall level of funding to TxDOT, and the State Transportation Commission makes the strategic-level decisions about how the allocated funding is to be distributed among different transportation programs, based on compliance with legislation and recommendations of TxDOT staff. This includes the allocation of funds to the different UTP categories in the construction program, and the approval of TxDOT's allocation formulas of maintenance and rehabilitation funds to districts.

PMIS and the Allocation of Funds to Districts

Historically, TxDOT's allocation procedures for maintenance and rehabilitation funds to districts have been based on extrapolation of data; therefore, they have been largely incremental in nature. The amount of allocations given to districts one year is very similar to that of the previous year, since the main factors driving the allocation formulas are based on historical traffic and length of the system. Even if the current pavement condition is considered as a factor in the allocation formulas, usually only a small weight of consideration is given (a maximum of 10 percent). Purposes of this type of incremental allocation concept were to assist districts plan over the long term, avoid radical changes in funding, and maintain continuous workloads in all areas. However, such a method of allocation does not allow for foreseeable changes in local conditions, nor does it consider the impact that the allocation itself might have on local conditions.

Realizing that current formulas stress the length of the highway system and the potential for damage due to traffic, TxDOT created an internal task force to review the criteria used in the existing allocation formulas and to propose modifications if appropriate. The review process began with UTP category 2 in 1996 (8) and followed with the rest of the maintenance and rehabilitation UTP categories 3C, 4F, 7, 8A, and 14 in 1997. As a result of this review process, the team concluded that the current pavement condition is an important factor for assessing pavement needs and that more weight should be given in the allocation formulas. Then, pavement condition weight was increased from 10 percent to 35 percent in UTP categories 3C, 4F, 8A, and 14, to 45 percent in UTP category 2, and remained the same (10 percent) in UTP category 7. Table 2.3 summarizes the allocation criteria used in UTP preservation categories before (using an incremental allocation concept) and after (using a needs allocation concept) the review process.

Table 2.3. Allocation Criteria Used in UTP Preservation Categories

UTP Category Number	DISTRICT ALLOCATION CRITERIA		
	Incremental Allocation Concept (Former Allocation Concept)	Needs Allocation Concept (Current Allocation Concept)	
	Criteria Used*	FY**	Criteria Used
2	45% Average equivalent single axle loads per interstate lane mile 45% Interstate lane miles 10% Interstate lane miles (main lanes only) in "substandard" condition, based on Pavement Management Information System (PMIS) Condition Score less than 35	98	45% Summation of flexible and rigid equivalent single axle loads per interstate highway section multiplied times the interstate highway section length 10% Interstate lane miles 45% Interstate lane miles (main lanes only) having "substandard" Distress Scores, based on Pavement Management Information System (PMIS) Distress Score less than 40
3C	45% Average equivalent single axle loads per non-interstate NHS lane mile 45% Non-interstate NHS lane miles 10% Non-interstate principal arterial lane miles (including interstate frontage roads) in "substandard" condition, based on Pavement Management Information System (PMIS) Condition Score less than 35	99	30% Summation of flexible and rigid equivalent single axle loads per NHS section multiplied times the NHS section length 30% Non-interstate NHS lane miles 35% Non-interstate NHS lane miles (including Interstate frontage roads) with "substandard" Distress Scores, based on Pavement Management Information System (PMIS) Distress Score less than 60 5% Square footage of bridge deck area with sufficiency rating between 50 and 80
4F	45% Average equivalent single axle loads per non-interstate lane mile 45% Non-interstate lane miles 10% Non-interstate lane miles (including Interstate frontage roads) in "substandard" condition, based on Pavement Management Information System (PMIS) Condition Score less than 35	99	30% Summation of flexible and rigid equivalent single axle loads per non-interstate section times the non-interstate section length 30% Non-interstate lane miles 35% Non-interstate lane miles (including Interstate frontage roads) with "substandard" Distress Scores, based on Pavement Management Information System (PMIS) Distress Score less than 60 5% Square footage of bridge deck area with sufficiency rating between 50 and 80
7	70% Lane miles 20% Vehicle miles traveled per lane miles 10% Lane miles in "substandard" condition, based on Pavement Management Information System (PMIS) Distress Score less than 60	99	80% Lane miles 10% Vehicle miles traveled per lane mile 10% Lane miles in "substandard" condition, based on Pavement Management Information System (PMIS) Distress Score between 70 and 89
8A	45% Average equivalent single axle loads per FM lane mile 45% FM lane miles 10% FM lane miles in "substandard" condition, based on Pavement Management Information System (PMIS) Condition Score less than 35	99	30% Summation of flexible and rigid equivalent single axle loads per FM section times multiplied times the FM section length 30% FM lane miles 35% FM lane miles (including interstate frontage roads) with "substandard" Distress Scores, based on Pavement Management Information System (PMIS) Distress Score less than 60 5% Square footage of bridge deck area with sufficiency rating between 50 and 80
14	45% Average equivalent single axle loads per non-interstate lane mile 45% Non-interstate lane miles 10% Non-interstate lane miles (including interstate frontage roads) in "substandard" condition, based on Pavement Management Information System (PMIS) Condition Score less than 35	99	30% Summation of flexible and rigid equivalent single axle loads per non-interstate section multiplied times the non-interstate section length 30% Non-interstate lane miles 35% Non-interstate lane miles (including Interstate frontage roads) with "substandard" Distress Scores, based on Pavement Management Information System (PMIS) Distress Score less than 60 5% Square footage of bridge deck area with sufficiency rating between 50 and 80

* Formulas also consider the relative cost of roadway materials in each district

** Fiscal Year implemented

Even though pavement condition weight was not increased in UTP category 7, the threshold value that defines when a section of pavement is considered to be in "substandard" condition, based on the PMIS Distress Score, was increased from a value of 60 to a value between 70 and 89. A section of pavement with a Distress Score below 60 is described as Very Poor and becomes a candidate for rehabilitation. Distress Scores between 80 and 89 and 70 and 79 are described as Good and Fair, respectively. It should be noticed that UTP state-funded categories 7 (State Preventive Maintenance) and 14 (State Rehabilitation) do not provide a clear threshold value for the allocation of preventive maintenance (PM) and rehabilitation (Rehab) funds to districts. Category 7 uses a Distress Score range between 70 and 89 while Category 14 defines a Distress Score value as less than 60. This currently leaves a Distress Score gap between 60 and 69 that may be considered for PM and/or Rehab treatments. Table 2.4 describes the different classes of Distress Scores with their corresponding treatment categories.

Table 2.4. Distress Score Classes

Distress Score	Class	Description	Category
90-100	A	Very Good	None
80-89	B	Good	PM
70-79	C	Fair	PM
60-69	D	Poor	PM/Rehab
1-59	F	Very poor	Rehab

A needs allocation concept is based on the fact that good roads cost less to maintain than bad roads. Usually, pavements are in Fair to Very Good condition 75 percent of the pavement life, and that period is known as the good condition plateau (2). After the good condition plateau, pavements deteriorate rapidly to the very poor level, with a 12 percent remaining pavement life and more expensive rehabilitation treatments needed. Therefore, considering a road section as a candidate for treatment when its corresponding distress score falls below 89, rather than waiting until it reaches a very poor level, allows earlier and less expensive treatments to be applied; this extends the good condition plateau as long as possible. The concept is illustrated in Figure 2.2. This concept, used in UTP category 7, was applied to UTP categories 2, 3C, 4F, 8A, and 14 as well.

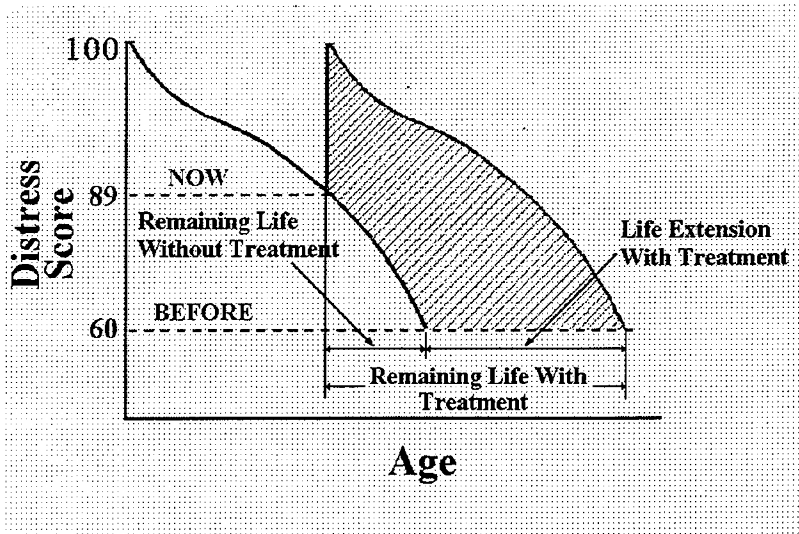

Figure 2.2. Effect of Treatment Timing on Pavement Life Extension

PROJECT SELECTION AT THE DISTRICT LEVEL

The decisions about which highway projects to fund for reconstruction, rehabilitation, and preventive maintenance are generally made at the project level within the district, rather than at the network level at the central office. Summarizing, the main differences between network-level and project-level management are (1) the amount and type of data required and (2) the type of decisions to be made. Since data collection is expensive, minimum data are usually collected at the network level. However, these data collected at network level are not adequate for making project-level decisions, because more complete and detailed data on individual highway sections must be collected. Decisions at the network level are related to the budget process, funding, and prioritization of candidate highway sections, while at the project level, the decisions are concerned with the detailed assessment of the cause of deterioration and the selection of the most cost-effective maintenance, rehabilitation, or reconstruction strategy. Otherwise, the principles involved at both network and project levels are the same.

In most districts, the decisions about which segments of pavement to fund are made through a series of steps; although these steps will vary among the districts, they generally include most of the following:

- The district pavement engineer provides area offices with condition maps and reports of their corresponding highway network.
- When a program call occurs, the area engineers take input from PMIS and maintenance personnel.
- They often drive to each candidate section and then decide on treatment type and cost estimates.
- The area engineer submits the request to the director of transportation planning and development (TP&D), who reviews the strategy selections and prioritizes the projects, considering needs, state of project readiness, workload balance, and UTP categories from which the project may be funded.
- Sometimes, the director of TP&D requests the assistance of the district pavement engineer in evaluating the needs of various proposed sections.
- Once the project is approved by the director of TP&D, it is programmed into the Design and Construction Information System (DCIS), funding is allocated, and plans are drawn.

The above project selection process identifies two levels of management: operational and strategic. Operational management includes district pavement engineers, area engineers, and maintenance engineers, who are responsible for the daily operation and oversight of the fieldwork. Strategic management includes district engineers and directors of TP&D, who are responsible for the overall strategic planning of the district. This project selection process is depicted in Figure 2.3.

Approximately 70 percent of the districts consider PMIS data an integral part of the project selection process, especially at the operational level (9). However, it seems that at the strategic level, a much lower percentage of districts believe PMIS is a reliable system for making project selection decisions. The main problem expressed by decision makers at the strategic level was the lack of confidence in the quality of data gathered, leading some of the districts not to use PMIS at all. In other cases, there was a lack of information in respect to what capabilities PMIS has, what its real limitations are, and what type of information can be accessed. Lack of interest in PMIS at the strategic level in many cases creates frustration at the operational level, where PMIS is used on a daily basis and its strengths and limitations are well understood.

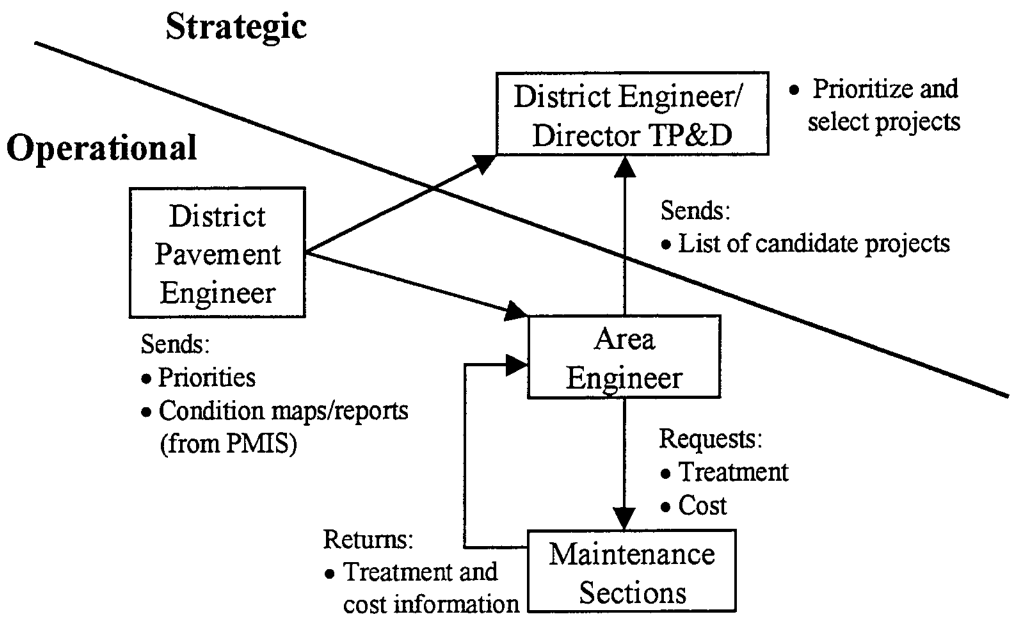

Figure 2.3. Project Selection Process at the District Level

PMIS and the Project Selection Process at the District Level

Several districts such as Abilene, Beaumont, Brownwood, Bryan, Corpus Christi, Dallas, Fort Worth, Houston, Laredo, Lubbock, Lufkin, Odessa, Paris, San Antonio, and Wichita Falls use PMIS data for making project selection decisions at the district level. Good coordination and communication between the operational and strategic management levels about how to include and use PMIS in the project selection process was found in most of these districts. Following is a description of how the Fort Worth and Laredo Districts use PMIS in their project selection process.

Selection of Preventive Maintenance Projects at the Fort Worth District

The Fort Worth District has developed and implemented a formula or index that assists decision makers in prioritizing and selecting preventive maintenance projects. Usually, a $30-35 million annual budget would be needed to fund all the preventive maintenance projects requested by area offices, but only a $7-8 million annual budget is available. The index is based on date of last surface (DLS), project length and cost, and percentage of the roadway needing preventive maintenance to medium rehabilitation (from PMIS Needs Estimate Report). The index gives values between 0 (lowest priority) and 1 (highest priority), and special cases are noted in which the index is set to the extreme values:

- if suggested treatment is a fog seal, the index is set to one,
- if priority assigned by area office is greater than 10, the index is set to zero, and
- if DLS is less than five years, the index is set to zero. On the other hand, this may also indicate that a more severe structural problem, needing rehabilitation instead of preventive maintenance, is present.

Then, the projects are ranked in decreasing order of index, and the projects are selected from the top of the list until the available budget is exhausted. This project selection process is summarized in Figure 2.4.

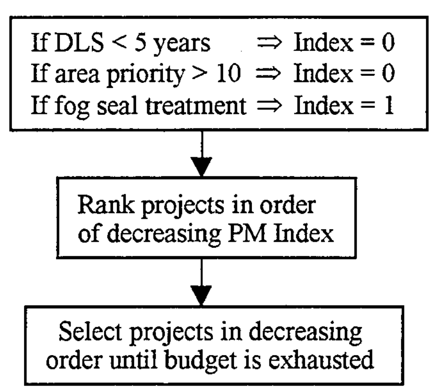

Figure 2.4. Project Selection Process for Preventive Maintenance Projects

It should be noticed that the preventive maintenance index developed by the Fort Worth District is a district version of the PMIS optimization program's ranking index, which is based on a cost-effectiveness ratio. Pavement surveys are conducted using in-house forces in order to make sure that good quality data are stored in the PMIS database. This decision has contributed to the acceptance and success of the preventive maintenance index.

Project Selection Criteria at the Laredo District

Identification of needs is the first step in the prioritization of projects. Color maps are used to visualize the condition and level of treatment of the district highway system. Roadway condition needs are also assessed from information submitted by area engineers and maintenance supervisors. In some cases, the district pavement engineer is required to physically visit the project area and rate the road again, if necessary, especially if there has been an increase of rain that may have damaged pavement surfaces after the pavement condition survey has been conducted. Once a list of candidate projects is assembled, projects are prioritized using a formula based on factors such as cost effectiveness (30 percent), safety index (30 percent), roadway condition (20 percent), economic benefit to the area (10 percent), and priority assigned by the area engineer (10 percent). Cost effectiveness is measured as cost-per-vehicle-mile, and the safety index is related to the number of accidents. Results of the formula are used for preliminary decisions and are not always the standard for a final decision.

PMIS AREAS REQUIRING IMPROVEMENT

The majority of the districts included in this study and TxDOT Research Project 0-1420 viewed PMIS as a critical resource in their pavement management efforts. This section provides a summary of district input about areas for improving the current PMIS system, and appropriate action items are proposed. The comments and recommendations expressed have been provided in the hope of making a good PMIS system even better.

Data Collection Improvements

Quality of Input Data

Pavement data collection is the most costly, labor-intensive, and time-consuming part of PMIS. Major concerns expressed by the districts were related to the repeatability, consistency, and uniformity of the visual pavement condition data collected throughout the state. This is an important issue for the acceptance and confidence of PMIS by decision makers, especially if the allocation of funds to districts at the central level and the project selection process developed by districts are based heavily on PMIS pavement condition data. Several directors of TP&D commented that this was one of the main reasons for their lack of use of the system. In addition, if pavement data collection is outsourced to the private sector, there is no confidence in the quality of data gathered. Consultants operate on a production basis and tend to drive the sections too fast, missing some of the distress types.

Action Item 1 — *Develop a standardized auditing procedure and guidelines at the central level to be implemented by district staff. This will include pre-rating of a set number of sections, comparison on ratings with pre-rated results, and statistical criteria for acceptability. Contracts should be written to include this review and certification period.*

Need for Automation to Improve Pavement Assessment

Visual pavement data collection is costly and dangerous. The collection cost is running from $18 to $28 per mile. Ride quality and flexible pavement rutting have been automated. However, all other distress ratings are still based on subjective opinion of certified pavement raters, and there is a need for improving reliability of their manual rating procedures.

Action Item 2 — *Provide funds to the development of automated distress equipment. Investigate other technologies (for example, Infrared) for crack* *detection. As soon as practical, implement a prototype system in the urban areas.*

Identification of Crack Sealing

Many districts requested that the visual inspection system be changed to include the state of crack sealing (sealed or unsealed). Some thought that sealed longitudinal and transverse cracks are not themselves a problem, but sealed cracks are still active and can reopen at any time. Also, the amount of unsealed cracks would be a very good item to estimate crack sealing contracts.

<u>Action Item 3</u> *Evaluate what impact including an extra item in the inspection would have on the entire system. The raters should note whether the longitudinal and transverse cracks are a) sealed, b) unsealed, or c) partially sealed.*

Sections with Stabilized Bases

The current flexible pavement inspection system does not adequately define the condition of pavements with stabilized bases. These types of pavements are common in many districts, especially those in east Texas. The Houston District has used this design exclusively for the past 10 years. Stabilized base pavements are not considered as a pavement type within PMIS, and there are no adequate inspection procedures or decision trees for needs estimation. On these pavements, the presence of base pumping is a critical item.

<u>Action Item 4</u> *Make the pavement type 7 designation "Asphalt Surfacing with Heavily Stabilized Base." This will be restricted to bases designed under Item 276 of the Specifications Book. Develop a new inspection procedure that focuses on the extent and severity of longitudinal, transverse, and block cracking. Develop new*

decision trees for this new pavement type as its performance and treatment is learned.

Bridges Causing Problem with Ride Values

A recurring problem identified was the impact on bridges of the pavement ride value. This is a problem particularly in urban areas with many bridges close together.

<u>*Action Item 5*</u> *Provide training to operators on how to exclude bridge roughness from pavement data. This may be accomplished by linking into a bridge database with exact locations of every bridge structure and dynamically segmenting out data prior to the calculation of Ride Scores.*

Automated Rut Measuring System

The rut measuring system was thought to be a big improvement, particularly in terms of operator safety. However, several districts commented that measurements made with the rut bars were inconsistent and not representative of actual rut depths. Some of the problems were thought to be weather related. Testing narrow pavements with no paved shoulder also impacted the accuracy of the automated rut measurement equipment.

<u>*Action Item 6*</u> *Provide funds for the next generation of automated rut measuring equipment. Consider placing more sensors on the rutbars. Also develop calibration facilities for annual certification of automated equipment.*

PMIS Data Analysis

Ride Utility Values

Most districts thought that the ride values were very reasonable. The only concerns were that, in some instances in urban areas, the ride score has too much impact on pavement scores. Recent research has indicated that the initial ride values on jointed concrete pavements in urban areas are not as high as initially thought. On top of this, in urban areas, curb and gutter drainage inlets and stop-and-go traffic often impact ride values.

<u>*Action Item 7*</u> *Expand Item 5 to include better training and/or improved capabilities to remove unrealistic ride values. These problem ride values on concrete pavements in urban areas also severely impact the needs estimation procedures. Recommendations should be developed to modify the decision trees to lessen this impact. For these pavements, the focus should be on the distress information, with the ride data being of secondary significance.*

District Supplied Costs

One concern was the need for district-specific costs. The current system uses statewide average costs; however, the urban districts pointed out that, if this system is to be used as part of the fund allocation system, then their treatment unit costs are substantially higher because of the additional traffic handling costs.

<u>*Action Item 8*</u> *Investigate the feasibility of switching to district- or county-specific treatment cost.*

Definition of Benefit and Cost-Effectiveness Ratio

The current system calculates benefit from an area under the curve concept for treatments ranging from preventive maintenance to reconstruction. The current definition of benefit appears to be appropriate for only maintenance and light rehabilitation treatments. The current system does not split maintenance and rehabilitation budgets; consequently, the majority of the treatments selected is preventive maintenance treatments. Cost-effectiveness ratio is defined essentially as benefit divided by cost. Values of cost effectiveness were calculated for all the pavement sections in the Paris District, and higher cost-effectiveness ratios were found for preventive maintenance and light rehabilitation treatments. The average values for preventive maintenance, light rehabilitation, medium rehabilitation, and reconstruction treatments were 811, 639, 413, and 204, respectively, and only a few of the reconstruction projects will ever be selected.

Action Item 9 — *Review the definition of benefit and the entire cost-effectiveness calculation procedure. Consider splitting budgets between treatment types and funding categories, as districts operate in this manner. Consider prioritizing preventive maintenance and light rehabilitation treatments together, as well as medium rehabilitation and reconstruction treatments.*

District-Specific Prioritization System

The districts view the current optimization scheme as largely a system for the central office to look at statewide needs and impact analysis. Most districts do not see how the system, as proposed, will ever meet their needs or how it fits into the decision-making structure already in place. Most of the districts recognize that this decision process needs help from improved strategy selection procedures and prioritization routines. Because of the delays in implementing Phase 2 of PMIS (district-level PMIS applications), several of the districts have attempted to build automated prioritization schemes in-house.

Action Item 10 — *In the Phase 2 implementation, the concept of a district-level prioritization scheme will need to be investigated. This will involve moving from the current 0.8 km (0.5 mi) sections to management sections. It should supply the area engineers with the PMIS needs estimate for the section but let the area engineer make the project and strategy selection and cost estimate. It should include the concept of workload balance between area offices in the prioritization scheme. It will be necessary to work with the directors of TP&D to define possible prioritization schemes; this may be a system in which different schemes are available.*

Improved Deterioration Curves

From discussion with the Austin PMIS group, researchers found that the deterioration curves for flexible pavements appear to be reasonable. However, the rigid pavement curves could be improved.

Action Item 11 — *None at this time, as this is the subject of a current research study.*

PMIS Output Reports

The quality of the current reports and the lack of flexibility in presentation format are two of the major complaints about the PMIS system. Considerable summarization is required to get the data into the format required by decision makers. The current problems are largely because the system is mainframe-oriented and includes few microcomputer applications (links to spreadsheets, etc.) and no map-based outputs.

Improved Report Format for Optimization Reports

For the optimization/prioritization routines and impact analysis, the current reports were viewed as poor. The mainframe system does not have the flexibility to present the data in an acceptable format for decision makers. Specific complaints about the prioritization reports were that there were numerous pages of sections with "do nothing," and it was difficult to find the top 10 or 20 projects. It was also thought that most of this information would be better in graph- and/or map-based format.

<u>*Action Item 12*</u> — *Develop a prioritization report that ranks the projects, providing the ability to identify several sections in every treatment group.*

Map-Based Reports

Every one of the districts takes the PMIS condition reports and transcribes the data onto maps. A few use the SAS graph reports available in Austin, but most want to tie the system to a GIS-based system, such as Arc/Info. Districts expressed that this need has been voiced for at least 10 years, and they do not see any coordinated progress from the central office on this critical issue. Because of the lack of progress in this area, several of the districts have initiated in-house, map-based pilot studies.

<u>*Action Item 13*</u> — *This, as it appears to have been for the last 10 years, is the subject of continual study. The technology has been in place for the past 10 years to develop a map-based interface for PMIS, and develop software that will facilitate interfacing PMIS data with GIS.*

Executive Level Training

The district PMIS coordinators did not perceive any problems with the training, documentation, and support they received from the Austin PMIS support group; they were very appreciative of the help. However, a common concern was that, even though they understood the strengths and weaknesses of PMIS, there was a lack of understanding at the senior district level. They recommended that some type of training be developed for district engineers and directors of TP&D about the best way to use PMIS data. They thought that this would best be achieved by some kind of video presentation.

<u>Action Item 14</u> *Prepare an executive-level video, no more than 30 minutes in length, explaining what PMIS is and how it can best be used at the district level.*

CONCLUSIONS AND RECOMMENDATIONS

California's PMS, which was implemented in 1978, provides a uniform systemwide basis for the identification of pavement distresses and a systematized method for prioritizing pavement rehabilitation needs. The 1995 State of the Pavement Report indicated that 22,400 lane-km (14,000 lane miles, which account for approximately 29 percent of the system) required corrective maintenance or rehabilitation, with 6,880 lane-km (4,300 lane miles) needing immediate rehabilitation. Several pavement rehabilitation projects were programmed using worst-first management strategy, but an increase in funding has allowed CALTRANS to implement a preventive maintenance strategy. This change in pavement treatment management strategy is expected to reduce rehabilitation costs by up to 10 percent (10). The change from worst-first to emphasis of preventive maintenance strategy was motivated by:

- the establishment of the Capital Preventive Maintenance (CAPM) strategies in FY 1995-1996,
- adoption of a long-term performance goal, and
- the implementation of benefit-cost analysis at the network and project selection levels within PMS.

CALTRANS is in the process of updating its PMS by including the following capabilities: network policy recommendations, pavement performance prediction model, project selection and total cost minimization, and tracking of performance goal achievements. It is expected that PMIS improvements will enhance the current project selection process regarding the identification of rehabilitation projects at an optimum time, pavement rehabilitation strategies, and an efficient use of support and capital resources (10). CALTRANS highway preservation programs, such as the Response Routine Maintenance and CAPM, include pavement treatments and cost treatment per lane mile comparable with PMIS Preventive Maintenance (PM) and Light/Medium Rehabilitation (LRhb/MRhb) treatment categories, respectively.

Regarding TxDOT PMIS system, it was encouraging that the vast majority of the districts at the operational level, approximately 70 percent, consider PMIS data an integral part of their network management, despite some system limitations. Although some decision makers at the strategic level do not have confidence in the quality of PMIS data or are simply unwilling to use PMIS, nearly two-thirds of the districts understand the benefits of PMIS and collected more than the 50 percent mandatory sample during FY 1998 (even with funding, personnel, and travel restrictions). In order to address PMIS quality issues of input data, TxDOT will fund a research project in FY 1999 to monitor the quality of distress data. At the operational level, there is good acceptance of PMIS since its strengths and limitations are well understood. Those limitations provide the districts with flexibility to incorporate local conditions into their project selection process. In addition, PMIS provides new pavement managers with information of past condition and performance of pavements and leverages personnel by taking care of routine decisions, which would otherwise consume time and take personnel away from more intricate projects and decisions.

Several districts have developed and implemented project selection formulas or indexes based on simple factors and common sense. Nevertheless, those procedures are limited to the selection of preventive maintenance and light rehabilitation projects. Similar procedures cannot be developed for the selection of medium rehabilitation or reconstruction projects due to the lack of information on pavement layer, previous work history, and sub-surface structural condition within PMIS. For instance, since PMIS provides only an assessment of surface condition, seal coats on pavements with deficient bases will cover superficial cracks/distresses and will be treated as completely rebuilt pavements.

Finally, the recent increase in weight of the PMIS condition information into the district fund allocation formula (UTP categories 2, 3C, 4F, 7, 8A, and 14) might accelerate district interest and use in PMIS activities. Clearly, now is the appropriate time to "go to Phase 2" in pavement management development. To proceed, the following are recommended:

1. A Pavement Management Steering Committee, similar to the committee in place in the early 1990s, should be reestablished (that committee consisted of division, district, and university personnel). The proposed committee should address the issues raised in this chapter and in TTI Research Report 1420-S (9).

2. The current PMIS system is well understood and generally liked by most districts. However, problems exist with the system. Several of the most critical problems perceived by the districts are presented above. A total of 14 action items were also proposed to address these perceived problems. More detailed information on those actions, as well as information on additional action items, is provided in Research Report 1420-S (9). The proposed steering committee should review and prioritize these items, as well as develop and initiate an implementation plan.

3. The proposed steering committee should also develop a clear implementation plan for the district-level Phase 2 implementation, identifying options, priorities, pilot test programs, research activities, and resource requirements. Important issues to include in this phase involve developing a pavement layer database, moving into management sections, integrating Geographic Information System (GIS) capabilities, and moving from a mainframe to a microcomputer application system. A timeline should be constructed and resource requirements identified. This plan should be presented to TxDOT Administration for approval.

REFERENCES

1. *Unified Transportation Program.* Texas Department of Transportation, Austin, Texas, September 26, 1996.

2. *Pavement Maintenance and Rehabilitation: Workshop.* California Transportation Commission, July 1996.

3. *Presentation to District 08 Maintenance Supervisors.* California Department of Transportation, July 1993.

4. *California's Pavement Management System (PMS).* California Department of Transportation. Undated.

5. *Pavement Management Information System.* Texas Department of Transportation, Austin, Texas, June 1996.

6. Smith, R.E., and T. Scullion. *Pavement Management Information System: Concepts and Data.* Report 997-1F. Texas Transportation Institute, College Station, Texas, 1995.

7. Stampley, B.S., B.E. Miller, R.E. Smith, and T. Scullion. *Pavement Management Information System: Concepts, Equations, and Analysis Pavements.* Report 1989-1. Texas Transportation Institute, College Station, Texas, August 1995.

8. *Report of the Task Force to Review Category 2 Interstate Maintenance Allocation Formula.* Texas Department of Transportation, Austin, Texas, November 22, 1996.

9. Scullion, T., and R.E. Smith. *TxDOT's Pavement Management Information System: Current Status and Future Directions.* Research Report 1420-S. Texas Transportation Institute, College Station, Texas, August 1997.

10. *Ten-Year State Highway System Rehabilitation Plan 1998-99 through 2007-08 and Recommendation for Funding within the 1998 State Transportation Improvement Program Fund Estimate.* California Department of Transportation, February 1998.

CHAPTER 3
MOBILITY PROGRAM

INTRODUCTION

Within the construction program, the purpose of mobility programs is to address the need for increasing the capacity of the highway system. This may be accomplished primarily by expanding the system (adding lanes to existing highways), building interchanges, building new loops and bypasses, or managing traffic on existing facilities. Table 3.1 shows the Unified Transportation Program (UTP) funding categories related to mobility projects and programs.

Table 3.1. UTP Categories Related to Mobility Projects and Programs

UTP Category Number	UTP Category Name	Expected Allocated Funds (FY 1998-2001)[1]	Percentage[2]
1	Interstate Construction	$59,676,200	0.79%
3A	National Highway System: Mobility	$1,056,738,944	14.01%
3B	National Highway System: Texas Trunk System	$336,694,110	4.46%
3D	National Highway System: Traffic Management Systems	$37,762,790	0.50%
3E	National Highway System: Miscellaneous	$35,123,468	0.47%
4C	Surface Transportation Program: Metropolitan Mobility/Rehabilitation	$625,119,188	8.29%
4D	Surface Transportation Program: Urban Mobility/Rehabilitation	$369,855,000	4.90%
4E	Surface Transportation Program: Rural Mobility/Rehabilitation	$221,748,000	2.94%
4G	Surface Transportation Program: Railroad Grade Separation	$76,357,522	1.01%
5	Congestion Mitigation and Air Quality Improvements	$466,372,000	6.18%
8B	Farm-to-Market Roads Expansions	$75,501,953	1.00%
12	Strategic Priority Programming	$568,145,781	7.53%
13A	State-Funded Mobility	$0	0.00%
13B	Hurricane Evacuation Routes	$64,513,124	0.86%
13C	NAFTA Discretionary Program	$24,800,000	0.33%
15	Federal Demonstration Projects	$180,944,309	2.40%
17	State Principal Arterial Street System	$81,627,363	1.08%
TOTAL		$4,280,979,752	56.75%

Source: TxDOT's Transportation Planning and Programming Division

[1] From Table 1.6
[2] Calculated using the estimated grand total = $7,534,098,614 from Table 1.6

Table 3.1 shows that mobility projects and programs comprised approximately 57 percent of total construction category funds. Most of the mobility UTP categories are project specific in which candidate projects are selected at the central level based on:

- statewide competition formulas or indexes such as cost-effectiveness index (categories 3A and 3B), traffic management index (category 3D), cost benefit (category 4G), and cost efficiency (category 8B);
- specific needs and deficiencies selected by the Texas Transportation Commission (categories 3E, 12, 13A, and 13B), and
- federal legislation that includes projects listed in the Intermodal Surface Transportation Efficiency Act (ISTEA) or Pre-ISTEA (categories 1, 15, and 17).

The rest of the UTP mobility categories (4C, 4D, 4E, and 5) are considered district bank balance programs in which TxDOT's central office allocates funds to districts to address local transportation needs not selected by statewide competition programs. The allocation of funds to districts is based on population criteria as follows:

- *Category 4C:* percentage of population in urbanized areas, with populations of 200,000 or greater, located within the district as compared to the state population in that category,
- *Category 4D:* percentage of the combined population of qualifying urbanized areas (with populations less than 200,000 and greater than 5,000) within the district as compared to the state population in that category,
- *Category 4E:* percentage of rural population (in cities of less than 5,000 population or outside any city limits) within the district as compared to the state's rural population, and
- *Category 5:* population and air quality non-attainment factors outlined in ISTEA.

Description of Project Objectives

This study will address the two district alternatives to finance mobility projects: (1) keeping the project within the district to compete districtwide, and (2) sending the project to the central office to compete statewide with other districts' projects.

At the district level, the emphasis will be on the project selection process involved for selecting mobility projects within UTP categories 4C, 4D, and 4E. At the central level, the emphasis will be placed on UTP categories 3A and 3B that use the cost-effectiveness index for the selection of mobility projects. Other criteria for statewide project selection, such as net present value (NPV), internal rate of return (IRR), benefit cost ratio (B-C ratio), and others, were analyzed as an alternative in a case study that involved 175 mobility projects. Both ranking and optimization techniques were used for selecting the projects.

DISTRICTWIDE SELECTION OF MOBILITY PROJECTS

Visits to rural, urban, and metropolitan districts were conducted. Special emphasis was placed upon the districts' selection of mobility projects for UTP categories 4C (metropolitan mobility and rehabilitation), 4D (urban mobility and rehabilitation), and 4E (rural mobility and rehabilitation). These UTP categories were selected for the analysis since they are considered bank balance programs, in which districts have the flexibility to identify, prioritize, and select their mobility (and rehabilitation) projects without much involvement from TxDOT's central office in Austin. Category 4C addresses metropolitan mobility/rehabilitation needs in those urbanized areas with populations 200,000 or greater. Category 4D addresses urban mobility/rehabilitation needs in those urbanized areas with populations between 5,000 and 200,000, while category 4E addresses those needs in rural areas with populations less than 5,000 or outside any city limits.

Even though the funds allocated to the districts for categories 4C, 4D, and 4E can be used for mobility and rehabilitation projects, most districts visited use these funds for mobility projects since these projects are usually more expensive than rehabilitation projects. Meanwhile, rehabilitation projects are commonly fed into category 4F (another district bank balance program), which addresses rehabilitation transportation needs in urban and rural areas. In most cases, districts must save their allocated funds for several fiscal years in order to accomplish a single mobility project, which may have a high priority within the district but a high cost-effectiveness index for competing statewide with other projects. Deferral of funding is accomplished through a trade fair that is conducted by TxDOT's Transportation Planning and Programming (TPP) Division. TPP Division meets with all districts annually to find out their funding needs for the next four fiscal years in federally funded bank balance programs 4C, 4D, 4E, and 4F. If a district is planning to save its annual allocations for several fiscal years to finance a specific project in one of those UTP categories, those monies are available to other districts in need for financing projects in current fiscal year, with the understanding that their future allocations will be transferred to the districts that were saving their current allocations.

Most districts try to avoid any ranking formula for prioritizing mobility projects because of political and subjective factors involved in the decision-making process, especially for selecting projects in categories 4C and 4D where metropolitan planning organizations (MPOs) and local authorities have a high influence on the selection process. Some problems with the establishment of a ranking formula are: (1) one area may get most of the projects, (2) factors and weights that may be involved in the formula will be difficult to justify to local politicians and community, and (3) projects are unique, and the selected factors and weights may not work well for all projects. The selection of mobility projects in categories 4D and 4E is commonly done by consensus among district decision makers who include the district engineer, the director of transportation planning and development, the district design engineer, and the district advanced project development engineer, in agreement with MPOs and local authorities. In category 4C, the projects are selected by MPOs in consultation with the districts. Common factors used for the selection of expansion mobility projects include the engineering expertise of area engineers, cost, economic benefits to the area, traffic data, number of accidents, condition of the road, acquisition of right-of-way, adjustment of utilities, concordance with the MPO Transportation Improvement Program, and political issues. The project selection process at the district level is depicted in Figure 3.1.

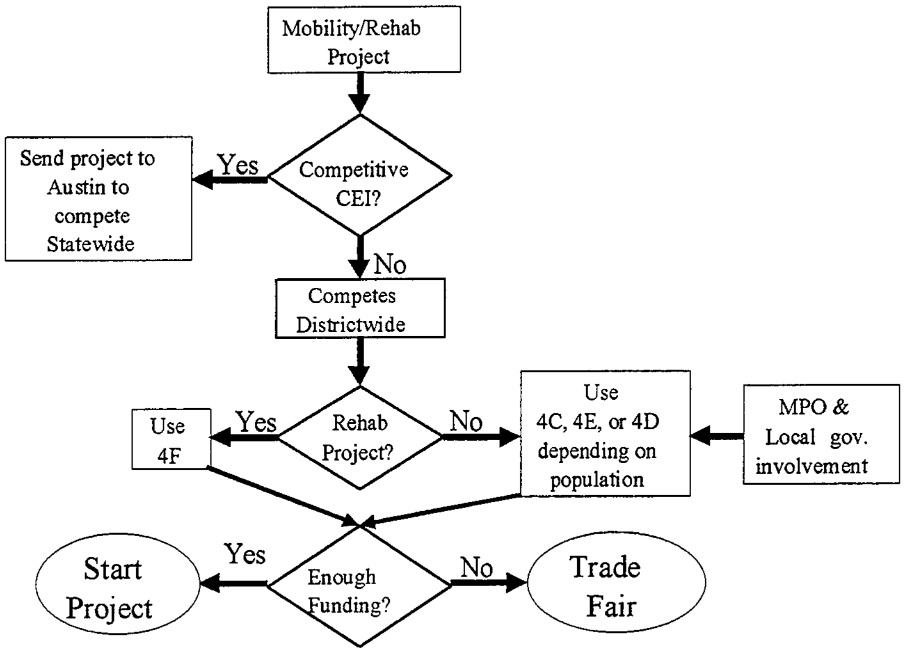

Figure 3.1. Project Selection Process at the District Level

STATEWIDE SELECTION OF MOBILITY PROJECTS

Overview of Allocation Methods Used for Statewide Selection of Projects

This section will describe different conceptually *pure* allocation methods that yield most of the existing allocation methods used by state transportation agencies when they are combined. The allocation methods are:

1. economic efficiency,
2. benefit/cost ratios,
3. consistency of resources and statewide level of service,
4. equity,
5. individual projects, and
6. political allocation (1).

The first five methods view the selection of projects proposed by regional offices as a technical analysis problem, while the last method views the process as a mechanism for negotiation of conflicts of interests that always arise between state and regional levels.

Allocation Based on Economic Efficiency

The conditions of economic efficiency method require that marginal benefit/cost ratios for all projects funded are equal. In addition, project size or scale needs to be divisible so it can be constructed in stages (e.g., 2, 4, and 6 lanes). Marginal benefits tend to decrease with increasing size and cost. Essentially, given total resources and a number of candidate projects, each one with a benefit versus cost curve, additional increments in benefits for an extra dollar of investment establish locations which receive projects and the best project size at each location.

The allocation process based on economic efficiency starts with the state sending each region an allocation guideline, specifying the factors involved in evaluating the benefits and costs of candidate projects. The regions then select the location and size of their candidate projects and send the state a list of candidate projects and the region's marginal benefit/cost ratio for review. Because of different investment opportunities, the marginal ratios provided by the regions will be different, and the state may choose to maximize aggregate net benefits to the state for a given amount of resources, without regard for their distribution among regions. Then, projects from regions with lower marginal ratios are dropped from the statewide list of candidate projects to move their corresponding funds to regions with higher ratios. The state issues new guidelines to the regions, and project sizes and locations will change in some regions. Then, new or modified lists of candidate projects are submitted to the state by the regions, and their marginal benefit/cost ratios are again checked for consistency. This process is repeated until the ratios are equal for all regions. A disadvantage of this allocation method is that it may emphasize investment in urban areas at the expense of rural areas.

Allocation Based on Benefit/Cost Ratios

The allocation of resources based on economic efficiency requires that project size and location are variable. Nevertheless, due to fixed project location and size, that requirement cannot be met by several projects. The allocation of resources based on benefit/cost ratios allows an efficient allocation given that size and location of candidate projects are fixed for each region. In this approach, each region computes benefits and costs for candidate projects it would like to build. Projects are ranked by aggregate benefit/cost ratio, and the list of candidate projects is sent to the state. The state combines these regional project lists into a master project list that contains all projects from all regions ranked by benefit/cost ratio. Then, this master project list is funded as far down the list as possible, until available resources are exhausted.

Allocation Based on State Level of Service

This method is based on maintaining a given transportation level of service (LOS) distribution over the state. First, the state selects a statewide candidate LOS and then checks the total cost required to accomplish all the projects included in a master project list of candidate projects from all regions. If total cost is less than available resources, the master project list is approved. Otherwise, the LOS is decreased until the total cost required to build the projects included in the master project list meets available resources.

Allocation Based on Equity Allocation

The allocation of resources based on equity, sometimes known as a fair share, may have several options to define equity. Some of those options may be the following:

- equal LOS distribution in all regions considering urban and rural subdivisions,
- equal expenditure per capita, per mile of road, per mile of travel, per political district, etc., that may help the state to overcompensate poorer regions, and
- regional expenditures equal to taxes paid (may discriminate heavily against rural areas).

Individual Project Allocation

Discretionary fund categories allow the states to capitalize on unique opportunities that may not be captured in analytical allocation formulas. Therefore, the state has the flexibility to select individual projects that promote and support the economic development and competitiveness of each local region.

Political Allocation

The political allocation process represents a mechanism for negotiating conflicts of interest between state and regional levels. Political allocation is based on a comprehensive analysis of what programs regions intend to implement with allocated funds. For this type of allocation, the state requests candidate programs from regions and provides guidelines for cost and for the particular type of transportation the state would like to see emphasized. Regions respond with candidate programs designed to meet state guidelines but also to promote their regional interests. Regional interests may conflict with statewide plans, and candidate regional programs may be returned to their regions as unacceptable or may be renegotiated so that bargaining over candidate programs usually solves potential statewide regional conflicts.

TxDOT's Allocation Method Based on Cost-Effectiveness Index

The Cost-Effectiveness Index (CEI) is the ranking index used by TxDOT for prioritizing statewide mobility projects involving expansions, interchanges, and new loops and bypasses. CEI is defined as the number of days it would take to recover the project cost in terms of user benefits (2). The CEI is a simplification of the cost/benefit ratio model used in classic economic analysis. Benefits to the traveling public are quantified as time savings through increased travel speed, while costs include construction, right-of-way, and environmental mitigation. Advantages of using the CEI include: easy calculations, the ability to use in all statewide categories of projects, the ability to use available data, the ability to neglect discount rates, and the ability to analyze cost and benefit aspects.

Case Study: Statewide Selection of Mobility Projects

For this case study, it is assumed that the objective of a public service institution that invests taxes collected from the population is to maximize the benefits that an investment provides to the people who paid those taxes. TxDOT is, therefore, assumed to choose among different mobility projects that will maximize the benefits of the road users. The overriding benefit that is being sought with these projects is to improve users' mobility by reducing congestion and distances, and by improving road geometry. These projects must be fully funded in order to attain their corresponding benefits; therefore, project divisibility is not allowed.

A total of 175[1] of TxDOT's mobility projects was used to compare different project selection criteria and compare their performance in terms of overall benefits accrued. The projects consisted of added capacity, new location (loops and bypasses), and interchange upgrade type projects. Partial details of these projects are given in Table 3.4. For each of these projects, user benefits were computed using MicroBENCOST. MicroBENCOST is a computer program developed by TTI for analyzing economic benefits and costs of a wide variety of highway improvements, which include added-capacity, bypass, intersection/interchange, pavement rehabilitation, bridge, safety, and highway-railroad grade crossing (3). MicroBENCOST defines user benefits as the savings of the user costs between an existing and a proposed alternative and includes vehicle operation costs, time costs, and accident costs.

The project selection criteria used in this case study included user benefits, net present value (NPV), NPV/cost (NPV/C) ratio, netted benefit/cost (B/C) ratio, internal rate of return (IRR), and CEI. MicroBENCOST was also used to obtain estimates of total discounted user benefits, NPV, NPV/C ratio, netted B/C ratio, and IRR for each of the projects. MicroBENCOST defines B/C ratio as the ratio of the benefits to the costs of the analyzed project over the period of analysis, with both benefits and costs discounted to the current time. Two netted B/C ratios are given by program: the gross B/C ratio and the netted B/C ratio. In the gross B/C ratio, benefits of the numerator are simply user benefits. Costs of the denominator represent construction costs minus salvage values, plus the increase in maintenance and rehabilitation costs. In the netted B/C ratio, benefits of the numerator are not only the user benefits but also the salvage value, minus the added maintenance and rehabilitation costs. Costs of the denominator are only the construction costs.

Then, with an assumed budget of $2,000,000,000, projects were chosen in order of selection criteria until the budget was exhausted, using both ranking and optimization techniques. Since ranking techniques do not guarantee an optimal solution, a binary linear integer-

[1]Details for these projects were supplied by TxDOT's Transportation Planning and Programming Division and included: CSJ number, highway, district number, county number, priority, estimated construction cost, estimated remaining right-of-way, urban or rural, existing number of lanes, existing highway type, existing length, proposed number of lanes, proposed highway type, present ADT, percent trucks, design speed, new location or interchange, existing interchange, proposed interchange, crossroad ADT, crossroad number of lanes, crossroad type, added-capacity project existing lane width, existing shoulder width, presence of signals, if signal crossroad ADT, and crossroad number of lanes. The calculated CEI for the projects was also provided.

programming model was used to achieve optimality for each of the selection criteria described above. The binary linear integer-programming problem written in mathematical form is as follows:

$$\text{Maximize } \sum_{j=1}^{n} b_j x_j;$$

$$\text{subject to } \sum_{j=1}^{n} c_j x_j \leq B; \tag{3.1}$$

$$0 \leq x_j \leq 1, \; x_j \text{ integer, for } j=1,\ldots,n.$$

In the above expression, b_j denotes the benefits in current dollars obtained from project j, c_j denotes the cost of funding project j, B is the available budget, n is the number of candidate projects that can be funded, and x_j is an indicator variable that is equal to one if project j is funded, and zero otherwise. This basic model was adjusted to maximize benefits B/C ratio, NPV, and IRR as project selection criteria. The optimization problems were solved using CPLEX optimization software version 4.0 (4). Figure 3.2 depicts the methodology used in this case study.

The solution of the model will maximize the benefits to the road users, but the selection of projects may be such that investment will be concentrated on only a few geographical regions. Revenues are collected across the state; thus the department may be transferring money from some part of the state to another. The stated assumption was that the public entity will maximize the benefits of those who paid taxes. By maximizing benefits across the state, the department will not necessarily maximize benefits of all the taxpayers in an equitable manner. It could be argued that maximizing road users' benefits across the state benefits all state residents; thus taxes are being utilized properly. Although this may be a valid argument, it may be desirable to add constraints that keep expenditures above a certain level in each geographical region or district. These levels must be set with care so as to keep the model feasible. They must be set below the proposed projects for that region and added to an amount less than the available funds. Equation (3.1) would be modified by adding the following constraints:

$$E_l \leq \sum_{i \in I_l} c_i x_{i,} \text{ for all districts } l=1,2,3,\cdots; \qquad (3.2)$$

where E_l is the minimum expenditure allowed in district l, and I_l is the set of projects available in district l.

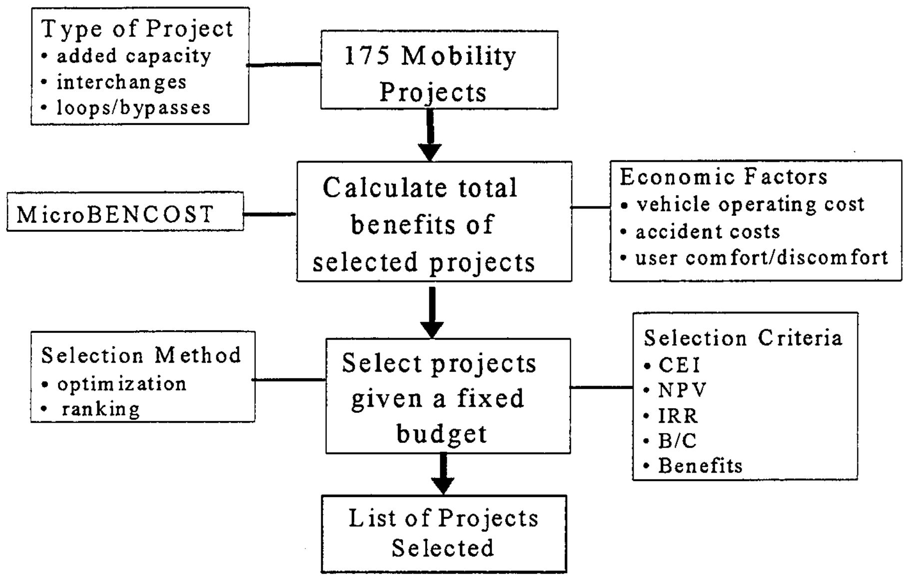

Figure 3.2. Description of Project Selection Methodology

Results

Overall results are contrasted in Table 3.2. In this table, each ranking and optimization procedure is paired with every other procedure, and three numbers are given. The first figure is the number of projects that both procedures selected for funding; the second figure is the number of projects that both procedures did not select for funding; and the third figure is the addition of the first and second figures, or the total number of same projects in which the two procedures are in agreement. The entries of the diagonal show the number of projects that each of the methods selected for funding.

Table 3.3 shows the total discounted user benefits in decreasing order, achieved under different selection criteria, and the difference with respect to the highest value in total discounted user benefits. The highest discounted user benefits, in decreasing order, were obtained when ranking and optimizing by the following selection criteria: benefits, B/C ratio, NPV, NPV/C, IRR, and CEI. The largest discrepancies occurred when the CEI values were used. These discrepancies are due partly to the fact that the department used a different approach to compute benefits and may have obtained different user benefits. In terms of total benefits, the difference between ranking using CEI, as currently done by TxDOT, and maximization of benefits using the optimization model, is $ –2,491.05 millions. Therefore, according to this very real example, it is possible to have an increment close to 17 percent in user benefits by better assessing benefits and using optimizing techniques.

CONCLUSIONS

Selection of mobility projects within UTP categories 4C, 4D, and 4E is highly dependent upon political factors, due to the involvement and influence MPO and local government officials have in the decision-making process. Therefore, trying to establish an allocation scheme based on economic or technical analysis within a district is likely to fail. However, political allocation has the benefit that it incorporates local community factors and needs into the system-planning process that otherwise may be overlooked by the state. High interaction, communication, and negotiation skills are required by TxDOT employees to effectively conduct business in this politicized environment, especially in urban and metropolitan districts.

With respect to the statewide selection of mobility projects using the cost-effectiveness index, other economic factors, such as vehicle operating costs, accident costs, and user comfort/discomfort costs, may be included in the benefits portion of the CEI formula. Total benefits, B/C ratio, NPV, NPV/C, and IRR, may be better options than using CEI for ranking the projects. MicroBENCOST is an existing tool TxDOT may consider implementing and using in the future. The only alternative obtaining an optimal list of mobility projects is using a mathematical optimization model. However, that option uses much more complex data than the existing system and may not be cost effective to develop, implement, and maintain.

Table 3.2. Comparative Results of Different Allocation Procedures

		Optimal Benefits	Ranking Benefits	Optimal B/C	Ranking B/C	Optimal NPV	Ranking NPV	Ranking NPV/C	Optimal IRR	Ranking IRR	Ranking CEI
Optimal Benefits	Funded	90	66	86	87	87	71	87	87	87	68
	Not	85	80	45	84	83	81	84	64	84	49
	Total	175	146	131	171	170	152	171	151	171	117
Ranking Benefits	Funded		71	65	66	67	70	66	67	66	51
	Not		104	43	82	82	99	82	63	82	51
	Total		175	108	148	149	169	148	130	148	102
Optimal B/C	Funded			126	84	85	70	84	105	84	89
	Not			49	45	45	44	45	46	45	34
	Total			175	129	130	114	129	151	129	123
Ranking B/C	Funded				88	87	71	88	85	88	66
	Not				87	85	83	87	64	87	49
	Total				175	172	154	175	149	175	115
Optimal NPV	Funded					89	72	87	86	87	68
	Not					86	83	85	64	85	50
	Total					175	155	172	150	172	118
Ranking NPV	Funded						75	71	72	71	55
	Not						100	83	64	83	51
	Total						175	154	136	154	106
Ranking NPV/C	Funded							88	85	88	66
	Not							87	64	87	49
	Total							175	149	175	115
Optimal IRR	Funded								108	85	82
	Not								67	64	45
	Total								175	149	127
Ranking IRR	Funded									88	66
	Not									87	49
	Total									175	115
Ranking CEI	Funded										104
	Not										71
	Total										175

Table 3.3. Difference Between Optimal User Cost Benefits and Other Procedures

	Discounted Benefits Millions	Difference Millions
Optima Benefits	$17,391.72	$0.00
Ranking Benefits	$16,990.60	$-401.12
Optimal B/C Ratio	$16,785.88	$-605.84
Ranking B/C Ratio	$17,310.77	$-80.95
Optimal NPV	$17,390.31	$-1.41
Ranking NPV	$17,161.01	$-230.71
Ranking NPV/Cost	$17,310.77	$-80.95
Optimal IRR	$17,133.93	$-257.79
Ranking IRR	$17,310.77	$-80.95
Ranking CEI	$14,900.67	$-2,491.05

Table 3.4. Characteristics of Mobility Projects

PROBLEM #	HWY.	DISTRICT	TOTAL COST	CEI/DAYS
1	US 82	1	$5,900,000.00	353.35
2	US 82	1	$8,446,000.00	1420.8
3	US 82	1	$6,991,000.00	517.98
4	US 82	1	$3,246,000.00	446.65
5	US 82	1	$4,922,000.00	400.19
6	US 82	1	$5,440,000.00	1179.87
7	IH 820	2	$16,882,983.00	199.84
8	IH 820	2	$1,875,887.00	16.28
9	SH 199	2	$18,130,000.00	11257.85
10	SH 199	2	$15,791,790.00	33493.46
11	BU 287p	2	$5,249,441.00	7192.19
12	SH 114	2	$8,900,000.00	21905.18
13	SH 114	2	$20,486,000.00	9541.28
14	SH 114	2	$18,738,000.00	24895.93
15	SH 114	2	$19,796,000.00	18786.87
16	IH 30	2	$23,895,800.00	1156.03
17	FM 1187	2	$4,833,900.00	2228.35
18	FM 1187	2	$5,462,700.00	3669.88
19	FM 1187	2	$7,561,000.00	3777.22
20	SH 360	2	$7,479,700.00	3091.35
21	US 287	3	$15,850,000.00	7750.55
22	US 82	3	$10,174,000.00	10626.5
23	IH 40	4	$3,200,000.00	2221.23
24	US 82	5	$9,500,000.00	16147.48
25	US 82	5	$7,000,000.00	10000000000.00
26	US 82	5	$8,900,000.00	26751.9
27	US 82	5	$16,900,000.00	2978.42
28	US 82	5	$24,600,000.00	26085.92
29	US 82	5	$44,600,000.00	78780.03
30	US 82	5	$11,200,000.00	9632.27
31	US 82	5	$13,300,000.00	20076.61
32	US 82	5	$29,200,000.00	51462.23
33	US 82	5	$5,200,000.00	1568.81
34	US 82	5	$29,000,000.00	42896.99
35	US 82	5	$17,000,000.00	10000000000.00
36	LP 289	5	$31,000,000.00	10000000000.00
37	LP 289	5	$6,800,000.00	30260
38	LP 289	5	$10,000,000.00	10000000000.00
39	LP 363	9	$1,520,000.00	1001.36
40	LP 340	9	$10,050,000.00	25424.98

PROBLEM #	HWY.	DISTRICT	TOTAL COST	CEI/DAYS
41	SH 6	9	$1,830,000.00	11041.73
42	US 259	10	$13,466,500.00	1305.56
43	US 259	10	$7,741,000.00	997.92
44	SH 155	10	$2,220,000.00	5599.12
45	LP 323	10	$3,740,000.00	3434.14
46	US 59	12	$41,050,000.00	39968.06
47	US 59	12	$20,811,960.00	2740.71
48	US 59	12	$28,545,476.00	8968.9
49	SH 3	12	$6,519,000.00	18244.12
50	IH 45	12	$39,700,000.00	10684.52
51	IH 45	12	$39,525,000.00	8042.18
52	IH 45	12	$40,900,000.00	1115.49
53	IH 45	12	$36,366,000.00	10000000000.00
54	US 59	12	$24,520,000.00	729.54
55	US 59	12	$43,980,000.00	8584.15
56	US 59	12	$33,014,000.00	3406.25
57	US 59	12	$71,168,000.00	3211.75
58	SH 35	12	$7,703,000.00	4337.38
59	SH 6	12	$3,090,000.00	1926.39
60	SH 6	12	$17,600,000.00	5923.89
61	LP 201	12	$5,325,000.00	2832.06
62	IH 45	12	$12,075,000.00	129.3
63	IH 10	12	$44,929,000.00	12260.28
64	SH 249	12	$33,168,000.00	10000000000.00
65	FM 518	12	$5,825,000.00	4084.91
66	FM 518	12	$3,675,000.00	6781.09
67	NASA 1	12	$30,130,000.00	1082.01
68	FM 529	12	$10,382,000.00	1475.5
69	SH 332	12	$24,448,000.00	6353.43
70	FM 1960	12	$17,800,000.00	1019.52
71	SP 55	12	$5,000,000.00	10000000000.00
72	SH 99	12	$37,410,000.00	911.11
73	SH 122	12	$663,000.00	400.37
74	SH 122	12	$17,219,000.00	488.88
75	LP 183	13	$4,000,000.00	8594.74
76	IH 35	14	$23,600,000.00	1255.31
77	IH 35	14	$15,550,000.00	7421.49
78	US 290	14	$56,000,000.00	6013.62
79	US 290	14	$2,505,000.00	4542.17
80	SH 71	14	$70,500,000.00	27163.48
81	US 290	14	$76,800,000.00	10764.09
82	SH 71	14	$39,410,000.00	8351.17
83	US 290	14	$5,429,000.00	11787.6

PROBLEM #	HWY.	DISTRICT	TOTAL COST	CEI/DAYS
84	US 183	14	$40,850,000.00	15798.95
85	US 183	14	$26,763,000.00	12354.55
86	US 183	14	$39,500,000.00	7285.5
87	US 183	14	$10,840,000.00	12078.6
88	US 183	14	$14,600,000.00	2787.63
89	SH 71	14	$15,300,000.00	4393.18
90	SH 71	14	$30,000,000.00	22754.45
91	US 183	14	$32,845,000.00	18804.14
92	SH 45	14	$16,200,400.00	359.66
93	SH 45	14	$58,000,000.00	1612.37
94	IH 35	15	$15,791,000.00	50059.26
95	IH 35	15	$17,909,000.00	21329.33
96	IH 35	15	$15,375,000.00	23652.67
97	IH 35	15	$7,104,000.00	27024.43
98	IH 35	15	$28,174,000.00	27975.14
99	IH 35	15	$7,931,600.00	1719.27
100	IH 35	15	$26,818,000.00	2728.07
101	IH 10	15	$5,415,000.00	10473.64
102	IH 10	15	$5,558,000.00	6461.68
103	IH 10	15	$14,550,000.00	7194.17
104	IH 10	15	$20,000,000.00	9888.89
105	IH 10	15	$18,860,000.00	2331.31
106	IH 10	15	$14,245,000.00	244.01
107	IH 10	15	$22,045,000.00	377.58
108	SH 27	15	$571,000.00	5243.15
109	SH 46	15	$3,660,600.00	3479.82
110	US 281	15	$22,317,000.00	27214.23
111	SP 421	15	$9,742,100.00	1185.67
112	IH 410	15	$63,005,800.00	10228.94
113	IH 410	15	$39,000,000.00	2272.34
114	IH 410	15	$82,081,100.00	11951.14
115	IH 410	15	$17,140,100.00	2581.09
116	IH 410	15	$27,880,000.00	3172.2
117	IH 410	15	$50,420,000.00	2937.73
118	IH 410	15	$9,120,000.00	355.22
119	IH 410	15	$14,300,000.00	556.98
120	MH	15	$2,815,000.00	87.55
121	MH	15	$7,313,000.00	538.18
122	MH	15	$14,896,000.00	960.88
123	LP 1604	15	$26,342,300.00	2861.25
124	LP 1604	15	$33,392,000.00	7884.22
125	LP 1604	15	$3,700,000.00	1610.28
126	LP 1604	15	$4,200,000.00	1844.67

PROBLEM #	HWY.	DISTRICT	TOTAL COST	CEI/DAYS
127	LP 1604	15	$14,309,700.00	2961.84
128	MH	15	$8,511,000.00	237.17
129	MH	15	$16,501,000.00	1733.31
130	MH	15	$19,626,600.00	954.46
131	US 181	16	$7,769,000.00	28360.13
132	SH 44	16	$11,345,000.00	868.26
133	SH 286	16	$12,855,000.00	1104.31
134	SH 286	16	$31,200,000.00	26632.34
135	US 77	16	$5,207,500.00	36357.26
136	SH 358	16	$3,013,544.00	1261.6
137	SH 289	18	$5,125,000.00	1808.2
138	IH 45	18	$50,926,827.00	10000000000.00
139	IH 45	18	$7,200,000.00	17597.93
140	IH 45	18	$38,000,000.00	72132.4
141	IH 45	18	$864,070.00	10202.22
142	US 380	18	$6,050,000.00	13229.46
143	US 380	18	$11,900,000.00	4767.83
144	US 287	18	$14,054,000.00	18133.02
145	US 287	18	$11,145,000.00	4022.96
146	US 287	18	$14,822,000.00	10595.55
147	US 287	18	$14,700,000.00	2890.42
148	SH 114	18	$16,926,000.00	17699.88
149	SH 114	18	$26,500,000.00	16767.19
150	IH 35E	18	$42,030,000.00	5323.62
151	IH 30	18	$73,213,000.00	6431.23
152	IH 30	18	$111,000,000.00	5335.66
153	SH 360	18	$13,384,800.00	6394.49
154	IH 635	18	$153,000,000.00	1468.86
155	IH 635	18	$63,900,000.00	10000000000.00
156	SH 161	18	$22,000,000.00	734.71
157	SH 161	18	$48,000,000.00	1603
158	SH 190	18	$66,700,000.00	2299.33
159	US 67	19	$5,346,029.00	2526.8
160	IH 10	20	$40,020,000.00	12574.57
161	IH 10	20	$6,990,000.00	21015.07
162	IH 10	20	$29,990,000.00	10000000000.00
163	US 96	20	$6,000,000.00	215.32
164	US 59	20	$62,000,000.00	74349.82
165	SH 105	20	$25,500,000.00	2322.63
166	IH 10	20	$25,000,000.00	57398.01
167	IH 10	20	$11,500,000.00	24558.64
168	BU 83-S	21	$8,044,460.00	4322.24
169	US 83	21	$35,000,000.00	39860.22

PROBLEM #	HWY.	DISTRICT	TOTAL COST	CEI/DAYS
170	US 281	21	$6,931,000.00	58599.5
171	US 77	21	$6,000,000.00	6282.35
172	US 83	22	$1,757,000.00	1103.8
173	IH 10	24	$17,000,000.00	5446.53
174	LP 375	24	$5,000,001.00	4341.46
175	SH 178	24	$3,780,000.00	1531.05

REFERENCES

1. Mead, Kirtland C. *Resource Allocation and the System Planning.* Highway Research Record 467, 1973, pp. 38-51.

2. *Report of the Task Force for the Review of Planning, Programming and Scheduling of Construction Projects.* Texas Department of Transportation, Austin, Texas, September 1991.

3. *MicroBENCOST User's Manual.* NCHRP Project 7-12, Texas Transportation Institute, Texas A&M System, College Station, Texas, 1993.

4. *CPLEX 4.0.* CPLEX Optimization, Inc., Incline Village, Nevada, 1995.

CHAPTER 4
DECENTRALIZATION OF FUNCTIONS

INTRODUCTION

The motivating force behind decentralization is political, since decentralization is viewed as the transfer of political power to regional and local entities of government. Political analysts suggest that decentralization resulted from declining credibility of the centralized state. Despite being politically motivated, decentralization seems to offer some promise for improved public sector performance. The potential to improve public service delivery is one of the main arguments made in support of the decentralization of job functions (1).

In previous research, the impact analysis of decentralization on the quality of highway services, traditionally provided by the public sector, has been measured using the following indicators of service quality: the ride quality road users receive (which is used to determine the vehicle operating costs and the comfort of the road network), and the unit cost of road maintenance (dollars per km) as a measure of cost efficiency. In the World Development Report (1994), governments were classified as centralized (more than 95 percent central government contribution to maintenance operations), partially decentralized (between 56 and 95 percent), and totally decentralized (less than 55 percent). The results of that analysis showed that:

- better highway conditions were found under decentralized systems than under centralized provision, indicating that local governments are better able to maintain higher service quality than central governments, and
- unit costs of maintenance under partial decentralization were the most expensive when compared to centralization and total decentralization.

However, the 1994 World Development Report (2) also indicates that decentralization does not guarantee that the quality of infrastructure services will improve. Performance depends upon the incentives facing decision makers, and incentives depend upon the financial, institutional, and political support given to the decentralization efforts. Moreover, average improvements do not necessarily imply universal improvements. The quality of highway service may worsen in some communities because of trade-off subsidies on a standard service with gains from the differentiation of the service. Many of the poorer communities, for instance, may lack the skills to take advantage of the choices made available by decentralization.

In recent years, TxDOT has seen a steady decrease in the number of full-time equivalents (FTEs). Impacts of this decrease vary among different district offices, categorized as rural, urban, or metropolitan. While FTE cutbacks are continually made in an effort to obtain a more productive and efficient central and district office, several factors must be taken into consideration:

1. How do FTE shortages affect each district type and its respective maintenance, construction, and design divisions?
2. What are viable remedies to FTE shortages?
3. Which job functions are best suited for district offices? (decentralization)
4. Which job functions should the central office perform? (centralization)

The objective of this chapter is to analyze TxDOT's current decentralization and centralization practices and to describe the impacts of limited FTEs on TxDOT's organization. Although analysis of specific management practices is beyond the scope of this report, input from representative rural, urban, and metropolitan districts on management practices and on the decentralization of job functions is provided. For this purpose, TxDOT maintenance, construction, and design personnel from each of the three district types were interviewed.

In order to have a better understanding of organization schemes and management of TxDOT and other state departments of transportation, personnel were interviewed.

DECENTRALIZATION IN STATE DEPARTMENTS OF TRANSPORTATION

Researchers selected the New Mexico State Highway and Transportation Department (NMSHTD) for interviews because of similarities in geographic location and proximity to Texas. Within this state transportation department, personnel including maintenance, construction, and design engineers, were interviewed. An explanation of this transportation department's organizational scheme and its relation to success in dealing with decreasing numbers of FTEs will be provided.

A contact person within the NMSHTD recommended each individual interviewed via telephone. Although this state's transportation organizational scheme may vary from that of TxDOT, interview preference was given to maintenance, construction, and design engineers in rural, urban, and metropolitan areas and district offices. By limiting interviews to maintenance, construction, and design engineers when possible, information obtained was directly compared to TxDOT district interview results.

Two basic questions were asked during the interview:

1. Which job functions are you, your office, or your division performing that you feel the central office should be performing? (centralization of job functions)
2. Which job functions is the central office performing that you feel you, your office, or your division should perform or is more capable of performing? (decentralization of job functions)

With this in mind, individuals were asked to elaborate on their responses and provide recommendations. Interview results for the NMSHTD follow.

New Mexico State Highway and Transportation Department

The New Mexico State Highway and Transportation Department (NMSHTD) is divided into six highway districts with one central office in Santa Fe. According to interview results, and when compared to TxDOT, the organization of NMSHTD is primarily centralized, although a trend towards a more decentralized scheme was indicated. Approximately five years ago, the Santa Fe central office primarily performed design functions while its highway districts were limited to maintenance and construction activities. In recent years, NMSHTD has delegated more functions to its districts, including some design work of book-type projects (e.g., overlays, pavement rehabilitation, and fencing). Although some districts are more advanced in their design functions, the central office performs the majority of design work (centralized).

NMSHTD is comprised of 10 design squads that service the state. New Mexico has three major populated areas, two of which are Albuquerque and Las Cruces. Based on the interviews, the District of Albuquerque contains a thorough and advanced design squad, when compared to other districts; consequently, it may be considered an 11th design squad for the state. Additionally, those interviewed suggested that Albuquerque's highway district is unique and performs some of the most advanced design work in the state. As does TxDOT, NMSHTD district offices have a district engineer, a construction engineer, and a maintenance engineer. Also within New Mexico districts are project managers and survey staff, and a district laboratory and support section. Each highway district has a design specialist. This person reports to a technical support engineer, who is responsible for providing district input to the central office in improvement programs and other situations. This, in addition to other methods, is used to provide district input to NMSHTD's centralized organization. It was noted that developing good communication between districts and the Santa Fe central office is a priority.

Like TxDOT, NMSHTD is also facing a decrease in FTE numbers and is, therefore, outsourcing a portion of their maintenance and design functions. One example of FTE decreases within NMSHTD involves striping crews. Their functions have now been outsourced. Outsourcing of design functions is also common, as well as a portion of right-of-way, environmental, and hazardous material work.

Based on the interviews, the New Mexico State Highway and Transportation Department is not only smaller and more centralized when compared to TxDOT, but it is also outsourcing similar functions. The degree of centralization within NMSHTD was not fully investigated; nonetheless, communication between district offices and the central office seemed optimal for NMSHTD; decreases in FTEs did not appear to affect operations significantly because of the centralized structure; and finally, any deficiencies in FTEs seemed to be alleviated by outsourcing.

DECENTRALIZATION AT TXDOT

Eleven listed TxDOT central office divisions were selected for study. They are: Aviation Division (AVN), Finance Division (FIN), Environmental Affairs Division (ENV), Human Resources Division (HRD), Construction Division (CST), Occupational Safety Division (OCC), Public Transportation Division (PTN), Right-of-Way Division (ROW), Traffic Operations Division (TRF), Transportation Planning and Program Division (TPP), and Vehicle Titles and Registration Division (VTR). Each division provided a list of recent list delegations. Results for tasks delegated by divisions to districts range from not having any tasks delegated (FIN and ROW), having tasks returned to divisions (AVN), and having divisions work cooperatively with district offices. Three primary methods of responsibility/function delegation, according to conversations with division members, include:

1. traditional delegations, which involve the division historically delegating a responsibility to the district over a period of time;
2. memorandums of agreement, which are filed with each individual district and allow for district input into functions they will perform (district and division *agree* on the responsibilities/functions); and
3. cooperative work between a division and district. Two other methods of responsibility delegation include procedural manuals and executive orders. Division delegations, ranging approximately the last five to 10 years, are provided in Appendix A.

Items listed in Appendix A are recent delegations and are intended merely to illustrate division's attempt to satisfy needs that arose within divisions or districts. Reasons for delegations vary – some may be strictly political, while others intended to serve a district's local public need and alleviate inefficiencies within divisions or districts. Nonetheless, because of FTE deficiencies, divisions must now consider the effects new delegations will have on district operations. After considering these effects, divisions have several alternatives:

- divisions may choose to perform the task themselves,
- divisions may delegate the new responsibility to districts,
- divisions may elect to outsource the function,
- divisions may decide to work cooperatively with districts, thus reducing district workload, and
- divisions may provide increased support to districts, depending upon the specific need.

This research does not intend to provide concrete, infallible solutions to every district or division dilemma. Every district is unique, geographically and operationally; therefore, division consideration of each new and former delegation and its repercussions on district operations is crucial to the development of an efficient and productive department.

Results of TxDOT Interviews

Texas Department of Transportation maintenance, construction, and design engineers (supervisors) for rural, urban, and metropolitan districts were interviewed in the same manner as NMSHTD. Interview results have varied among the different district types. While all districts interviewed have voiced a strong concern over diminishing FTEs, interview results indicate rural districts are affected the most. Although the vast majority of districts favor decentralization, rural districts are primarily concerned with the impact a decreased workforce will have on district operations with increased delegations. Urban and metropolitan districts interviewed expressed concern about the decrease in FTEs, but for different reasons. Urban districts share the same concerns as rural districts, but these concerns differ in that urban districts are simultaneously interested in policy procedures. Metropolitan districts share the concerns of both rural and urban districts, but the majority of metropolitan districts expressed an interest in increasing communication with the central office. Results that follow are by no means applicable to every district since even responses within districts are themselves variable; however, these results are a means of assessing the needs of each particular district type.

Maintenance Activities

Maintenance section responses were similar for all districts, with some exceptions. Rural district maintenance sections expressed many concerns, mainly those involving inefficiencies in operations due to decreased personnel and to increased delegations, namely, routine maintenance contract work. Urban and metropolitan districts shared the concerns of rural districts but were also interested in obtaining guidelines and legal advice from the divisions. Urban districts sought information (legal advice from division) pertaining to right-of-way and outsourcing agreements. Metropolitan districts suggested a need for both increased communication with divisions and guidelines pertaining to standards for minimum levels of service. All district types felt that routine maintenance contract work was time consuming and compromised supervisory time from daily operations. Several consequences arose from this:

- in some instances, desired level of service decreased compounded by decreased crew sizes, because supervisory input was not provided (FTEs),
- non-transfer of supervisory skills to FTEs results since supervisory roles have changed from fieldwork to contract management,
- some districts questioned the safety of crews involved in fieldwork without supervision, e.g., new FTEs with little experience, knowledge, training, and too little time to learn process before placed in field, and
- pressure and responsibilities placed on current FTEs has increased as a result of smaller crews responsible for more functions. The latter statement holds true for all TxDOT districts' maintenance sections, as well as construction and design sections.

Budgetary allocations were also district concerns. Strategy 144 money provides for any contract work. Strategy 105 money is used to provide for non-contract work, including but not limited to roadway materials and salaries. Some districts, while they were content with Strategy 144 allocations, felt that more money should be provided in Strategy 105. Some districts may exhaust their funds differently due to materials purchased, overtime, etc. Policies developed by Austin should be more sensitive to state regions. What may be appropriate for Amarillo (e.g., mowing of highways and ice treatments) may not be appropriate for Corpus Christi. Policies developed by the central office should also provide some flexibility. For example, districts are allowed to take bids on routine maintenance contracts if below $100,000. According to the interviews, the legislature passed a law allowing the executive director to provide districts with a $300,000 limit. If extending this limit may provide more efficient district responses, then consideration should be given to these alternatives.

Construction Activities

Within construction sections of all district types, one resounding concern involved federal oversight of district projects. Until recently, the Austin central office performed internal audits for these projects, but the task was delegated to districts without an increase in FTEs to fulfill the function. Now, districts not only have the function of administering projects, but they must also perform their own audits. This may be disadvantageous, since this delegation has lost the objectivity of a "third party review," in which having an outside entity (outside of districts) may provide better editing procedures and an unbiased, objective review. Other concerns involved the approval of field changes. Districts currently have a $100,000 limit. As with maintenance, increasing this limit would prove helpful and may alleviate any inefficiency, especially in the turnaround period for authorization requests. This would prove beneficial for all district types but especially for metropolitan districts. It is important to note that few districts felt that current delegations were not conflicting with their construction section operations. Non-traditional solutions to current construction section problems should be studied.

Design Activities

Increased delegations and a decreased workforce have also affected district design sections. Again, some districts felt that overall, current division delegations were adequate for their design sections. On the other hand, because workload for all design sections has increased, whether involving small or large projects, the design and review process is the same. As with construction sections, design sections suggest that Austin's central office design review is necessary because of its objective nature. Furthermore, with respect to programming aspects, specifically Design and Construction Information System (DCIS), districts interviewed suggested that they would prefer to enter changes (e.g., project length and/or type of work to be performed) into the program. They further suggested that the turnaround time for the division to make changes was long. Districts also asked for more guidance regarding management of agreements (contract administration).

RECOMMENDATIONS

Although decentralization proves beneficial in the majority of instances (e.g., districts are closer to their local public needs) increasing delegations with a decreased workforce is destructive. This report recommends that consideration and further study should be given before further delegations are transferred to districts. At present, with current delegations, districts appear to be, for the most part, at the peak of a threshold, so to speak. Instead of providing more delegations, divisions might consider providing districts with increased support, flexibility, training, and workforce — the latter when appropriate. As an example, for maintenance sections, providing guidelines pertaining to level of service may be the first step in alleviating current inefficiencies before further delegations occur.

Allowing increased flexibility with maintenance budgets, routine maintenance, and emergency maintenance contract work may also alleviate current maintenance needs. Decreasing turnaround time for district requests may also help. Within construction sections, providing districts with more budgetary flexibility and additional division oversight may produce solutions to current needs until further evaluation. Finally, design sections require the central office's review process, increased budgetary freedoms for authorizations, and flexibility in data entry.

Other recommendations include the union and cooperation of construction, maintenance, and design sections. There seems to be a very clear separation among all three sections, but if the process were viewed as a continuation and progression of the three — each a vital step in the process, from the design of a project, to the actual construction of the project, and finally to the maintenance of the project — then with more united planning, preventative measures could be taken during the progression that may alleviate and avoid future inefficiencies. While these suggestions may not remedy all inefficiencies within maintenance, construction, and design sections, in a perfect world there would be adequate numbers of FTEs and funding.

REFERENCES

1. *Decentralizing Infrastructure: Advantages and Limitation.* World Bank Discussion Papers. The World Bank, Washington, D.C., 1995.

2. *Infrastructure for Development.* World Development Report 1994. The World Bank, Washington, D.C., 1994.

CHAPTER 5
STAFFING LEVELS

INTRODUCTION

State departments of transportation (DOTs) across the nation are in the process of implementing new job classification systems and decision methodologies that may assist them to relieve the strain on personnel reductions. As the Texas transportation infrastructure continues to grow and legislative mandates of capped levels of full-time equivalents (FTEs) limit the availability of manpower, a staffing methodology that can aid decision makers in the management of personnel seems imminent for the Texas Department of Transportation (TxDOT). Table 5.1 shows TxDOT's reduction of FTE levels in the last decade.

Table 5.1 Total Number of FTEs at TxDOT in the Last Decade

	FY 1987	FY 1992	FY 1997
Districts	13,051	12,308	11,858
Division	2,524	2,883	3,018
Total	15,575	15,191	14,876

Source: TxDOT's Finance Division

The objective of this research is *not* to find an optimal staffing level to meet long-term staffing level requirements. Instead, this research focuses on possible alternatives for TxDOT to better utilize existing staffing levels during short-term peak workloads. In order to meet this objective, the following tasks were completed:

- A literature review to investigate short-term staffing level management efforts that have been documented by other state DOTs,
- Personal interviews, along with phone interviews, were conducted with TxDOT district personnel in the design, maintenance, and construction sections from metropolitan, urban, and rural districts, and
- Analysis of a labor pool concept that may assist TxDOT to relieve temporary shortages in personnel.

METHODS USED BY OTHER STATE DOTs

Personnel management practices that have been developed and currently practiced by two state highway agencies, namely the Florida Department of Transportation (FDOT) and the Illinois Department of Transportation (IDOT), are surveyed. These two particular states' personnel management practices are chosen because they represent current trends in personnel management practices by different state DOTs across the nation. Although this section describes only existing staffing management practices used by two states' DOTs, it provides a starting point for those interested in pursuing the subject in greater detail.

Florida Department of Transportation

FDOT has developed and implemented a new job classification system. The objectives of this new job classification system are the following:

- To create a classification system such that it can be easily understood by supervisors, managers, and employees;
- To reduce administrative costs and paperwork;
- To provide rational standards for evaluating jobs, classifying positions, and establishing pay ranges; and
- To eliminate the practice of using position classifications as an arbitrary mechanism to grant employee pay increases.

Description of the former job classification system was modified such that *a position classification is based on how employees do their jobs, not entirely on what kind of work they do*. A major change in the new position classification system is that new class specifications no longer contain minimum qualification requirements. Instead, employees now qualify for individual positions by demonstrating they possess the knowledge, skills, and abilities necessary to perform essential duties and responsibilities of a specific vacant position as documented on the position description. As a result of the new classification, the current number of individual classes in the State Classification Plan decreased from 1,700 to less than 100.

The new job classification system consists of 16 occupational groups, and six-class series within each occupational group. Based on the assignment of old classes to the new class structure, concept of pay ranges (bands) were created and used in conjunction with a flexible compensation plan. Generally, the new statewide minimum and maximum of each pay band are the lowest and highest old level classes consolidated into the new class. This new job classification system provides a rational approach to management and pay practices. In addition, the new system allows flexibility in assigning work; reduces the need for frequent reorganization of work units; adapts to changes in technology because the classes are broad enough to encompass future changes; and as a result, reduces administrative costs.

Illinois Department of Transportation: Section of Highways

In order to provide training and an opportunity to become acquainted with various district activities, IDOT developed a formal cross-training program for all entry-level engineers. This was made possible by precisely defining district organization functions and grouping each function's responsibilities into mutually exclusive subsets, called bureaus. An entry-level engineer then chooses three different bureaus based on his/her chosen field, each for one year, to broaden his/her work experiences. To counsel and encourage entry-level engineers during the rotational program, they are assigned to an experienced engineer within IDOT. Once they have completed the rotational program, a concept similar to a labor pool is applied to fulfill staffing needs of the department. Definitions of district organization functions with their corresponding bureaus are given below:

1. *Engineer for Program Development*
    - The Bureau of Programming,
    - The Bureau of Design, and
    - The Bureau of Land Acquisition.
2. *Engineer for Project Implementation*
    - The Bureau of Construction,
    - The Bureau of Materials, and
    - The Bureau of Local Roads and Streets.

3. *Engineer of Operations*
    - The Bureau of Maintenance,
    - The Bureau of Traffic, and
    - The Bureau of Electrical Operations.

CURRENT STAFFING METHODS USED BY TXDOT

Several personal interviews and phone interviews were conducted with TxDOT district personnel in the design, maintenance, and construction sections from metropolitan, urban, and rural districts. Interviews consisted of the following five core questions:

1. Given a specific project to be performed, how do you determine the required number of personnel? Is this the minimum number of personnel for initiating the project?
2. Given a specific project to be performed and the required number of personnel needed, how do you assign personnel to the project?
3. Do you have some type of cross-training or rotational program in place (among design, maintenance, and construction sections)?
4. Have you ever loaned or borrowed personnel to fulfill personnel requirements? From which sections?
5. In what situations do you make a decision to outsource a project?

The purpose of the first question was to find out whether a district initiates a project with available personnel on hand or waits until the required number of personnel is met. The second question was aimed at whether a district uses strictly personnel job classifications as the qualifying criteria or uses some other means to satisfy the required number of personnel. The third question was to learn about the efforts of each section to meet short-term peak workloads within the district. The fourth question was to find out about possible trade-offs that exist among sections for sharing personnel. Finally, the last question was to determine the timing of the decision to outsource a project. Some key findings from these phone interviews are given below. It should be noted that the following summary of responses does not necessary represent methods used by all districts or one particular district.

Metropolitan and Urban Districts

This survey revealed no simple way to describe metropolitan and urban districts' personnel management tactics, except for their "whatever it takes" mentality to accomplish the work to be performed. Based on interview responses, supervisors or engineers are responsible for the project and are given authority to make personnel decisions. Past experiences along with past history of similar projects are the main inputs used to select the required number of personnel for a specific project. Furthermore, if a project on hand is a routine project with which a supervisor is familiar, he/she may decide to work on the project with fewer than the required number of personnel. On the other hand, if the number of available personnel is inadequate, the supervisor may decide to delay this project and work on other projects that can be handled with available personnel. It was emphasized that supervisors know the personnel skills, personnel knowledge, and available resources (e.g., equipment and budget); therefore, they are capable of assigning necessary personnel to tasks. When assigning personnel to projects, supervisors must logically allocate available personnel based on projects on hand and forthcoming projects, such that they will have an adequate number of both skilled and less skilled personnel available for other projects.

All metropolitan and urban districts have some informal training and cross-training programs. However, most of these types of training were performed within each section and were intended to serve corresponding sections' needs. That is, each section uses training to diversify its own personnel and to satisfy its own needs, not to meet other sections' short-term workload peak. Most cross-training programs offered to entry-level engineers involved cross-training with different sections. But again, this training program was intended to improve communication among sections through better understanding of other section operations, not to have engineers available among sections.

A mixed response from different districts was received concerning sharing personnel among sections. While some districts do share personnel among sections, others do not consider this as an option to meet short-term workload peaks. Also, for those districts that use personnel sharing among sections, it is limited to emergency situations. Most personnel sharing occurred between the district section office and corresponding section area offices. Districts do this in an effort to balance workload. As an example, if one district area office's workload is significantly increased, while the number of FTEs remained the same over a one-year period, district section offices would send a number of FTEs to this area office from either another area office or district office, and vice versa. For some districts, sharing personnel was not an option because sending personnel could jeopardize district section and area office operations. Surprisingly, these districts also responded by saying that shortages in FTEs do not translate into delay in project completion time but in a loss of confidence in the quality of a completed project. This is due to the compromising of many steps in work methodology resulting from FTE shortages and heavy workloads.

As for the timing of outsource decisions, most metropolitan and urban districts reported that this decision is made on an ongoing basis. Although they all agreed that prior planning based on available personnel, budget, and equipment would be beneficial to the district, it is currently used as the last resort. Because they are losing skilled personnel to private companies all the time, it is difficult for them to plan ahead who will be available and for what project. Compounding the difficulty is that available budget is frequently not enough to outsource certain functions on hand. These projects are then put off until available funds can be allocated or the personnel necessary to perform this project is available. Districts apparently need some stability in job security for its personnel and enough budgets to maintain the quality of Texas roadways.

Rural Districts

The responses from urban and rural districts were very similar to these of metropolitan districts. The only difference in response from these smaller districts was that their methods of managing personnel are much more critical than those of metropolitan districts, due to their smaller number of available personnel. For example, for smaller districts, the number of available personnel has a significant impact upon the decision of determining which project will be performed, whereas in metropolitan districts, a project typically determines the required number of personnel.

Additionally, sharing of personnel among different sections (design, construction, and maintenance) is much more common in smaller districts. There are two main reasons for this. First, a person responsible for one section (such as a construction engineer) has a dual role (as a maintenance engineer) for some rural districts, and the ability and authority to shift personnel from one section to another to meet workload requirement is much greater. Second, sharing personnel is a necessity in most situations for rural districts. For example, if pavement repair work is needed, they must have a minimum of three personnel: two personnel for traffic control and one person to perform actual pavement work. Every district employee is assumed to be eligible to substitute for a traffic control worker.

Most of the rural districts recognize the importance of construction over maintenance work. In their opinion, permanently shifting some maintenance personnel to construction will be beneficial for the district. In order to fill the gap in maintenance, methods of identifying which *routine*-maintenance functions are both cost-effective and beneficial to the districts must be developed. Additionally, selection criteria for hiring private contractors need to be refined to include not only bidding cost but other important issues, such as stability, reliability, and past performance record of the private contractor.

SPECIFIC FINDINGS

Through personal interviews and phone interviews, the researchers learned that five methods are currently practiced by TxDOT to alleviate shortages in personnel. They are:

1. Outsourcing the project,
2. Pooling personnel within the district,
3. Initiating the project with fewer than the number of required personnel,
4. Waiting until the required number of personnel is available, and
5. Sending the project to another district.

Except for the last two methods, which seldom occur, TxDOT districts use these five methods to deal with shortages in personnel. Sending a project to another district is used primarily by design sections, which send design work electronically to other districts. This method is seldom used since it usually involves uncertain, secondhand information for the receiving districts. Also, for most districts, the luxury of having enough personnel is nonexistent. Therefore, the option of waiting until the required number of personnel is available is used only when work on hand requires highly technical skills. Some specific findings concerning the first four methods are listed below.

Outsourcing

- Used only as a last resort to meet the workload
- Outsource decisions are made on an ongoing basis
- If a budget is not available, project is usually dropped
- Reduction in personnel confidence in the completed project
- Reduction in district's ability to perform frequently outsourced projects
- Loss of district personnel due to increased competition with private sector
- Increase in need for new training programs to properly handle/inspect outsourced work

Pooling of Personnel within the District

- Most personnel pooling done within district section (e.g., between district office and area office and between area offices)
- The required distance of travel by shifted personnel must be considered
- Method of selecting personnel to shift is required
- Needs clear chain of command for authorizing personnel pool
- Good possibility of personnel pool between sections exists between construction and maintenance sections
- Great potential for personnel pool exists in emergency situations

Initiating a Project with Fewer Than the Number of Required Personnel

- This method is used most often by all districts
- Many steps in the methodology that have been developed to satisfactorily perform a job function are compromised due to shortage in personnel
- Because of this compromise, confidence in the completed project is low

- Personnel fatigue is high due to multiple responsibilities
- Letting time is usually kept
- Completion time is not delayed
- Often, required personnel are substituted by personnel knowledge and experience rather than by job classification

Waiting Until the Required Number of Personnel Are Available

- Often letting time can not be met
- Completion time is often delayed
- Tends to favor outsource after certain waiting period
- Need to anticipate personnel who will be available
- Job classification is used to satisfy required personnel
- Rarely will personnel from other sections be used

LABOR POOL

An analysis of the *labor pool* concept of organization is a major component of this research. This concept relates each available individual to certain job functions that he/she is capable of performing and machines he/she is able to operate, within allowable boundaries (district, section, area office, etc.). Then, by using this information in an interactive database format, decision makers are able to meet current shortages in personnel. In order to construct such an interactive labor pool database, possible trade-offs among construction, maintenance, and design sections must be identified. Trade-offs are evaluated by relating different job function codes used by each section that describe the similar work that is being performed.

The construction of a labor pool database can be simplified by using the hierarchical levels of difficulty associated with the job functions being performed among the different sections (design, construction, and maintenance). Design job functions are considered relatively more technical than both construction and maintenance job functions, while construction job functions are viewed as having more details than maintenance job functions. Using this property, the pool of available personnel can be reduced.

Very recently TxDOT proposed a new job classification methodology that is similar to the one used by the Florida DOT, and it is expected to decrease the current number of job classifications from 1,700 to approximately 800. In this proposed methodology, an employee belonging to a certain job classification may have the knowledge to perform tasks in multiple fields (cross-trained among different sections), up to a certain capacity. For example, an Engineering Technician I, class No. 2121, may be able to perform work in maintenance, design, and construction such as:

- Performing transportation maintenance related activities,
- Preparing drawings and cross sections of maintenance and construction projects,
- Conducting surveys, inspections, and tests associated with maintenance and construction projects, and
- Maintaining records of construction contracts, monthly and final estimates, field changes, and supplemental agreements.

If this proposed job classification is implemented, the construction of a labor pool becomes a simple matter of listing different job functions he/she is qualified to perform and inputting those qualifications into a database. This personnel qualification information will then be available to all sections within the district. The information can help identify the personnel needed to meet short-term peak in workload.

In addition to having the ability to acquire required personnel with required skills and knowledge within the district, the existence of a labor pool database has other advantages as well. As an example, in cases in which a management-level position is vacated, the knowledge of district personnel is preserved. Also, the labor pool database can be used to handle personnel competencies information and to handle personnel requirements in emergency situations, such as snowstorms and flooding. In such emergency situations, all qualified personnel from area offices within a district or from neighboring districts may be pooled using a labor pool database. A schematic representation of the labor pool database concept is shown in Figure 5.1.

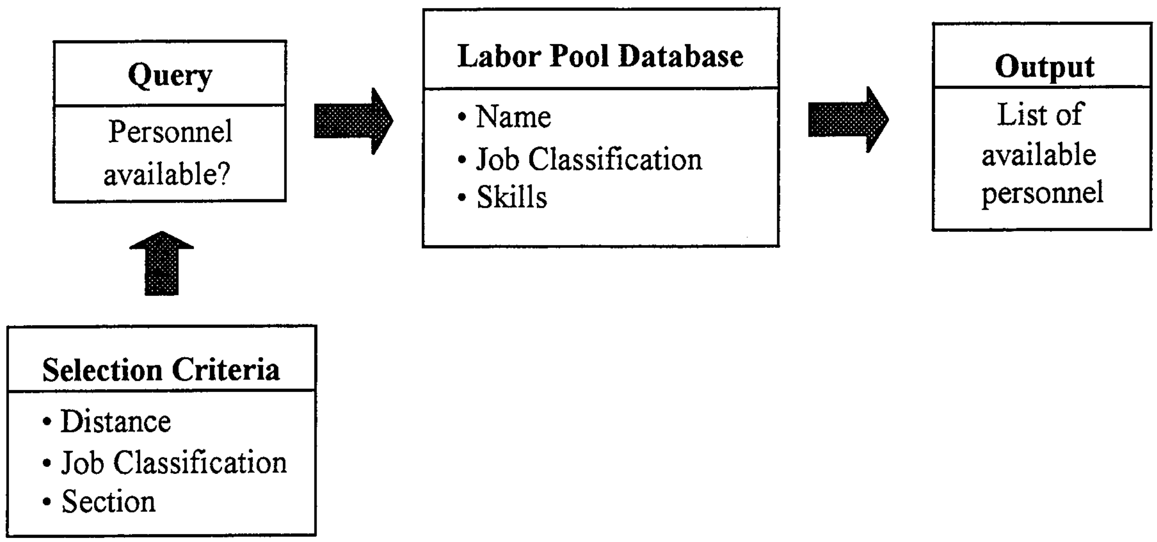

Figure 5.1. Schematic Representation of a Labor Pool Concept

Determining the number of personnel required to perform a specific project may be highly subjective, since most of the time it depends on past experience and knowledge of decision makers. In addition, offices requesting personnel from the labor pool database may use several factors as a basis for searching for potential matches (setting priorities). As an example, if project duration were an issue, it would be desirable to first find personnel belonging to neighboring offices within the district, rather than from neighboring districts. In case of multiple matches, employees with lowest job classifications may be requested first to minimize disruptions from the lending office. Lastly, a formal request procedure must be in place to approve and work out arrangements between offices.

PUBLIC-PRIVATE PARTNERSHIPS

In 1995, the Virginia General Assembly enacted the Public-Private Transportation Act (PPTA) authorizing private entities to acquire, construct, improve, maintain, and/or operate transportation facilities. As a result of PPTA's enactment, the Commonwealth of Virginia Department of Transportation (VDOT) contracted with Virginia Maintenance Services, Inc., (VMSI) to pilot asset management services that will provide turnkey maintenance of 400 kilometers (250 miles) of Virginia's 1,760 km (1,100 mi) interstate system.

The pilot program is for five and a half years (until June 2002) and will cost $131,000,000. It includes all maintenance and operations (e.g., snow and ice removal, safety management and traffic control, emergency response, customer response, routine maintenance services, pavement repair and replacement, and rehabilitative and restorative work) and requires VMSI to provide equal or higher levels of service than those of VDOT. The total cost of the program is paid through annual lump-sum payments requiring bond usage and encourages the use of smaller subcontractors. It is projected that approximately $22 million in savings over the life of the pilot program will be accrued.

Since all maintenance and operations are performed by VMSI, only a reduced number of VDOT FTEs is required to oversee the project, conduct annual inspections, review plans, and provide service support to the contract. TxDOT should explore the feasibility of implementing this type of public-private partnership to reduce the strain on personnel reductions.

REGIONALIZATION OF FUNCTIONS

Recently all the aviation responsibilities (except airport maintenance) that had been delegated to districts in the past were returned to the Aviation Division in Austin. The Abilene District said that one FTE is available to continue performing project management, inspection, and testing activities not only within the district, but also for neighboring districts. Discussions are being held to create an aviation regional center based in the Abilene District to provide such airport services to the San Angelo, Brownwood, and Childress Districts. Functions such as human resources, public information, warehousing, and automation seem to be good candidate functions for regionalization.

SUMMARY

The proposed labor pool concept described in this chapter is a viable alternative for meeting short-term personnel requirements at the district level. It appears that the development of this concept may be more successful if implemented in urban and metropolitan districts with large numbers of employees. However, due to other external factors, such as decentralization of functions to districts, personnel turnover and retirement, legislative constraints, competition with private sectors, and increasing infrastructure needs and non-highway responsibilities, any given staffing level will eventually saturate to a point at which the labor pool concept can not be further extended. The effects of staff saturation are already being felt by most of the small rural districts, and it seems that the only solution for keeping a safe transportation system will be to increase the number of FTEs.

Finally, other options that may be used to alleviate shortages of personnel may include temporary hiring, temporary transfers, and overtime. However, those options are not likely to satisfy districts' needs given that the time and cost required to train a temporary person may be wasteful, and TxDOT employees may also be unwilling to take a temporary job for which they have to be transferred. Since there are many constraints in the use of overtime, this may not be a viable option to alleviate shortages.

CHAPTER 6
OUTSOURCING OF JOB FUNCTIONS

BACKGROUND

Outsourcing is perceived to have significantly impacted TxDOT's performance. Most of TxDOT's spending each year is on construction contracts, which are accomplished by employing services from the private sector. TxDOT has already concluded that the construction function itself is best outsourced; however, a systematic decision support system is required for making decisions at the agency level and at the district level, for all other functions that may be selected as candidate functions for outsourcing. Recently, some functions that have historically been accomplished by department employees are being considered for outsourcing, or have been outsourced. Primary reasons for this move are as follows:

- TxDOT personnel reductions,
- TxDOT workforce inexperience, and
- Legislative mandates.

A widespread application of the concepts of privatization (in its many facets) to the activities of public-sector agencies occurred in the late 1980s and continues to occur throughout the 1990s. The fundamental presupposition is that private sector enterprises utilize practices and procedures that can be adapted to public agencies to secure the benefits that typically accrue to the market-driven private enterprises. Another assumption is that private sector is more efficient and that efficiency cannot be transferred to the public sector. Cost reduction, improved efficiency, enhanced performance, and better resource allocation are among the many benefits that are desired when the activities of public agencies are selected for privatization. The continuum of privatization for a public agency extends from ad hoc decisions on a project-by-project basis all the way through complete outsourcing of major and significant agency functions. A public agency is challenged to develop a strategic and operational approach to assure that its mission remains achievable even as its resource base becomes restructured due to privatization efforts resulting from political and economic sectors.

The approach that any agency develops must include mission-specific concerns (both short- and long-term), as stated in a strategic plan, as well as implementable procedures to achieve the desired outcomes, including: performance, efficiency, sustainability, and acceptability.

Performance. When developing outsourcing decisions, an agency must remain able to achieve the mission requirements established by law. Individual functions (such as selected maintenance activities, engineering tasks, ROW acquisition, etc.) may, in a narrow assessment, be prime candidates for outsourcing because of the availability of private sector providers. However, the privatization of a particular function must be assessed within the context of the overall ability of the agency to perform its mission.

Efficiency. Outsourcing a particular task or functional activity may produce a least-cost result that creates a compelling case for privatization. Before these assessments are complete, however, a review of cost structures (agency versus outsourcing) must be conducted to assure that resulting comparisons are valid. Without such a valid comparison, the expected improved efficiency of the outsourcing may never be realized. Also, the overall impact upon efficiency of the agency needs to be evaluated, since saving a few dollars on one item (e.g., reduced maintenance FTEs for pavement repairs) may create inefficiencies elsewhere in the agency (e.g., reduced ability to respond to emergency pavement conditions due to severe weather conditions).

Sustainability. This aspect of privatization/outsourcing refers to the long-term implications of the agency's mission when various activities become privatized. How will the agency performance be strategically affected? Quantification of this aspect is difficult to achieve, as are many other aspects of evaluating the choice of in-house versus outsourcing, but is crucial to the survival of the agency. Agency leadership and core-essential personnel must be preserved during the process of reaching and implementing outsourcing decisions. For example, it would be very shortsighted for an agency to outsource all of its core business functions since the ability of the agency to sustain itself depends essentially on the expertise of the personnel who plan and implement the core business. Long-term sustainability of an agency presumes that its core elements remain intact.

Acceptability. Decisions to outsource agency functions or to keep them in-house also occur in a broader political and economic context which needs to be evaluated. Part of this assessment involves the maintenance of market competition for a particular service. Thus, if a particular agency function (e.g., roadside mowing) becomes an exclusively outsourced activity, the initial cost advantages, where they existed, may diminish over time as the market-provided price competition becomes lessened and "market-sharing" becomes more and more a characteristic of the contractors. This tendency occurs as a typical development in market growth in which the number of sellers is reduced by competitive pressures. In its extreme form, a single seller emerges and exerts upward pressure on prices, which tends to negate the initial rationale for outsourcing. Also, the agency must arrive at a mix of in-house and outsourced functions that is acceptable to the political climate in which the agency operates. Typically, this is a short-term equilibrium that needs constant evaluation and assessment.

LITERATURE REVIEW AND PREVIOUS FINDINGS

The most significant piece of literature dealing with outsourcing in public agencies is the NCHRP Synthesis 246, published in 1997 (1). This synthesis presents information on current outsourcing practices of state departments of transportation with regard to transfer or placement of work which might previously have been performed by state staff, to contractors or consultants. The findings of this research, based on a survey of state transportation agencies, determined reasons for and extent of outsourcing, expected trends or changes, methods of monitoring and evaluation in use, and lessons that have been learned. The synthesis concludes that despite the existence of well-developed procedures for outsourcing contracts and professional services, there is no conclusive evidence to either support or discard the contention that outsourcing is an efficient and/or desirable approach. The responses obtained from various state agencies in this respect suggested substantial variability among states and in the procedures themselves. Several research needs identified in the NCHRP synthesis include: methods for identifying core competencies of state transportation agencies, a study of models for assessing whether to outsource, and an examination of outsourcing impacts on in-house human resources.

Public agencies outsource job functions with the objective of utilizing their resources more efficiently. Some major reasons for an organization to outsource services with private sector firms have been:

- to supplement in-house staffing, especially for peak workloads and staff constraints,
- to obtain use of specialized equipment,
- to obtain services of specialized personnel,
- to obtain services at a lower cost,
- to meet executive policies,
- to perform emergency work, and
- to improve responsiveness.

However, some state DOTs have expressed problems with the quality of work, performance, project completion, contractor knowledge of state procedures, and cost factors such as claims, overruns, and the high level of project costs (1). While many agencies currently outsource a percentage of their overall budget, formal methodologies are rarely used in order to arrive at those decisions. A summary of outsourcing experience within the Texas Department of Transportation (TxDOT), the Department of Defense, and other departments of transportation is given below.

Legislative Mandates in the State of Texas

As public agencies evolve, executive policies and/or legislation often mandate ceilings on the number of full-time equivalents (FTEs) an agency may have at a given time. Table 6.1 shows TxDOT's total reduction of FTE levels in the last decade.

Table 6.1. Decrease of FTEs at TxDOT in the Last Decade

	FY 1987	FY 1992	FY 1997
Districts	13,051	12,308	11,858
Division	2,524	2,883	3,018
Total	15,575	15,191	14,876

Source: TxDOT's Finance Division

In 1991, the First Called Session of the Texas Legislature mandated that by August 31, 1996, a minimum of 50 percent of the dollar amount of expenditures used by TxDOT for maintenance projects for the fiscal year be expended through contracts awarded by competitive bidding (2). This requirement applies only if TxDOT determines that a "function of comparable quality and quantity can be purchased or performed at a savings through utilization of private sector contracts." In determining whether the maintenance function should be outsourced, the only metric used is cost. Cost accounting measures are stipulated, but no other methodologies for analysis of comparable quality, efficiency, or relative project duration is specified. In the same legislative session, the policy written effectively polarized TxDOT and the consultant industry. Article 6647g-1 stated only that "a balance between the use of department employees and the use of private contractors" should be obtained, provided the costs are equivalent. The costs were to be determined by the state auditor (2).

Research sponsored by TxDOT prior to this particular legislative mandate had investigated the cost of consultant use in preliminary design. Given the different basis of accounting principles of private and governmental agencies and the fact that governmental agencies do not operate on a for-profit basis, it was readily apparent that TxDOT could, in fact, perform the work in-house more effectively (3). However, some research reports concluded that there was no significant difference between performing the work in-house, or with the use of private forces (4). This narrow scope of comparing the cost of only the two entities prompted more in-depth investigation into the various other factors affecting the utilization of consultants. This spurred several research reports that attempted to determine the effectiveness of the use of consultants in the area of engineering and design contracts. In 1987, additional issues, namely quality and project duration, were addressed (5).

In the 1997 legislative session, the Consulting Engineers Council introduced legislation which would have mandated that 50 percent of all engineering activities, by category, be performed by the private sector. This included engineering, land surveying, environmental, transportation feasibility and financial, architectural, real estate appraisal, and materials testing. The approved revised legislation stated that beginning in fiscal year 2000, TxDOT should have 35 percent of the activities, as a whole, performed with private forces. If activities are not at 35 percent, the percentage must increase by 1 percent each year until 35 percent is achieved. The percentage in each category was left to the discretion of TxDOT (6). Once again, no specific methodology was given as to determining the organization best equipped to provide the service.

If these new mandates are to be implemented effectively, then TxDOT must be able to build trusting relationships with the private organizations that will be providing the services. The focus of the legislative mandates is the processes involved in providing the service, not necessarily the individual job functions and skill needed to perform these functions. The difference in the outsourcing of the process means trust and responsibility are placed with the contractor, with defined performance and quality measures. The profit of the contractor is directly tied to the performance measures. With the outsourcing of a given job function, an agency still retains control over the process, and the risk must be shared equitably between the two participating organizations.

Implemented Outsourcing Efforts at TxDOT

TxDOT has utilized private forces to accomplish given tasks in various fields. These include, among others:

- Preliminary Engineering,
- Construction,
- Bridge Inspection,
- Traffic Operations (studies, counts, etc.),
- Materials Testing,
- Construction Engineering,
- Office Maintenance,
- Routine Maintenance,
- Vehicle Maintenance, and
- Vehicle Parts Acquisition.

Benefits that have been observed by TxDOT in the course of privatization efforts have been:

- quickens response time,
- better uses in-house resources,
- expands capabilities,

- supplements technical expertise,
- promotes exchange of ideas for better efficiency,
- is cost effective (materials testing), and
- reduces amount of inventory required (materials testing).

TxDOT recognizes the need for outsourcing efforts, stating "to utilize the private sector to perform work in all functional areas where applicable but a detailed analysis should be performed on a case-by-case basis to ensure cost effectiveness and that the department mission is being carried out" (7). While TxDOT's basic assumption of the use of private forces for completion of given job functions is to implement if cost-effective, other parameters and constraints may influence the level of outsourcing in different job functions.

Texas State Council on Competitive Government

Established in November of 1993, the Council on Competitive Governments has as its purpose to develop a program to encourage competition, innovation, and creativity in providing state services in order to improve the quality and cost-effectiveness of those services (8). The council is comprised of state officials representing the Governor of Texas, Lieutenant Governor, Comptroller of Public Accounts, Speaker of the House, General Services Commission, and Texas Employment Commission. Upon receiving suggestions by various sources, the council gathers information regarding the following topics:

- Quality and quantity of work performed by the agency in relation to the service,
- Direct and indirect costs,
- Full-time employees and salaries used to provide the service,
- Contractual obligations related to the service, and
- Agency's level of satisfaction with the service provider (9).

After gathering this information, the council uses a cost methodology developed in-house to determine whether a state agency should engage in competition with private commercial sources. This methodology allows state agencies to perform cost analysis methods that consist of the following five steps:

Step 1. Determine the service to be analyzed,

Step 2. Determine the scope of the service to be analyzed,

Step 3. Determine total in-house costs,

Step 4. Determine total cost to contract, and

Step 5. Determine savings from contracting, if any (9).

The cost methodology clearly defines the steps to be taken in order to calculate total in-house costs, direct costs (including salaries, overtime, fringe benefits, supplies, maintenance, telecommunications, and depreciation), indirect costs (including a variety of allocation methods), and total cost to contract. From the work of the Council on Competitive Governments, it is apparent that the state of Texas is interested in sourcing job functions within a public agency. The principal concept to the establishment of the council is the belief that absent competitive pressures may cause the state agency to operate as a monopoly, lacking the incentive to reduce costs, improve quality, and increase efficiency. Noticeably absent from the Council on Competitive Government's methodology is any consideration to the timeliness, exposed risk, legal barriers, or other issues pertaining to the sourcing of job functions. Quality is briefly considered, but only as a preliminary measure and without any type of qualitative or quantitative measurement. The detailed cost methodology provides a thorough cost basis for analysis of the sourcing of job functions, but neglects other vital issues to the sourcing decision of various job functions.

Department of Defense

The Department of Defense (DOD), in the course of its reorganization, or "attempt to achieve infrastructure savings," made outsourcing and privatization the centerpiece of their reforms to reduce infrastructure and support costs. However, the DOD found that many of the savings initiatives fell short of the initial goals (10). Examples were cited in the Defense Management Review and base realignment and closure process. The DOD identified substantial opportunities for savings, but questioned the magnitude of the targeted savings. Outsourcing should take place when it makes economic and operational sense, based on accomplishing the following steps:

- Clearly describe the function in objective terms of what should be accomplished and how it should be done, but not who does it;
- Categorize the function as either core or non-core;
- Establish detailed, specific performance requirements for each function based on the commander/manager's mission and customer requirements;
- Analyze legal, supplier, and performance requirements for each function to determine the source that best balances economic benefits with operational risks;
- Produce a detailed performance agreement and associated documents for the function (e.g., performance work statement and request for proposals if the function is to be outsourced); and
- Introduce cost competition (10).

The DOD states, "Fundamental to determining whether or not to outsource is the identification of core functions and activities that DOD should continue to do." Critical to the success of outsourcing is the identification of the core competencies. A risk assessment process is used to aid the DOD in identifying these core competencies (10). Other key issues that were discovered by the DOD were factors that influence outsourcing savings. It was determined that outsourcing savings are dependent upon or highly influenced by:

- The continual existence of a competitive commercial market;
- The ability to clearly define tasks to be done and measure performance;
- The assumption that the private sector can perform required work more cost-effectively than a reengineered DOD activity;
- The extent that commercial contracting and contract management practices can be applied to the outsourced activity;
- The relative cost-effectiveness of the public activity being outsourced; and

- The ability to reduce existing public infrastructure and personnel costs associated with the outsourced activity (10).

By stating that outsourcing makes sense when it is economically and operationally feasible, the DOD acknowledges that there are issues other than cost that lead to the success of outsourcing efforts.

Arizona Department of Transportation

The Arizona Department of Transportation (ADOT) Competitive Government committee has put together a generalized set of ratings to evaluate the feasibility of candidate services for a more detailed review. The function of the ADOT Competitive Government committee is similar to that of the Texas Council on Competitive Governments. The set of ratings is placed in a summary matrix and given an overall rating from which the committee then decides to either consider the service for outsourcing or maintain the current job function in-house. Questions relate to the strength of the competitive market, quality of service, level of control, amount of risk, legal barriers, political resistance, impact on public employees, and resources available. ADOT clearly states that this matrix is not used in the review process, but rather as an initial screening to eliminate the less feasible candidate job functions (11). This set of ratings poses a solid framework for the establishment of a quantitative evaluation model that can support sourcing decisions. The rating matrix is used in the feasibility process only, due to the general nature of the questions, and the nonscientific approach to the survey design, data collection, data reduction, and data analysis. If the current concept that ADOT uses is expanded and further developed, it is possible that a methodology similar to that proposed by ADOT could be used effectively in analysis of sourcing decisions.

California Department of Transportation

The California Department of Transportation has a maintenance program and a rehabilitation program to preserve the state highway infrastructure of approximately 79,014.4 lane kilometers (49,384 lane miles). Approximately 70 percent of the total lane miles are asphalt concrete (AC) pavements and 30 percent are Portland cement concrete (PCC) pavements.

Maintenance activities and projects are performed by state forces if the work costs less than $24,000. Otherwise, they are outsourced to the private sector (most of preventive maintenance and rehabilitation projects). Table 6.2 shows maintenance and rehabilitation activities performed by state forces or by contract (12).

Table 6.2. Maintenance and Rehabilitation Activities Performed In-House or by Contract

Pavement Type	Strategy	Work Performed By		Expected Life	Cost per Lane Mile
		State Forces	Contracted Out		
Asphalt Concrete	Crack Seal	X		1 - 3 years	$1,000 - $6,000
	Patching	X		1 - 3 years	$1,000 - $10,000
	Slurry Seal	X	X	2 - 4 years	$10,000 - $15,000
	Chip Seal	X	X	2 - 5 years	$6,000 - $20,000
	Thin Blanket	X	X	2 - 5 years	$20,000 - $25,000
	Thick Blanket		X	4 - 7 years	$70,000 - $100,000
	Asphalt Overlay (rehabilitation)		X	7 - 15 years	$100,000 - $200,000
Portland Cement Concrete	Crack Seal	X		2 years	$1,000 - $6,000
	Shoulder Grind or Fill	X		2 - 5 years	$5,000 - $7,000
	Mudjacking	X	X	3 - 10 years	$10,000 - $40,000
	Lane Grinding	X	X	5 - 10 years	$50,000 - $70,000
	Slab Replacement	X	X	3 - 7 years	$2,000 - $3,000 per slab
	Crack, Seat, and Asphalt Overlay		X	10 - 15 years	$150,000 - $225,000
	Lane Replacement		X	15 - 20 years	$200,000 - $300,000+

Note: State forces work is limited to a maximum of $24,000

The State of California Competitive Government has developed a decision tree for evaluating whether an activity should be retained in-house, transferred to another public agency, or outsourced. The decision tree starts with identifying which functions are critical to the department's mission. If a function is critical to the department's mission, measures for cost, quality, and delivery (time) of service or product are developed. These measures, along with improvement and control decisions, assist the decision maker to evaluate if an advantage exists in performing the function using in-house forces rather than by outsourcing. On the other hand, if a function is not critical to the mission of the department, an evaluation to transfer such a function to another state department or level of government is made (1).

Construction Industry Institute Sourcing Decision Methodology (13)

The Construction Industry Institute (CII) research project that resulted in a work process to evaluate competencies and the sourcing of them for capital projects was driven by issues similar to those that TxDOT has encountered in recent years. Two key issues included: (1) reduction of personnel, and (2) pressures within owner organizations to outsource more functions related to capital projects. The process focuses on the owner/contractor work structure, which is defined as the distribution of key roles and responsibilities between owners and contractors. Contractors could be any firm, such as design firms, consultants, vendors, and construction firms, that contracts with an owner for project services. Two independent but interrelated processes were developed from the owner's perspective for application both at the corporate capital program level and at the project level. These two levels of application would be analogous to the agency level and district level within TxDOT.

A key concept associated with the processes is a project competency. A project competency is defined as a project process comprised of functions and critical capabilities. A project competency would be similar to a job function in TxDOT terms. The main reason why this definition has two components is because functions, related to activities and/or tasks, required performing the process. Critical capabilities of the skills, experience, knowledge, and expertise required performing the functions. Both are necessary components that must be evaluated in decisions to perform a project competency in-house or to outsource the competency.

Two components of the work processes are common to both the corporate level and project level. The first component is known as *Determines Key Capital Program/Project Competencies*. Key competencies are identified based on strategic plans, policy/procedures, internal factors such as organizational structures, and project characteristics. Key competencies are described in terms of functions and critical capabilities. The relative importance of the competency to the success of the capital program and/or project is assessed. Once the key competencies are identified, then the process helps determine whether the competency is core or non-core to the program/project. A core competency is defined as one that is critical to capital program and/or project success and must reside with the owner (e.g., the owner must perform the function to a significant degree). Key factors that influence this decision, such as cost, quality, level of control, and risk if not retained in-house, are identified.

Once the key competencies are determined, the next component of the process is *Evaluates Sourcing of Competencies*. For core competencies, this component evaluates the owner's ability to perform the competency in-house in terms of having personnel with the required critical capabilities. If satisfied, then decisions are made with respect to the role of the owner in performing the competency. The owner could perform the competency with his/her own staff or have some level of involvement of contractors in performing the competency. If the competency is non-core then the owner is typically placed in an oversight role with respect to the contractor. When a contractor is involved in a competency, the process evaluates the availability of contractors to perform the competency. Contractors must have the critical capabilities and resources necessary to perform the competency to the requirements of the owner. Many issues are considered and identified in support of making this evaluation. A final step is a review for alignment. This review occurs periodically throughout the work structure process and at the conclusion of the sourcing evaluation to ensure decisions are consistent with overall corporate and/or project strategies to meet the mission of the organization.

Worksheets are provided to document the decisions made through the various steps in the process (core versus non-core and work relationships). The outcome of the process is a strategic alignment of owner and contractor resources to complete a specific project or maintain a capital program. The process also incorporates mechanisms to re-evaluate alignment of owner and contractor work relationships and resources over time. Both corporate and project-level processes are documented in a stand-alone handbook. Decision flowchart techniques are used to guide users through each component of the process and the decisions that are made.

The systematic, flexible, and structured process of the CII methodology provides a rationale for evaluating resources and skills needed to perform a competency. This process is particularly relevant to organizational changes made by owners as they make decisions regarding deployment of staff to ensure that the organization can achieve its mission and strategic goals. The owner/contractor work structure process can help an organization clearly define its core competencies, and define the work processes that are critical to the success of the organization, and those that are candidates for outsourcing. Key findings of the study by CII regarding the process include:

- Systematic approach to determine project competencies and their sourcing,
- Rationale for evaluating project skills and resources needed,
- Accomplishment of efficient operations by avoiding gaps and eliminating overlaps through alignment of work relationships,
- Vehicle for discussion when different viewpoints are presented on sourcing, decisions, and the documentation of these decisions,
- Flexibility for use in different situations and by different organizations, and
- Instrument for rational organization change.

Finally, industry members of the research team involved with the development of the work process suggested that the process is really a business process that can be adapted to fit any situation in which decisions regarding sourcing of resources must be made.

DEVELOPMENT OF METHODOLOGY

In the process of developing the methodology, several characteristics were desirable. The methodology should be:

- statistically based,
- easy to understand,
- relatively simple in regards to experimental design,
- simple in regards to data collection and reduction, and
- easy to calculate in regards to decision variable.

The methodology should provide a basis for analysis of candidate job functions. This methodology is intended to provide an organized framework for surveying various decision maker opinions on a variety of issues deemed critical to the sourcing decision for various job functions. This should provide insight into how internal staff might receive the outsourced job function. The methodology provides for the compilation of opinions, which can then be reduced for statistical analysis to test a hypothesis about the sourcing of the job function. A flowchart describing the methodology is shown in Figure 6.1.

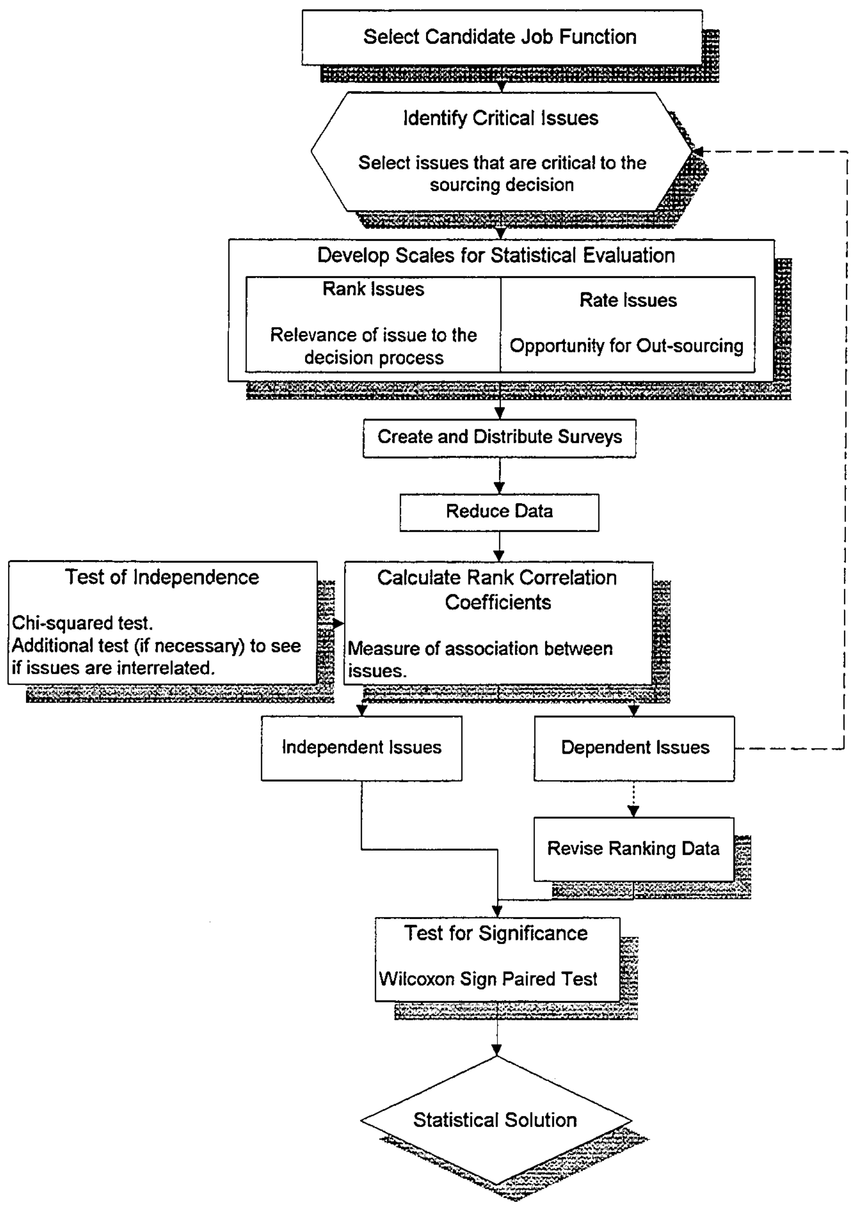

Figure 6.1. Methodology Flowchart

The various components of the flowchart are described in detail in the following description. The methodology takes form by adhering to the following steps:

1. Selection of a candidate job function,
2. Identification of the critical issues,
3. Development of scales for statistical evaluation,
   3a. Ranking of issues to the relevance of the sourcing decision,
   3b. Rating of issues for the opportunity for outsourcing,
4. Creation of the survey,
5. Calculation of correlation coefficients,
6. Calculation of Chi-square values, and
7. Test for significance.

Selection of Candidate Job Function

The development of the methodology begins with the selection of the candidate job function. The job function may be one that internal decision makers are considering for outsourcing, or may be defined by the pressures of external groups demanding better use of governmental resources (e.g., viewing outsourcing as a viable alternative). The job function is selected by the decision makers as having characteristics that might make outsourcing a viable sourcing option. Examples of some of the factors to consider when defining sourcing options for various job functions are defined below. This list is not meant to be comprehensive or all-inclusive:

- Consideration of the company's capabilities. These are major areas within the organization in which the owner has retained the necessary resources to perform certain competencies. Corporate policies, directives, business strategies, and capital program strategies determine company capabilities (13).
- Consideration of the factors determining the nature of a competency. Example factors to be considered when deciding the nature of a competency are shown in Table 6.3.

Table 6.3. Factors Affecting Competencies (13)

Factors	Competencies
Front-end-related competencies	Financial state of company
Process proprietary technology	Related to core business
Cost efficiency	Critical to long-term maintenance and operation of facilities
Leadership-related competencies	Corporate/business/engineering strategy
Safety	Financially driven
Risk and liability	Directly aligned with corporate/business goals
Competitiveness	Interface points during project development and execution

In the Construction Industry Institute Report 111-2, a non-core competency is defined as a competency that could either be outsourced to a contractor(s) or performed in-house if the resources are available. Non-core competencies are typically those which are outsourced. However, under certain conditions, the owner may want to perform a non-core competency (13). If this is the case, then the in-house resources, along with other factors, must be evaluated. The methodology described herein provides one method of evaluating those other factors.

Selection of Critical Issues

The next step is to identify the issues critical to the sourcing of the job function. These are the issues that would be considered by a decision maker. The issues are not limited solely to quantitative issues such as costs but, rather, include qualitative issues that are important to decision makers, such as the ability to manage the contract and the risk of exposure. These issues were identified as applicable across a variety of job functions and are not specific to any particular job function or process. These issues include:

- strength of the competitive market,
- quality of service,
- level of control,
- ability to manage the contract,
- cost-effectiveness of the service by private forces,
- amount of risk,
- legal barriers,

- political resistance,
- impact on public employment, and
- resources available.

Develop Level of Opportunity Scale

These series of questions relate to the level of opportunity that each issue has for outsourcing a particular job function. In other words, based on a particular issue, is it better or worse to perform the job function with private forces?

The type of rating scale selected for use in this methodology is a graphical rating scale. The rudimentary case of the graphical rating scale consists of an unbroken line with divisions representing points on a continuum, each point being defined by a trait label, definition, and adjectives (14).

In the case of rating the opportunity for outsourcing, various response alternatives for the issues are presented in Table 6.3. The number of response categories is chosen to describe the various levels of opportunity. There is apparently no gain in reliability if one increases the number of categories from five to nine, but reliability drops with less than three (too gross) or more than seven (too fine) (15, 16, 17, 18, 19). Other statisticians state that there appears to be little utility in having more than five scale categories (20). The only benefit to having more than five is the dispersion of answers for the rating, and the less likelihood of having ties in the ranking portion of the statistical analysis.

The scale chosen to describe a particular issue will depend upon how the issue is defined and how the decision maker wishes to rate that particular issue. In the selection of the scale it is important to realize that the more levels of opportunity given, the more opportunity for dispersion by the respondents. That is to say, the more levels, the more selective respondents may be as to their positions on the various issues. Using scale values and standard deviations to select response alternatives provides a more refined set of phrases than an order of merit list. In general, response alternatives selected from lists of phrases with scale values should usually have the following characteristics:

- The scale values of the terms should be as far apart and as equally distant as possible.
- The terms should have small variability.
- Other things equal, the terms should have parallel wording (6).

Table 6.4 shows a list of response alternatives that are phrased so that the scale values are as far apart and equally distant as possible, and have parallel wording.

Table 6.4. Sets of Response Alternatives Selected so Phrases Are at Least One Standard Deviation Apart and Have Parallel Wording (14)

Set No.	Response Alternatives	Set No.	Response Alternatives
1	Completely acceptable Reasonably acceptable Barely acceptable Borderline Barely unacceptable Reasonably unacceptable Completely unacceptable	2	Wholly acceptable Largely acceptable Borderline Largely unacceptable Wholly unacceptable
3	Largely acceptable Barely acceptable Borderline Barely unacceptable Largely unacceptable	4	Reasonably acceptable Slightly acceptable Borderline Slightly unacceptable Reasonably unacceptable
5	Totally adequate Very adequate Barely adequate Borderline Barely inadequate Very inadequate Totally adequate	6	Completely adequate Considerably adequate Borderline Considerably inadequate Completely inadequate
7	Very adequate Slightly adequate Borderline Slightly inadequate Very inadequate	8	Highly adequate Mildly adequate Borderline Mildly inadequate Highly inadequate
9	Decidedly agree Substantially agree Slightly agree Slightly disagree Substantially disagree Decidedly disagree	10	Moderately agree Perhaps agree Neutral Perhaps disagree Moderately disagree
11	Undoubtedly best Conspicuously better Moderately better Alike Moderately worse Conspicuously worse Undoubtedly worst	12	Moderately better Barely better The same Barely worse Moderately worse

Develop Ranking Scale

Ranking of the issues relates to the relevance of the issues to the decision-making process. In other words, how important is each of the issues to the decision-making process? Does one consider cost to be more important than quality? In order to accomplish this ranking scale, it is necessary to understand the effect of various levels on the testing procedure. Similar in relation to the number of response levels described in the preceding section, the number of values used to describe ranking the relevance of the issues to the decision-making process will impact the utility of the statistical process. The greater the range of values for the response levels, the greater the opportunity for a diverse response from the sample population. Past surveys show that a graphical scale ranging from 1 to 10 is familiar to respondents (14). Although Bendig and Finn (17, 19) claim that seven or more categories produces too fine a segregation, a scale from 1 to 10 lends itself well to the Wilcoxon signed rank test. Given the qualitative nature of the data to be analyzed and the relative strength of the statistical test being performed, the use of a scale from 1 to 10 is justified.

Create Questionnaire

A questionnaire was created in order to sample opinions of decision makers regarding the opportunity for outsourcing of a given job function and the relative importance of a given cue to the decision-making process. In the course of creating a questionnaire, several issues must be addressed:

- The questionnaire must clearly define its purpose,
- The questionnaire must clearly define the various cues to be evaluated for outsourcing,
- The questionnaire must remain unbiased as to the sourcing preference,
- The response alternatives to the opportunity for outsourcing must be phrased such that they are close to one standard deviation apart and have parallel wording, and
- The questionnaire should be pretested to see if it conveys the proper meaning.

A sample of the survey used in this study is given in Appendix B.

Rank Correlation Coefficient

Rank correlation coefficients describe the degree of association between two variables. The rank correlation coefficient is used due to the qualitative nature of the data, and the ranking and rating of the variables involved in the study design. The issues related to the decision-making process for the sourcing of job functions might be interrelated. As described earlier, issues such as *cost* and *quality* may have a direct impact upon one another. If quality is increased from a given level, then typically the cost associated for the service will increase. As quality increases, performance standards are higher, and the number of man-hours required to complete the work to a higher level of quality increases, and therefore the cost associated with the service increases. Other issues may not have such apparent relationships, and a better understanding of possible associations may be possible with the information from the rank correlation coefficients.

Rank correlation relates to cases in which the variables cannot be expressed in terms of numbers. Such is the case with the design study involving the opportunity for outsourcing. In this case, the variables are ranked in order from 1 to n. This data is then analyzed to establish the correlation among the ranks of the variables by rank correlation. The correlation coefficient r for discrete data is computed from:

$$r = 1 - \frac{6\sum D^2}{n(n^2 - 1)} \tag{6.1}$$

where n is the number of pairs of data (x, y) and D is the difference between the ranks of corresponding values of x and y.

The use of rank correlation coefficients is one method available for use in determining association among variables. Another statistical test for analyzing the degree of association among variables is the chi-square test of independence.

Test for Independence

The chi-square test of independence is used as follows to decide statistically whether two variables in a population are independent.

Assumptions

A. The data consists of a simple random sample of size n from some population of interest;
B. The observations in the sample may be cross-classified according to two criteria, so that each observation belongs to one and only one category of each criterion. The criteria are the variables of interest in a given situation; and
C. The variables may be inherently categorical, or they may be quantitative variables whose measurements are capable of being classified into mutually exclusive numerical categories.

The data is displayed in a contingency table as shown in Table 6.5, in which the observed number n_{ij} of subjects characterized by one category of each criterion is placed in the cell formed by the intersection of the ith row and jth column. The cell entries are referred to as *observed cell frequencies* and are usually designated O_{ij}. This is also represented as $O_{ij} = n_{ij}$. The observed cell frequencies represent the joint occurrence in the sample subjects of the ith category of the first criterion of classification with the jth category of the second.

Table 6.5. Contingency Table for Chi-square Test of Independence (21)

First Criterion of Classification	**Second Criterion of Classification**						
	Category						
Category	1	2	...	j	...	c	Total
1	n_{11}	n_{12}	...	n_{1j}	...	n_{1c}	$n_{1.}$
2	n_{21}	n_{22}	...	n_{2j}	...	n_{2c}	$n_{2.}$
...	...	...	...	...	...	...	...
i	n_{i1}	n_{i2}	...	n_{ij}	...	n_{ic}	$n_{i.}$
...	...	...	...	...	...	...	...
r	n_{r1}	n_{r2}	...	n_{rj}	...	n_{rc}	$n_{r.}$
Total	$n_{.1}$	$n_{.2}$	...	$n_{.j}$	...	$n_{.c}$	N

Hypothesis

H_o: The two criteria of classification are independent

H_1: The two criteria of classification are not independent

To obtain the expected cell frequencies, the following elementary law of probability is used: If two events are independent, the probability of their joint occurrence is equal to the product of their individual probabilities. If H_o is true, the probability that a subject in a sample size n will belong to cell ij is equal to the probability that the subject will belong in the ith row times the probability that the subject will belong in the jth column. These probabilities can be estimated from the sample data by $n_{i.}/n$ and $n_{.j}/n$, respectively. Then the estimated probabilities that a subject will belong in cell ij can be written as follows:

$$P(\text{subject belongs in cell } ij) = (n_{i.}/n)(n_{.j}/n) \tag{6.2}$$

To obtain the expected frequency for cell ij, multiply the estimated probability by the total sample size. Thus the expected frequency for the cell ij of the contingency table shown above is:

$$E_{ij} = n(n_{i.}/n)(n_{.j}/n) \tag{6.3}$$

Rewritten, this is represented by:

$$E_{ij} = n_{i.}\, n_{.j}/n \tag{6.4}$$

An expected cell frequency can easily be computed by multiplying together the appropriate row and column totals and dividing by the total sample size. Once the observed cell frequencies and the corresponding expected cell frequencies are known, the magnitude of the differences between them are of interest. Specifically, are the differences small enough to be attributable to chance (sampling variability) when H_o is true, or are the differences so large that some other explanation (namely that H_o is false) is necessary? From the expected and observed frequencies, the test statistic can be computed that reflects the magnitudes of the differences between the two quantities. When H_o is true, this statistic has approximately an χ^2 distribution with $(r-1)(c-1)$ degrees of freedom, where r is the number of rows and c is the number of columns in the contingency table. The test statistic is

$$\chi^2 = \sum_{i=1}^{r}\sum_{j=1}^{c}\left[\frac{(O_{ij} - E_{ij})^2}{E_{ij}}\right] \tag{6.5}$$

When the differences between observed and expected frequencies are large, χ^2 is large; when there is close agreement between them, χ^2 is small. The purpose of performing the chi-square test in addition to the rank correlation coefficients was to provide the decision maker with the opportunity to analyze the weights (rankings) being used in the test.

Nonparametric Statistics

Nonparametric methods have less restrictive assumptions than other "parametric" methods. No underlying assumption of the distribution of the data is required. This method, rather than actual numerical values of the observations, can be used when *ranks* or *orders* are used (22). A method like this may be applied to analysis of data used in ADOT's rating scheme. Taking input from decision makers over the range of questions, rank correlation coefficients (measure of the degree of correlation that exists between the sets of ranks) can be computed. Rankings can be assigned to the weight of the individual issues to the decision. For example, the cost of land might have a higher rank than the threat of labor strikes in the decision of a plant location. This method requires that the analyst have working knowledge of the area of analysis. The results from the test simply reflect the analyst's view of the system, but provide statistical support, rather than simple qualitative approaches, to the decision-making process.

The Statistical Sign Test

The statistical sign test is a simple statistical test for judging whether one of two treatments is better than the other. Such is the case in a sourcing decision, in which it is necessary to know if outsourcing the job function is better than performing with in-house forces.

The test is based on the signs of the differences between the pairs of observations (23). In this test, it is immaterial whether all the pairs of observations are comparable or not. This makes the sign test a quick preliminary appraisal of data. The minimum sample size given for the sign test is at least six pairs of observations at the 5 percent level of significance. This is due to the probability of the signs being alike. Four signs alike will occur by chance 12.5 percent of the time, and five signs alike will occur by chance 6.25 percent of the time (23). Therefore, it is necessary to have at least six pairs of observations even if all signs are alike before any decision can be made. One would not ordinarily use the sign test for samples as small as 10 or 15, except for rough or preliminary work. The sign test merely measures the significance of departures from a 50-50 distribution (23). It is important to note that the "pairs of observations" here would relate to the number of issues being compared in the methodology.

The Wilcoxon Signed Rank Test

As demonstrated above, the sign test utilizes only the signs of the differences between observed values and the hypothesized median. The Wilcoxon signed rank test uses the magnitude of the differences. To use this test, additional information is needed in order to be able to rank the differences between each sample measurement and the hypothesized median. First the differences are ranked in order of absolute size. Then the ranks are assigned their original signs and two sums are calculated: the sum of the ranks with negative signs and the sum of ranks with positive signs. The Wilcoxon signed rank test is a more powerful test than the sign test, due to the additional information used (21).

Assumptions

A. The sample available for analysis is a random sample of size *n* from a population with unknown median M. The individuals in the sample population have the same level of knowledge and experience regarding the candidate job function;
B. The sampled population is symmetric. The individuals have no preference in the sourcing decision. In other words, they can respond to the survey in an objective manner;

C. The observations are independent. One person's results are independent of another person's results;

D. The variable of interest is continuous; and

E. The scale of measurement is interval.

Hypothesis

A. H_o: $M = M_o$ and H_1: $M \neq M_o$;

B. H_o: $M \geq M_o$ and H_1: $M < M_o$; and

C. H_o: $M \leq M_o$ and H_1: $M > M_o$.

Case C is the hypothesis used in this particular statistical test design. This assumes that the candidate job function selected for analysis is a bad candidate for outsourcing until it can be proven good. The hypothesis is tested a level of significance α.

Test Statistic

To obtain the test statistic, use the following procedure.

1. Subtract the hypothesized median from each observation; that is, for each observation, find

$$D_i = X_i - M_o \tag{6.6}$$

If any other observation X_i is equal to the hypothesized median M_o, eliminate it from the calculations and reduce the sample size accordingly.

2. Rank the differences from smallest to largest without regard to their signs. In other words, rank the $|D_i|$, the absolute values of the differences. If two or more $|D_i|$ are equal, assign each tied value the mean of the rank positions occupied by the differences that are tied. For example, if the three smallest differences are all equal, rank them 1, 2, and 3, but assign each a rank of (1 + 2 + 3)/3 = 6/3 = 2.

3. Assign to each rank the sign of the difference of which it is the rank.
4. Obtain the sum of the ranks with the positive signs; call it T_+. Obtain the sum of the ranks with negative signs; call it T_-. Actually, only one of the sums has to be calculated directly; the other can be obtained by the relationship

$$T_+ = [n(n + 1)/2] - T_- \qquad (6.7)$$

If H_o is true – that is, if the true population median M is equal to the hypothesized median M_o – and if the assumptions are met, the probability of observing a positive difference $D_i = X_i - M_o$ of a given magnitude is equal to the probability of observing a negative difference of the same magnitude. Then, when H_o is true and the assumptions are met, the expected value of T_+ is equal to the expected value of T_-. For a given sample, T_+ is not expected to equal T_-. When H_o is true, a great difference in their values is not expected. Consequently, a small value of T_+ or a sufficiently small value of T_- causes us to reject H_o.

Specifically, the test statistic for each hypothesis is as follows:

A. Since we reject H_o: $M = M_o$ for either a sufficiently small value of T_+ or a sufficiently small value of T_-, the test statistic for the hypothesis stated in A is either T_+ or T_-, whichever is smaller.
B. For a sufficiently large sum computed from ranks with negative signs, we reject H_o: $M \geq M_o$, since under this null hypothesis we expect a fairly large sum computed from ranks with positive signs. A sufficiently small value of T_+, then, causes us to reject the null hypothesis specified in B.
C. By a similar line of reasoning, for the hypothesis stated in C, the test statistic is T_-. This is the test statistic used in this specific study design for the sourcing of job functions.

Decision Rule

Exact probability levels (P) are given for all possible rank totals (T) that yield a different probability level at the fourth decimal place, from 0.0001 up to and including 0.5000. The rank totals (T) are tabulated for all sample sizes from n = 5 to n = 30.

Decision rules for each of the sets of hypotheses above are as follows:

A. We reject H_o at the α level of significance if the calculated T is smaller than or equal to tabulated T for n and preselected $\alpha/2$. Alternatively, we may enter Table A-2 with *n* and our calculated value of T to see whether the tabulated P associated with calculated T is less than or equal to our stated level of significance. If so, we may reject H_o.
B. Reject H_o at the α level of significance if T_+ is less than or equal to tabulated T for n and preselected α.
C. Reject H_o at the α level of significance if T_- is less than or equal to tabulated T for n and preselected α. This is the decision rule used in the study design presented.

Interrelated Issues

If two issues were found to be dependent, then their respective contributions to the decision-making process could be adjusted. From Figure 6.1, there are two options for accommodating the interrelated issues. The preferred method would be to go back to **Selection of Critical Issues** and revise the critical issues to reflect the interrelationships. If one particular issue is highly associated with a number of other issues, then the issue can be removed from the list of critical issues for the sourcing study. Retention of the associated issue would bias the data toward the associated issue, due to the associated issue's reflection in the other issues. Another alternative would be to rephrase the critical issues to incorporate the associated issue. Both of these methods require the analyst to recreate the sourcing study and the questionnaire, redistribute the questionnaires, and reduce the data. This is a time-consuming procedure for the accommodation of interrelated issues, and other less time-intensive procedures are possible. The second alternative is to acknowledge that the association exists, identify possible relationships, and then remove the issue and the data associated with the issue from the Wilcoxon signed pair test of significance. This alternative is presented in the following sections as a comparison of statistically testing with and without the associated issue.

Select a Level of Significance

Selecting a level of significance, α, for the statistical tests is important. This will indicate how confident the analyst may be of the survey's results. Common values used for α are 0.80, 0.90, and 0.95 (80%, 90%, and 95%, respectively). In consideration of the level of significance to be used, the following points are considered:

- The qualitative data used in this methodology is subjective, and representative of each individual sampled;
- The methodology is not a decision model incorporating vast amounts of information on an array of topics, but rather a framework to analyze various decision maker opinions. The methodology provides information to the user about the viability of outsourcing candidate job functions;
- The higher the value of α, the more congruent the sample population must be in its opinions as to the sourcing decision, in order to arrive at a statistically meaningful result; and
- The Wilcoxon signed rank test is a relatively weak statistical test of significance. This test is well suited as an initial screening of significance for preliminary data (24).

Case 1: Non-Core Job Function

Non-core job functions are those most likely to be considered for outsourcing (13). If the job function is non-core, then a conservative value of α should be chosen. This is in congruence with the assumption for non-core job functions: that they are good candidates for outsourcing until proven otherwise. The conservative value allows the decision makers to be more likely to accept the null hypothesis and outsource the job function. An α of 0.95 is recommended based upon the problem presented in this sourcing study and the hypothesis outlined in the previous section.

Case 2: Core Job Function

For core job functions, if a value of α similar to the one chosen for the non-core job functions is chosen, then rarely would the job function be found to be adequate for outsourcing. Given the qualitative and subjective nature of the data collected from the survey, a more liberal value of α is recommended. Based on this information, the nature of the problem examined in this sourcing study, and the hypothesis outlined, a liberal value of 0.80 was chosen for α.

Test for Significance

In order to perform a test of significance on the survey data, it is necessary to reduce the data into a usable form. The seven response alternatives given in the survey are converted into a numbered scale. The response alternatives form part of the basis for the statistical test and are phrased such that they are one standard deviation apart and have parallel wording. For the statistical testing of qualitative data, the Wilcoxon signed rank test is an appropriate statistical test. There are two cases possible in the test for significance. The cases are distinguished by their job function classification as core or non-core.

Case 1: Non-Core Job Function

If the job function were deemed non-core by the agency, then the assumption would be that the job function is a good candidate for outsourcing until proven otherwise. Non-core job functions are those most likely to be considered for outsourcing (18).

Case 2: Core Job Function

In the case of this specific study design, the underlying assumption is that the job function to be considered is a core job function. The job function is assumed a bad candidate for outsourcing until it is demonstrated statistically to be not true. Justification for this is given below:

- If an agency is using the methodology to analyze the opportunity for outsourcing of a particular job function, then the underlying assumption is that the agency currently performs the work (at least some level of work) with internal forces.
- Assuming the job function is a poor candidate until proven otherwise maintains status quo in the agency. This enables operations to continue as previously performed, without the immediate assumption of outsourcing the job functions, and the proliferation of information, work, time, and manpower required to reengineer the process.
- If the evaluation methodology is to be used as a proactive tool for decisions by legislative bodies, then the burden of proof lies with the agency. Proving a job function as a "not bad" candidate implies a level of confidence at which outsourcing of the job function may be considered "not bad."

DEVELOPMENT AND ANALYSIS OF A SAMPLE SOURCING STUDY

The purpose of this section is to illustrate the use of the concepts described in the development of methodology section. It was decided to choose a job function that was of timely interest to numerous public agencies attempting to justify outsourcing a core job function and to make the case study as relevant as possible.

Selection of Job Function

Through initial research and informal interviews of decision makers within TxDOT, Florida Department of Transportation (FDOT), and Arizona Department of Transportation (ADOT), construction engineering management was the job function chosen to test the operational characteristics of the decision methodology. This job function is of timely interest to a number of public transportation agencies responsible for the construction of capital improvement projects. State and federal agencies are attempting to determine the best use of their existing staff, and are considering outsourcing various job functions. This is often referred to as construction engineering and inspection (CEI) services. Typically, construction engineers administer highway construction projects that include:

- Staking or checking contractor staking,
- Conducting or attending preconstruction meetings,
- Performing field sampling and testing of materials,
- Inspecting, documenting, and preparing progress reports and final estimates,
- Computing final quantities and costs,
- Preparing change orders, and
- Investigating claims (25).

Selection of Critical Issues

When creating the sourcing study, clearly defining the issues and phrasing a question to rate the opportunity to outsource a job function is critical. Additional points for consideration by the decision makers was created to provide insight into the issues being considered. The rating question was developed with consideration to the response alternatives. In other words, given the set of response alternatives, the rating question was phrased such that a set of response alternatives matched or required minimal modification. Selection of the critical issues to the sourcing decision was made through informal interviews with various TxDOT managers familiar with CEI services. The issues listed below are those believed to be contemplated by a decision maker when considering the sourcing alternatives for CEI services. Their respective definitions for inclusion in the sourcing study are listed below and are summarized in Table 6.6.

Cost

Definition: The estimated cost of construction engineering management services, as defined by direct labor and indirect labor costs. When evaluating this issue, the decision maker should assume a comparable level of quality.

Question: What is the cost difference between performing construction engineering management services with private forces and keeping the job function in-house? (Private-Public)

The purpose of identifying individual issues was to isolate and analyze the effect each issue had on the sourcing decision. Therefore, a comparable level of quality was assumed. All things being equal, quality will typically increase as the cost of the service increases. That is, the more you pay for a service, the higher the performance standards are and the higher quality the contractor must provide, therefore leading to more manpower and thus higher costs. If this cannot be assumed, then the resulting contribution of the two issues to the decision-making process (rankings) needs to be adjusted by modifying the *ranking* values.

Ability to Manage the Contract

Definition: The ability of the government to oversee, monitor, measure, and control the delivery of the activity.

Additional points for consideration:

- Monitoring the delivery of services by the public agency;
- Ability of public agency to develop and maintain control mechanisms over privatized service; and
- Measurement of quality and quantity of the service.

Question: Based on the ability to manage the contract, are construction engineering management services an acceptable job function to consider for outsourcing?

The agency must be able to effectively write, award, and monitor the contract through the duration of the agreement. While the manpower required for performing the work might decrease due to contracting out the service, the monitoring of the contract may offset some of the reduction in manpower. Intuitively, work will be shifted to a different area in the organization, with or without an overall total reduction in staff.

Risk

Definition: The degree to which contracting out exposes the government to additional hazards, including legal and/or financial exposure, service disruption, or corruption.

Additional points for consideration:

- Ability of the contractor(s) to complete the contract of the service,
- Consequences of any service interruptions,
- Consideration of any effect to legal exposure as a result of contracting out,
- Consideration of any effect to risk of corruption,
- Consideration of any effect to risk sharing with the contractor, and
- Responsible party for any and all cost overruns.

Question: Based on the risk to the organization, is this job function acceptable to consider for outsourcing?

Fear of exposure is a real issue for implementation of any new concept that changes the way an organization does business. In an attempt to consider this issue, the various aspects of risk must be weighed. The amount of risk sharing with the contractor can affect the performance of the contract. Identifying the responsible party for cost overruns and clearly establishing the roles of respective parties in the contract will aid in reducing the amount of risk to which an agency is exposed.

Quality of Service

Definition: The performance, effectiveness, timeliness, and thoroughness of the provided service.

Additional points for consideration:

- Quality of the service if construction engineering management services are contracted out,
- Impact on accountability and responsiveness by the public agency, and
- Ability of well-defined quality objectives to be included in a contract.

Question: If construction engineering management services are performed with private forces, how will the quality compare to similar services provided by public forces? (Private-Public)

The quality of the service provided is contingent upon the competence of the contractor, the accountability of the agency for the service provided, and the ability to clearly define performance measures in the contract. In similar fashion to the issue of *cost*, it is imperative to assume comparable costs for this issue, since quality and cost are directly related.

Future Strength of Competitive Market

Definition: The private-sector interest and ability to provide construction engineering management services in the future.

Additional points for consideration:

- Consider the future quantity of interested contractors (if private forces were to be utilized). Would the market for the services be sustainable?
- Consider the size of the financial commitment required.

Question: Will the strength of the competitive market be adequate to support construction engineering management services being performed with private forces in the future?

Originally, the definition was simply "the strength of the competitive market." However, from the pretesting, several points surfaced. The strength of the competitive market is a function of time. The longer a service is provided by private forces, the more competitive the marketplace becomes to support the given job function. This is the justification for the issue being titled *Future Strength of the Competitive Market*. With this title, the respondents should consider the competitive market in the future, after an initial period of time when the market has begun to reach equilibrium with available providers.

The strength of the competitive market is to be considered on either an agencywide or a geographical basis. This was intended to provide insight as to the focus of the respondents to this issue. Depending upon the job function, an agencywide or geographical basis for consideration may be appropriate. In the case of CEI services, local providers are essential to the success of the job function being provided by private entities. The ability to immediately respond to the needs of the contractor and the agency necessitates that the provider have local operations capable of decision-making for the support of the construction project.

Legal Barriers

Definition: The legal implications of attempting to perform construction engineering management services with private forces.

Additional points for consideration:

- Does law, statute, or ordinance mandate the mode of service delivery, public or private;
- Must laws, statutes, or ordinances be changed to permit contracting out of the service or activity; and
- Is contracting out compatible with the legislative, commission, or council intent that created the service or activity?

Question: Based upon the legal implications of attempting to perform construction engineering management services with private forces, are construction engineering management services a viable candidate for outsourcing?

In order for the service to be provided by private forces, there may be legal barriers to accommodate. In the case of CEI services, the Texas legislature has mandated that a given percentage of engineering services be performed by private forces. This issue can easily be considered a positive attribute in cases in which statute dictates that private forces provide the service. In other cases of particular job functions, statutes may need to be changed in order to allow contracting out of the services.

Impact on Public Agency Employment

Definition: The effect on public agency employment by using outside forces to complete construction engineering management services previously done by public employees.

Additional points for consideration:

- How will contracting out impact public employees;
- How many employees will be affected;
- Will the contractors be required to hire displaced public employees;
- How do current state wages compare to the private sector, and what effect do they have on personnel turnover; and
- Will any public employees be involuntarily terminated?

Question: Based upon the impact on public employees, are construction engineering management services a viable candidate for outsourcing?

This issue is intended to gather the opinions of the respondents on the issue of what happens to the agency's overall employment, rather than to individual employees. If a more strategic viewpoint is taken, with an overall interest in the welfare of the agency, then consideration of the agency's employment is an appropriate issue to rate. This is congruent with the idea of the methodology being used as a strategic decision process tool. If the agency's employees are considered, then the issue will most likely be viewed as having poor opportunity for outsourcing. The resistance to change is strong in all organizations which, when coupled with the threat of displaced employees, creates a great deal of tension.

Political Pressure

Definition: The amount of opposition to change in the provider of the service. Resistance can come from the public, users, interest groups, or public officials.

Additional points for consideration:

- What are the various group's (concerned citizens, users of the service, interest groups, or public/elected officials) positions regarding change;
- Is there a preference by these groups as to who the provider of the service (in-house, private) will be; and
- What is the overall political support for this service?

Question: Based on the political pressures in the external and internal environment, is it better or worse to perform construction engineering management services with private forces?

Regardless of the job function considered, the issue of political pressure is important to the sourcing decision. By means of laws, statutes, and ordinances, the legislative bodies have the ability to direct the function of the agency under their control. They have the ability to dictate the budget, the staffing level, the scope of services performed by the agency, and the use of private forces to accomplish certain services either directly or indirectly involved with the agency's primary function. Because of this legislative ability and the accountability of the agency to the taxpayers, the interest or opposition by interest groups, public officials, and the public to the sourcing decision is important and should be considered.

Resources

Definition: The efficient and effective use of government assets (e.g., personnel, investments) is reflected within this criterion. This includes in-house or private-sector advantages in terms of professional expertise, facilities or equipment, time constraints, and state revenue or expenditure restrictions.

Additional points for consideration:

- How would the private sector's expertise in this area compare to the government's (over time);
- Do time constraints exist that preclude in-house government delivery; and
- Will contracting out reduce required completion times?

Question: Based on the resources required for construction engineering management services, are the services an acceptable candidate for outsourcing?

Resources should be considered in the future tense. In other words, given that the immediate implementation of outsourcing CEI services occurs, what is the impact in the long term on the use of a public agency's resources? Is it better equipped to handle future workloads? Is it utilizing its resources more efficiently by outsourcing CEI?

Develop Level of Opportunity Scale

Once the issues have been defined, it is necessary to develop a set of response alternatives to rate the individual issues, and to define the number of levels that the scale will include. The number of levels used in the scale should be selected such that the scale provides adequate levels of description for the varying opinions as to the opportunity to outsource. In reviewing the set of response alternatives in Table 6.6, it is apparent that the sets typically number from five to seven levels.

Selection of five levels instead of seven produces less dispersion of the responses from the respondents and corresponds to the probability of more ties in the Wilcoxon signed rank test. For the example job function, seven levels of response alternatives were selected. The next step involved matching each cue to be described to an appropriate set of response alternatives. The objectives of the matching exercise included:

- Selecting a set of response alternatives that accurately describes the issue being questioned,
- Using language that will be understood by the survey respondents, and
- Providing wording that describes the limits of the opportunity to outsource.

Table 6.7 summarizes the various response alternatives chosen to describe the cues. The choices were made based upon definition of the cue and the question developed for the respondents to answer.

A set of response alternatives related to the incremental increase or decrease in cost when using private forces to accomplish the work was used. To define the limits of the opportunity for outsourcing, consideration was given to the cost at which the Texas State Council of Competitive Government mandates a particular job function to be outsourced, based on cost. Typically, if cost comparison of the job function determines that cost to supply the job function is 10 percent less by using private forces, then the agency is required to begin utilizing private forces to complete the work (9).

Table 6.6. Issues Critical to the Sourcing Decision of Job Functions

Issue	Definition
Strength of the competitive market	The private-sector interest and ability to provide construction engineering management services in the future.
Quality of service	The performance, effectiveness, timeliness, and thoroughness of the provided service.
Level of control	Considers the level of oversight of the service or activity the agency retains and the amount given to the contractor. Government's ability to oversee the provision of the service or activity.
Ability to manage the contract	The ability of the government to oversee, monitor, measure, and control the delivery of the activity.
Cost to manage the contract	The estimated cost of construction engineering management services, as defined by direct labor, and indirect labor costs. When evaluating this issue, the decision maker should assume a comparable level of quality.
Cost-effectiveness of the service by private forces	The direct and indirect cost of the service provided by the contractor.
Amount of risk	The degree to which contracting out exposes the government to additional hazards, including legal and/or financial exposure, service disruption, or corruption.
Legal barriers	The legal implications of attempting to perform construction engineering management services with private forces.
Political resistance	The amount of opposition to change in the provider of the service. Resistance can come from the public, users, interest groups, or public officials.
Impact on public employment	The effect on public agency employment by using outside forces to complete construction engineering management services previously done by public employees.
Resources available	The efficient and effective use of government assets (e.g., personnel, investments) is reflected within this criterion. This includes in-house or private-sector advantages in terms of professional expertise, facilities or equipment, time constraints, and state revenue or expenditure restrictions.

Table 6.7. Selected Response Alternatives for Sample Study

Cue	Response Alternative Set Number
Cost	Custom, (see below)
Ability to manage the contract	1
Risk	1
Quality of service	Modified 11, (see below)
Future strength of market	5
Legal barriers	1
Impact on public agency employment	1
Political pressure	11
Resources	1

With this consideration, a scale was developed to encompass this value, along with other measures. No definition of how to evaluate the cost of construction engineering management services was given. As this methodology is an attempt to quantify a variety of qualitative measures, and to organize a set of decision maker opinions as to the possibility for outsourcing of a particular function, the amount of detail required for investigation into the cost of the service need not be great. The greater the detail in consideration of the cost of service, the more thorough an investigation is required into the issues regarding outsourcing of a particular job function, and thus, more confidence can be placed in the results. The resulting response alternatives chosen are shown below:

25% More than in-house		25% Less than in-house
15% More than in-house	No Difference	15% Less than in-house
10% More than in-house		10% Less than in-house

Based upon the definition of quality and the question posed to the respondents, the response alternative set number 11 was chosen, as shown in Table 6.7. It is noted, however, that the limits of the scale were changed from "Worst" to "Worse" and from "Best" to "Better," after the survey was pretested. Thorough discussion of the pretesting of the survey will be discussed in a later section.

Develop Ranking Scale

The ranking scale developed utilizes discrete and numerical descriptors. Values from 1 to 10 describe the relative weight (importance) that the decision makers place upon the individual cues. This was chosen to provide ample dimensions to describe the opinions of the respondents.

Creating the Questionnaire

When all portions of the survey instrument were defined, the questionnaire was created. The questionnaire attempted to clearly define CEI services and presented a clear description of the issues relating to the sourcing decision. After the questionnaire was constructed, it was mailed to mid- and high-level decision makers in several transportation agencies across the nation. These agencies included TxDOT, FDOT, ADOT, the Pennsylvania Department of Transportation (PennDOT) and the Washington Department of Transportation (WashDOT). The questionnaire consisted of three parts: Introduction, Rating, and Ranking.

Introduction

The introduction to the questionnaire identified to the respondents the sponsor of the questionnaire, the research report, and the purpose of the survey. It also gave definitions of sourcing and of the sample job function (e.g., construction engineering services). Finally, the introduction provided basic instructions on how to complete the *Rating* and *Ranking* sections of the survey.

Part 1: Rating This portion of the questionnaire contained the issue, the appropriate definition, points to consider (if applicable), and the set of response alternatives for the issue. The issues selected were the ones identified in the section **Selection of Critical Issues**.

Part 2: Ranking This portion of the questionnaire contained the numeric scale for the various issues included and prompted the respondent to rank them in order of importance.

Pretesting

Once the questionnaire was complete, it was pretested with two individuals who were considered descriptive of the sample population. The individuals selected included a strategic manager and an operational manager within TxDOT. The individuals were asked to complete the questionnaire, making notes as to the following:

- The clarity of the introduction in defining the job function, and the steps of the questionnaire,
- The validity of the issues to the decision-making process,
- The clarity of the definitions of the issues presented,
- The adequacy of the points for consideration of the various issues,
- The clarity of the set of response alternatives for the rating of the issues, and
- The time taken to complete the questionnaire.

From the pretesting stage, changes were made to the questionnaire in several areas. The length of the introduction, including definitions, purpose of the questionnaire, and the directions, were shortened slightly. The issues cited as being important to the decision-making process were judged valid by the pretesters. The definition of the issue *Impact on Public Agency Employees* was changed to *Impact on Public Agency Employment* to give indication of a managerial approach, instead of a human resources viewpoint. In other words, the question was directed to the impact on the agency's employment (reduction in staff and loss of expertise), not necessarily the impact on the individual employee (morale and change in job requirement). In addition, some of the wording on the set of response alternatives was deemed difficult to interpret and was modified accordingly. Since the respondents would not interpret the qualitative issue in the manner described with the original descriptors, the limits of the scale for the issue of quality were modified. The time to complete the questionnaire was estimated at 20 minutes and was confirmed by the pretesting since the pretesters completed the survey in 19 and 23 minutes, respectively. The final version of the questionnaire is provided in Appendix B.

Analysis of Sample Sourcing Study

Once development of the sourcing study was complete, the process of collecting, reducing, and analyzing the data from the sampling frame of decision makers began. The sample population was defined and the sampling frame identified. Then the following sequence of activities was performed to lead to the statistical solution:

Data Collection: Identifying the sample population and sampling frame and sending out the surveys to the appropriate individuals.

Data Reduction: Reducing the data from the questionnaires into tabular form that can be used to perform the statistical tests.

Data Analysis: Performing the statistical tests on the data. This includes the Wilcoxon signed rank test for significance, analysis of the rank correlation coefficients of the issues, and the chi-square test for independence.

Data Collection

The sample population was a stratified random sample and was identified as decision makers in various transportation agencies (DOTs) who were familiar with outsourcing of CEI services. The sample population reflected those transportation individuals most closely associated with the job function, and the questionnaire was forwarded to them once they were identified. Typical job descriptions of those individuals thought to possess the desired information included:

- directors of construction,
- district engineers,
- area engineers, and
- project engineers.

Two important points to consider in the selection of the sample population were:

- *Level of management.* Selection of individuals across a range of managerial levels may provide beneficial insight into opinions of outsourcing a particular job function. Operational managers responsible for the daily operation and oversight of the job function, as well as strategic managers, those responsible for the strategic planning of the organization, should be surveyed; and
- *Survey other agencies.* Individuals outside the agency should be included in the sample population. If possible, select those individuals who have had direct experience in outsourcing the sample job function selected for analysis. This provides an alternative point of view to the issues and the importance those issues have in the decision-making process.

Six states were identified with varied experience in outsourcing CEI services and are listed in Table 6.8, along with their respective percentage of CEI services outsourced by dollar amount.

Table 6.8. Percent CEI Services Contracted Out by Selected DOTs

State Transportation Agency	Percent CEI Services Contracted-out (by $)
Arizona	25
Florida	40
North Carolina	5
Pennsylvania	40
Texas	1
Washington	20

As shown in Table 6.8, Texas had little experience in contracting out CEI services. In addition, TxDOT has not had the problem of construction workload exceeding capacity of the existing workforce. If this issue were coupled with the constraint of a mandated level of FTEs, which limits available manpower to accomplish the task, then private forces most likely would be required to accomplish the work. This situation occurred in Florida. A recent tax increase provided FDOT with additional funds for the construction of backlogged projects. However, at the same time as the tax increase, the Florida legislature instituted a hiring freeze and constrained the number of FTEs available. In order to accomplish the work, FDOT had to look to the private sector for provision of those services they no longer had the manpower to provide.

Besides TxDOT and FDOT, only one contact was identified in four of the six DOTs petitioned. Table 6.9 is a summary of the number of surveys mailed out and the number of surveys returned by agency.

Table 6.9. Survey Response Rates by State

State DOT	Surveys Mailed	Surveys Returned	Return Rate (%)
Arizona	1	1	100
Florida	4	21	525
North Carolina	1	0	0
Pennsylvania	1	0	0
Texas	36	56	156
Washington	1	0	0
Total	44	78	177

Once the surveys had been returned, the process of reducing data into a viable form for analysis began.

Data Reduction

For the *rating* portion of the survey instrument, response alternatives were given numeric values to be used for data reduction. Since there were seven response alternatives and the purpose of the Wilcoxon signed rank test was to see if the job function was a good or bad candidate for outsourcing, the graphical scale created was from –3 to +3. The value of –3 corresponded to the job function being a poor candidate for outsourcing, while the value of +3 corresponded to the job function being a good candidate for outsourcing. The mean, median, mode, and percent responses were calculated for the various issues and disaggregated by agency. Graphical representations of the percent responses were prepared. For the *ranking* portion of the survey instrument, mean, median, and mode of the importance of various issues to the decision-making process were computed.

Stratification

Data was stratified at two levels: by agency and by level of management. Given that FDOT and TxDOT were the principal respondents, those two agencies were chosen for comparison by agency. Another important comparison was the opinion of managers from various levels in the organization. It is possible to categorize the levels of management into two key strata: operational and strategic. The total number of TxDOT respondents classified as *operational managers* was 32 and 24 for those classified as *strategic managers*. Data was further reduced to compute the correlation coefficient of the issues, based on only the sample population from TxDOT. The purpose of this study was to demonstrate use of the rank correlation coefficients for one particular agency in order to provide an example of how relationships between the issues might be compared mathematically.

Abbreviation of the variables used in the data analyses are shown in Table 6.10.

Table 6.10. Critical Issue Abbreviations

Critical Issue	Abbreviation
Cost	Cost
Ability to manage the contract	Ability
Risk	Risk
Quality of service	Quality
Strength of the competitive market	Strength
Legal barriers	Legal Barriers
Impact on public agency employment	Employment
Political pressure	Political Pressure
Resources	Resources

DISCUSSION OF RESULTS

Data analysis of the rating portion of the survey was performed. The mean, median, and mode of the rating values of various issues were performed by computing the mean, median, and mode of the *rating* values of various issues. In addition, a graphical representation of the percent respondents in each response alternative, by issue, was calculated. The analysis of the *ranking* data was performed, and the mean, median, and mode values were also computed for each issue.

Comparing TxDOT to FDOT

In this section, data is analyzed so that inferences can be drawn between the opinions of FDOT and TxDOT to the viability of outsourcing CEI services. This provides two disparate viewpoints in the analysis: one of an agency with very little experience outsourcing this particular job function, and another of an agency currently performing 40 percent of its CEI services with external forces.

Rating

Figures 6.2 through 6.10 show the percent response rate and the mean, median, and mode of issues rated for viability of outsourcing. The darker bars on the figures represent FDOT's responses, while the lighter-shaded bars represent TxDOT's responses. The percent responses were calculated to show responses across the rating scale, so that a fair comparison between the two agencies could be performed, regardless of total sample size. Using the statistical measures of central tendency (mean, median, and mode) and a visual inspection of the percent responses, values used in the Wilcoxon signed rank test were identified.

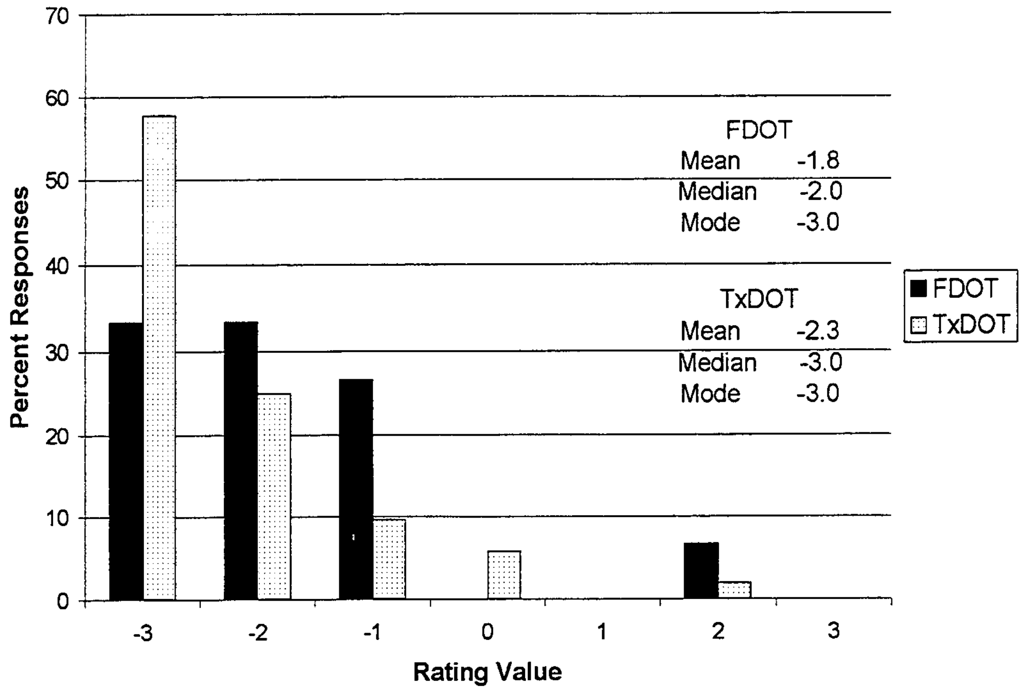

Figure 6.2. Percent Rating Responses for *Cost*, by Agency

Figure 6.2 shows that TxDOT had a strong preference for the value of –3 (outsourcing 25 percent more expensive than in-house), with over 55 percent TxDOT respondents. FDOT showed slightly more dispersion across the negative rating values with a median value of –2 (outsourcing 15 percent more expensive than in-house). Both TxDOT and FDOT were in agreement that, based upon *cost* alone, CEI services were a poor candidate for outsourcing. Based upon the graphs and measures of central tendency, *rating* values of –2 and –3 were selected for FDOT and TxDOT, respectively.

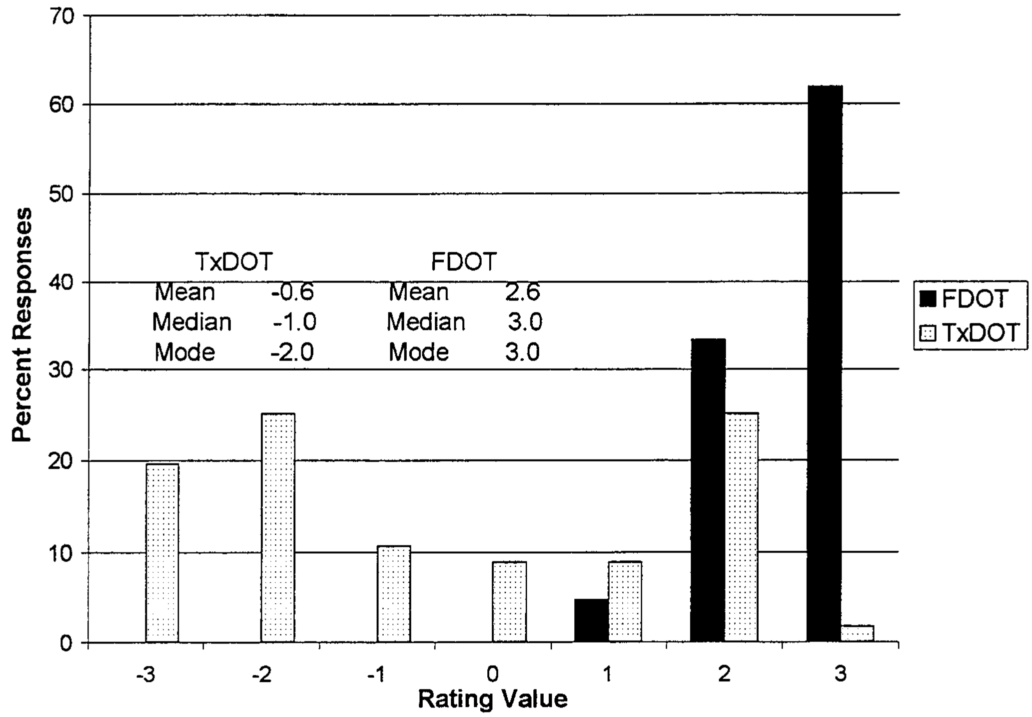

Figure 6.3. Percent Rating Responses for *Ability*, by Agency

Figure 6.3 shows FDOT with a strong preference towards the value +3 (completely acceptable). This indicates a response that based on *ability*, CEI services were a good candidate for outsourcing. TxDOT responses were widely scattered across the range of *rating* values, leaning slightly towards negative *rating* values of –1 (barely acceptable). A *rating* value of +3 (completely acceptable) was selected for FDOT and –1 (barely acceptable) for TxDOT, for the issue of *ability*.

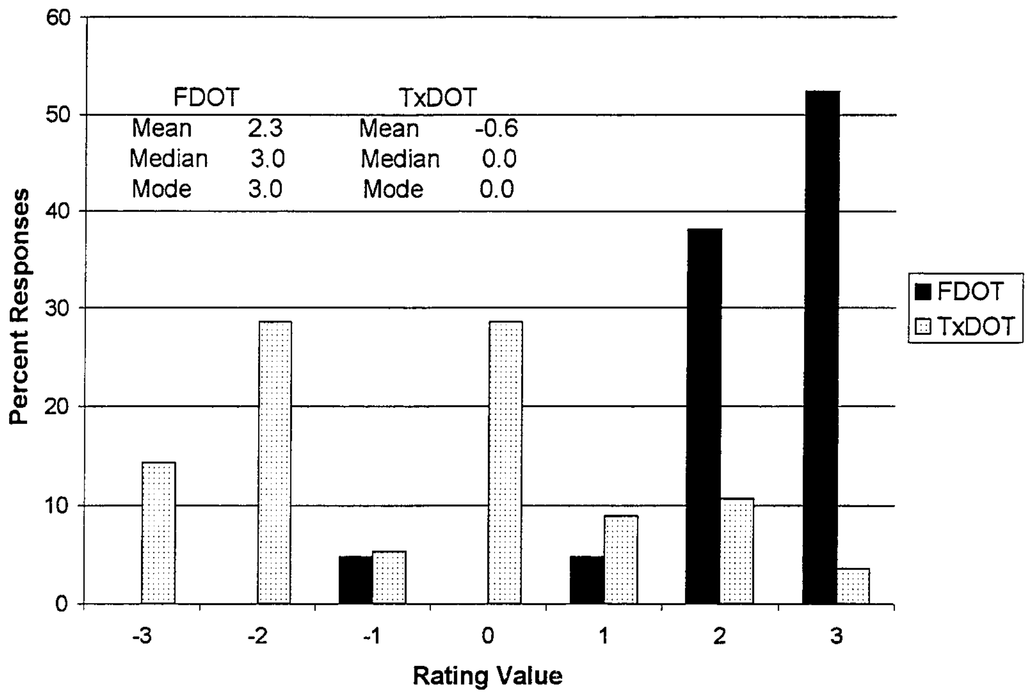

Figure 6.4. Percent Rating Responses for *Risk*, by Agency

Figure 6.4 shows that based on *risk*, FDOT indicated a strong preference for CEI services being a good candidate for outsourcing. TxDOT showed more dispersion based upon the figure, with a tendency to have no preference in the sourcing decision. In reviewing the statistical measures and the graphical representation of those measures, *rating* values of +3 (completely acceptable) and zero (borderline) were selected for FDOT and TxDOT, respectively.

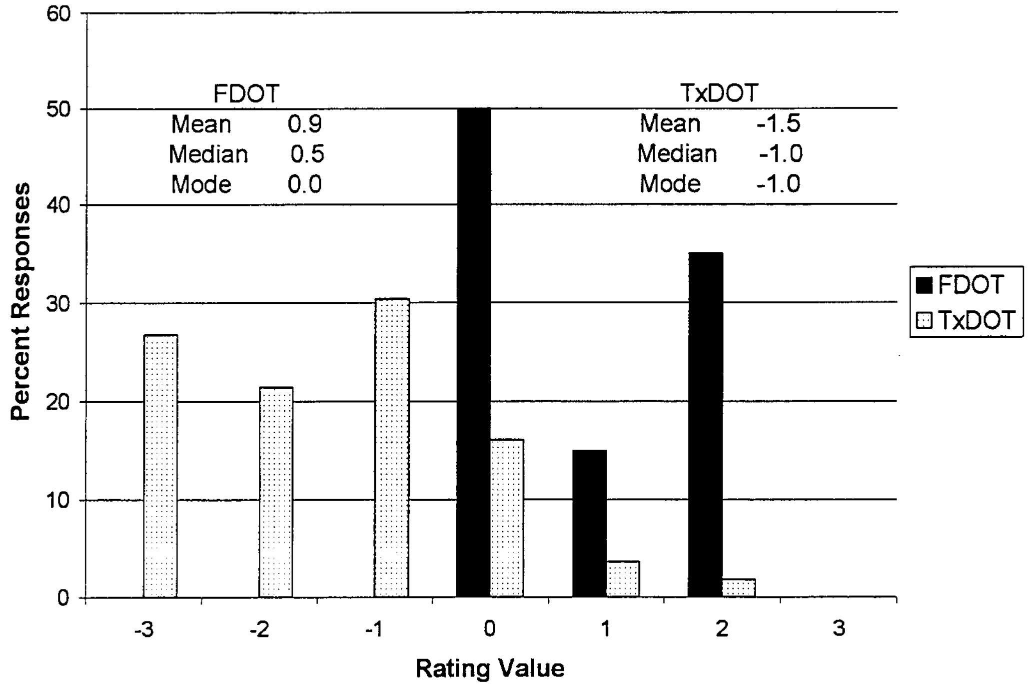

Figure 6.5. Percent Rating Responses for *Quality*, by Agency

Figure 6.5 indicates that FDOT and TxDOT again differed in their opinions as to the sourcing preference, based on the variable *quality*. FDOT indicated that the job function was, marginally, a good candidate for outsourcing, with little dispersion in the responses. All responses from FDOT were in the range from zero to +2. TxDOT showed a tendency to consider the job function a poor candidate. In addition, TxDOT showed more dispersion in its responses. From this information, *rating* values of +1 (marginally better) and –1 (marginally worse) were chosen for FDOT and TxDOT, respectively.

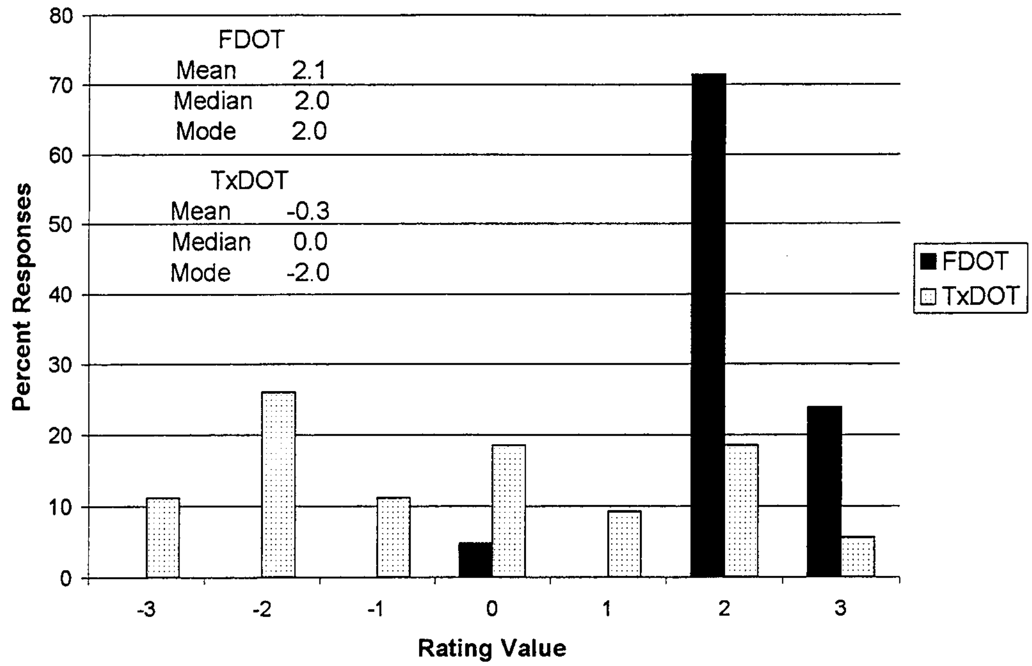

Figure 6.6. Percent Rating Responses for *Strength*, by Agency

Figure 6.6 demonstrates the continuing trend of FDOT to consider the job function a good candidate for outsourcing, based on *strength*. Over 70 percent of FDOT responses corresponded to the *rating* value of +2 (very adequate). TxDOT responses were well dispersed across the entire range of *rating* values, indicating varied preferences of the sourcing decision. Based on the statistical measures of central tendency and the graphical representation, *rating* values of +2 (very adequate) and zero (borderline) were selected for FDOT and TxDOT, respectively.

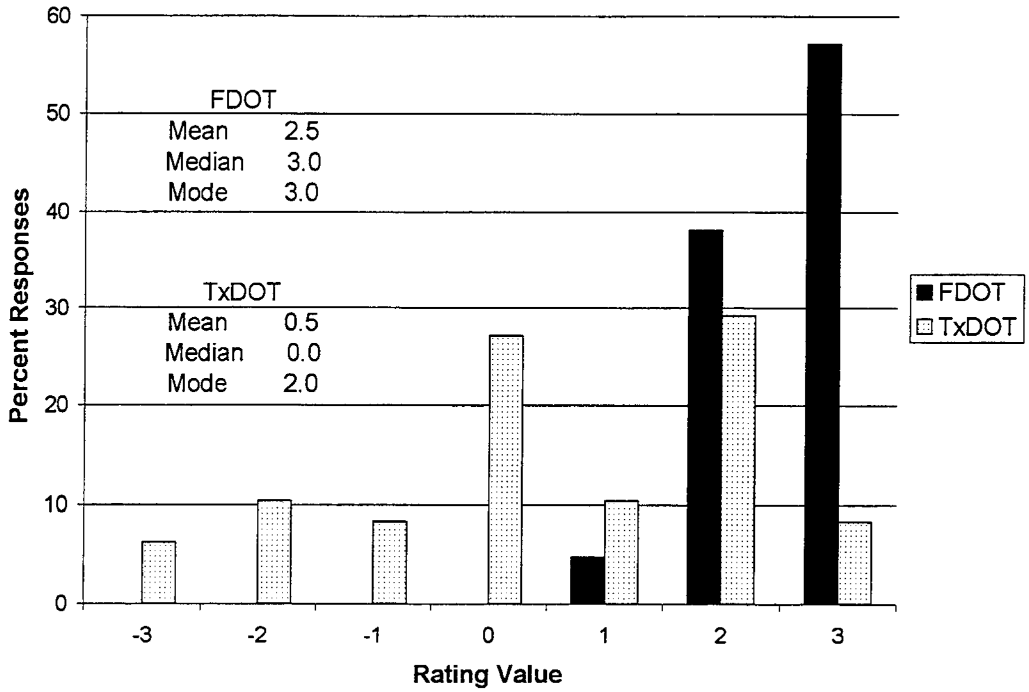

Figure 6.7. Percent Rating Responses for *Legal Barriers*, by Agency

Figure 6.7 shows a strong tendency to consider CEI services a good candidate for outsourcing, based upon *legal barriers*. TxDOT responses were more dispersed, with the majority of the responses falling into the positive *rating* value range. Based upon this information, a *rating* value of +3 (completely acceptable) and +2 (reasonably acceptable) were chosen for FDOT and TxDOT, respectively. This was the only positive *rating* value chosen for the TxDOT respondents.

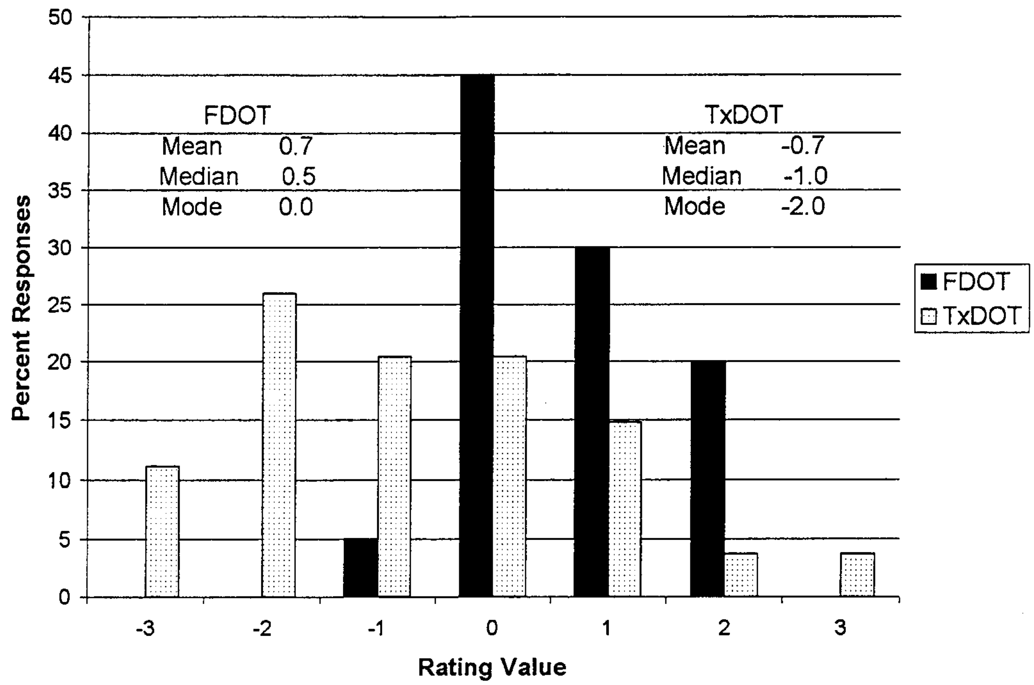

Figure 6.8. Percent Rating Responses for *Employment*, by Agency

Figure 6.8 indicates a wide dispersion again for the TxDOT respondents, with a mode of –2 (reasonably unacceptable), and a median of –1 (barely unacceptable), for the issue of *employment*. FDOT respondents again showed less dispersion, with a marginal preference for considering the job function to be a good candidate for outsourcing. From this information, *rating* values of +1 (reasonably acceptable) and –1 (barely acceptable) were selected for FDOT and TxDOT, respectively.

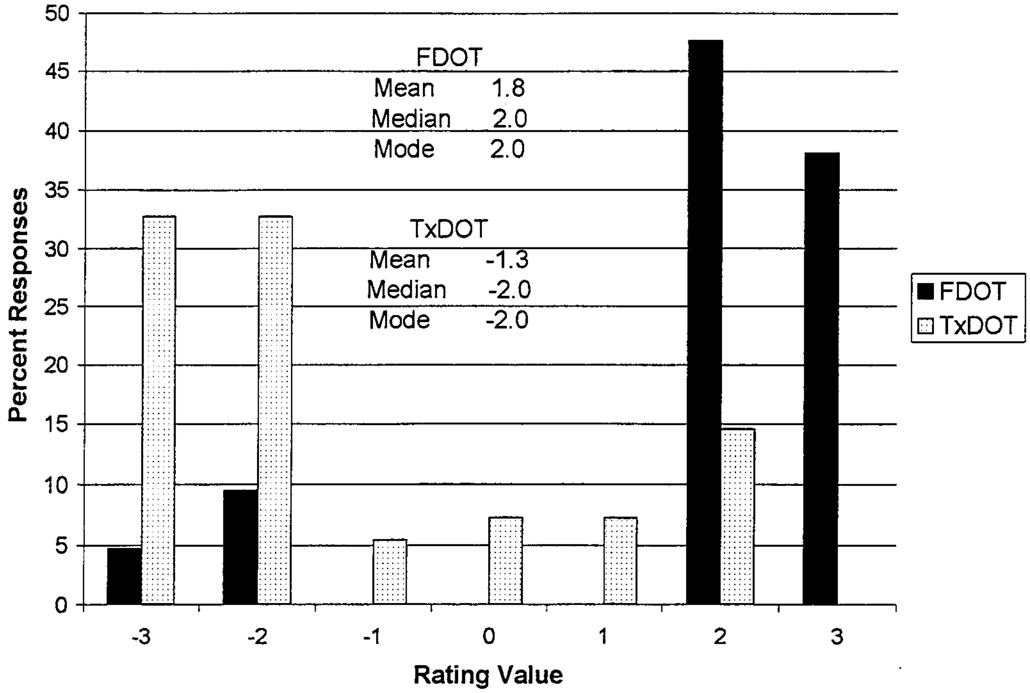

Figure 6.9. Percent Rating Responses for *Political Pressure*, by Agency

Figure 6.9 indicates a clear difference in the opinions for the opportunity of outsourcing, based upon *political pressure*. FDOT indicated the job function was a good candidate for outsourcing, while TxDOT indicated CEI services was a poor candidate for outsourcing. From the measures of central tendency, and the plots of the percent responses, *rating* values of +2 (moderately better) and –2 (moderately worse) were chosen for FDOT and TxDOT, respectively.

It is hypothesized that the reason FDOT was so positive about the outsourcing opportunity was the limiting by legislature of the number of full-time employees. Because of this political decision, CEI services became a very good candidate for outsourcing.

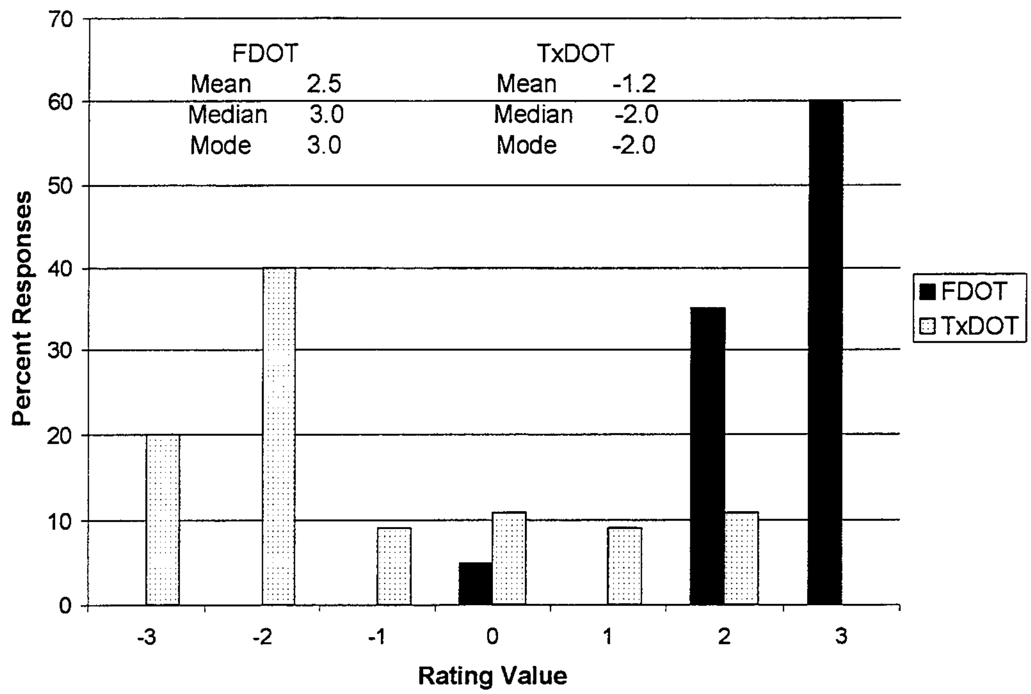

Figure 6.10. Percent Rating Responses for *Resources*, by Agency

Figure 6.10 once again shows FDOT had a tendency to consider CEI services to be a good candidate for outsourcing, based on *resources*. TxDOT responses had more dispersion, with a general preference for CEI services being a poor candidate for outsourcing. Over 90 percent of FDOT respondents felt strongly that outsourcing CEI services was a better utilization of their resources. Based upon this information, *rating* values of +3 (completely acceptable) and –2 (reasonably unacceptable) were selected for FDOT and TxDOT, respectively.

Tables 6.11 and 6.12 are summaries of the statistical measures of central tendency calculated, and the values selected for use in the Wilcoxon signed rank test for the *rating* value for FDOT and TxDOT.

Table 6.11. Mean, Median, Mode, and Selected Rating Value for FDOT

Issue	Mean	Median	Mode	Value Selected
Cost	–1.8	–2.0	–3	–2
Ability	2.6	3.0	3	3
Risk	2.3	3.0	3	3
Quality	0.9	0.5	0	1
Strength	2.1	2.0	2	2
Legal Barriers	2.5	3.0	3	3
Employment	0.7	0.5	0	1
Political Pressure	1.8	2.0	2	2
Resources	2.5	3.0	3	3

Table 6.12. Mean, Median, Mode, and Selected Rating Value for TxDOT

Issue	Mean	Median	Mode	Value Selected
Cost	–2.3	–3.0	–3	–3
Ability	–0.6	–1.0	–2	–1
Risk	–0.6	0.0	0	0
Quality	–1.5	–1.0	–1	–1
Strength	–0.3	0.0	–2	0
Legal Barriers	0.5	0.0	2	2
Employment	–0.7	–1.0	–2	–1
Political Pressure	–1.3	–2.0	–2	–2
Resources	–1.2	–2.0	–2	–2

TxDOT showed a clear tendency for rating the job function a poor candidate for outsourcing. Only one issue, *legal barriers,* had a positive *rating* value assigned for use in the Wilcoxon signed rank test. On the other hand, FDOT considered CEI services a good candidate for outsourcing on all but one issue; *cost*. This suggests that both agencies may believe outsourcing the job function costs would incur a higher cost to the organization.

Ranking

Given that the process of ranking is a subjective procedure and assignments of the values indicate the relative importance to the decision-making process, the mean, median, and mode of the nine issues were calculated. Based on the measures of central tendency and the graphical representation of the percent responses over the range of ranking values, a *ranking* value was assigned. Figures 6.11 through 6.19 show percent responses for the *ranking* values of identified critical issues.

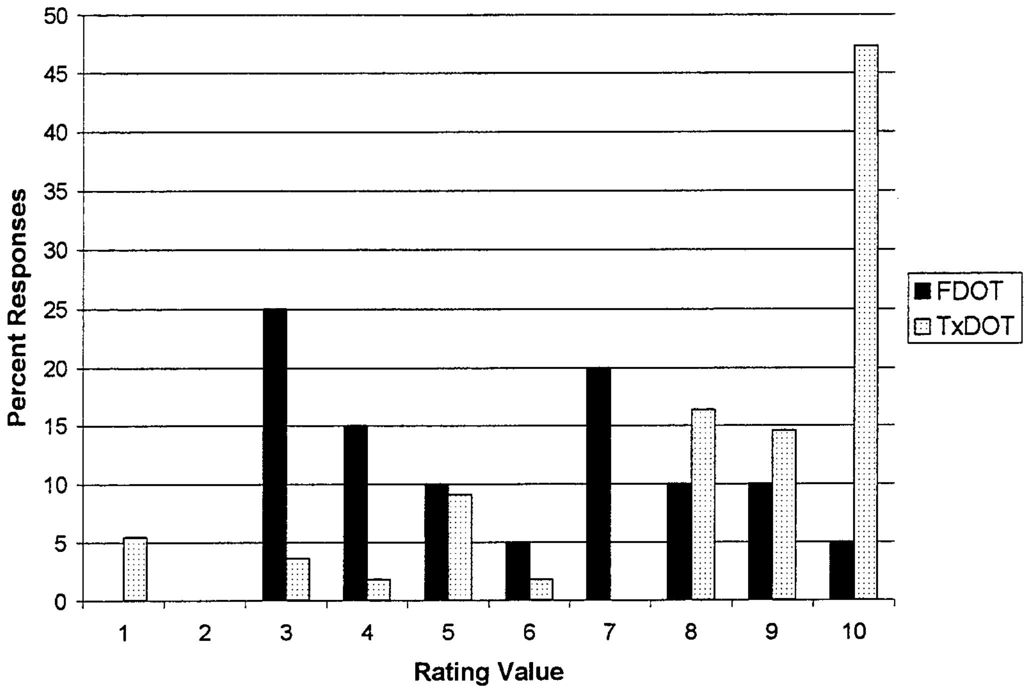

Figure 6.11. Percent Ranking Value Responses for *Cost*, by Agency

Figure 6.11 shows TxDOT personnel felt quite strongly that the issue of *cost* was of high importance when deciding on a sourcing option. FDOT, on the other hand, placed much less emphasis on the same issue. It is hypothesized that the reason for this disparity was due to FDOT already outsourcing a considerable percentage of CEI services. In addition, FDOT was essentially forced to use private forces for the completion of its construction projects. Even though the construction budget could support completion of the projects, FDOT was unable to hire additional staff to accommodate the necessary CEI services. This suggests that FDOT accepted the fact that a premium would be paid for CEI services and placed little importance on the issue in regard to the sourcing decision. This also supports the response from FDOT shown in Figure 6.2 regarding the *rating* value. FDOT tended to indicate the job function was a poor candidate based on *cost*. Due to the environmental conditions facing FDOT, they placed little importance on higher cost to the sourcing decision. From Figure 6.11, and the measures of central tendency, *ranking* values of six and 10 were chosen for FDOT and TxDOT, respectively.

Figure 6.12. Percent Ranking Value Responses for *Ability*, by Agency

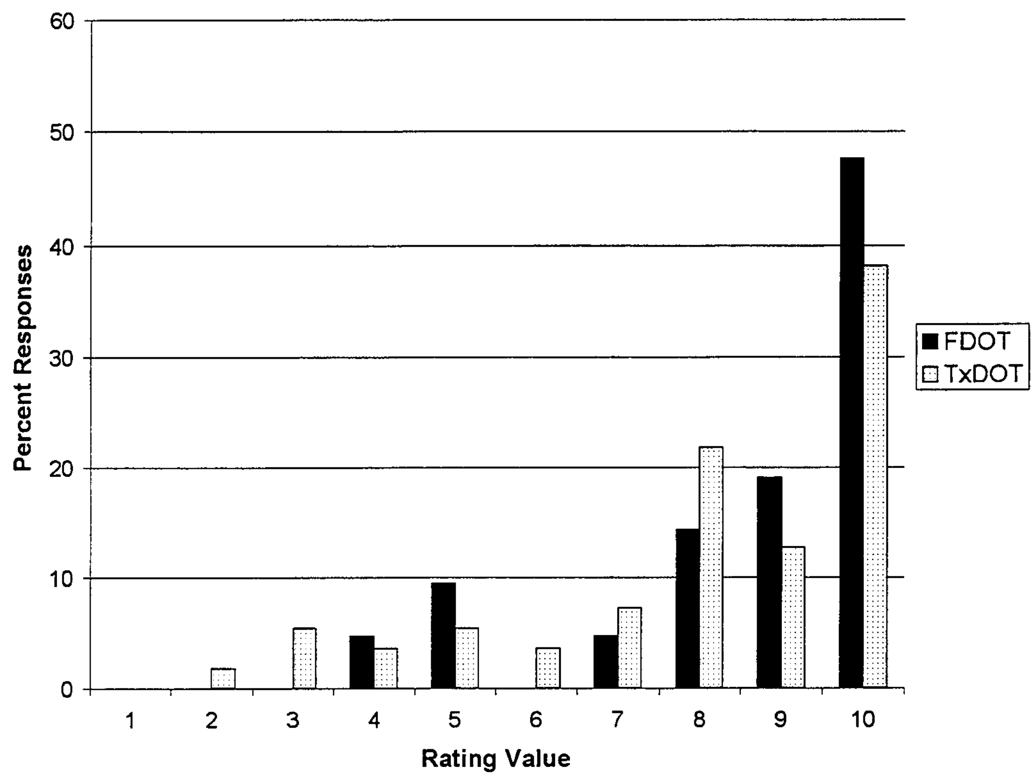

Figure 6.12 shows that TxDOT and FDOT had similar trends in their responses on the issue of *ability*. TxDOT placed slightly more importance on this issue than FDOT. The median and mode were equal for both agencies. Based on this information, a *ranking* value of nine was selected for both agencies.

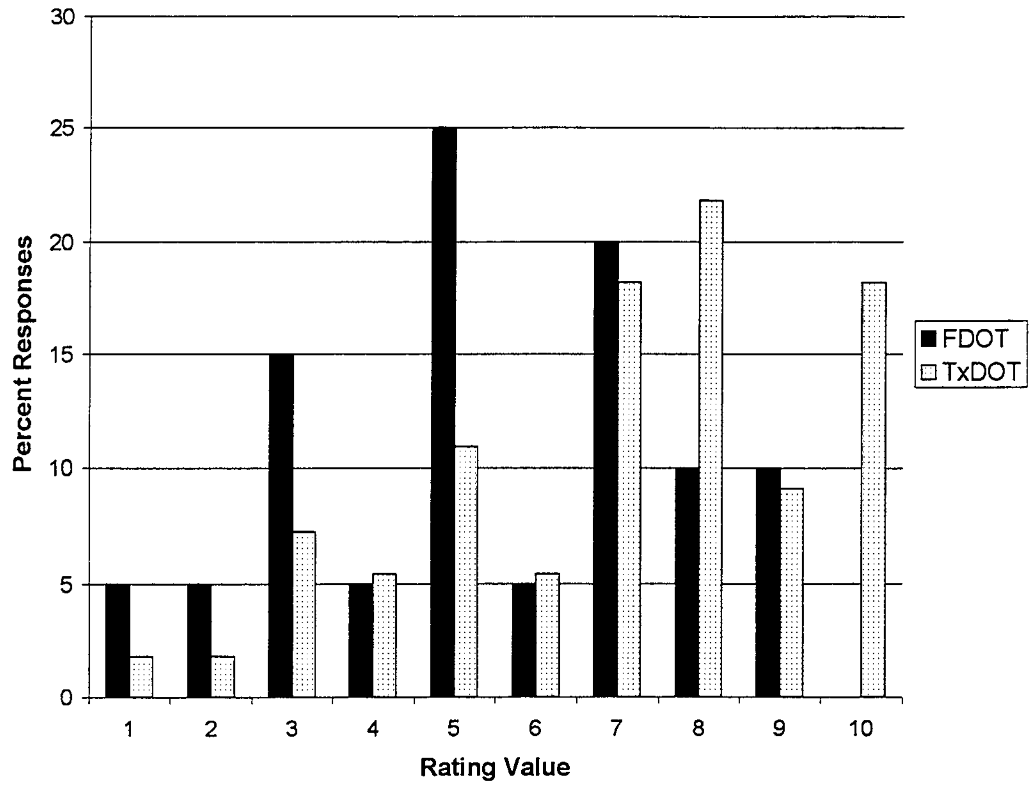

Figure 6.13. Percent Ranking Value Responses for *Risk*, by Agency

Figure 6.13 shows wide dispersion of the responses across the entire range of *ranking* values. As described earlier, TxDOT placed slightly more importance on *risk* than did FDOT. From the mean, median, and mode, and Figure 6.13, *ranking* values of six and seven were selected for FDOT and TxDOT, respectively.

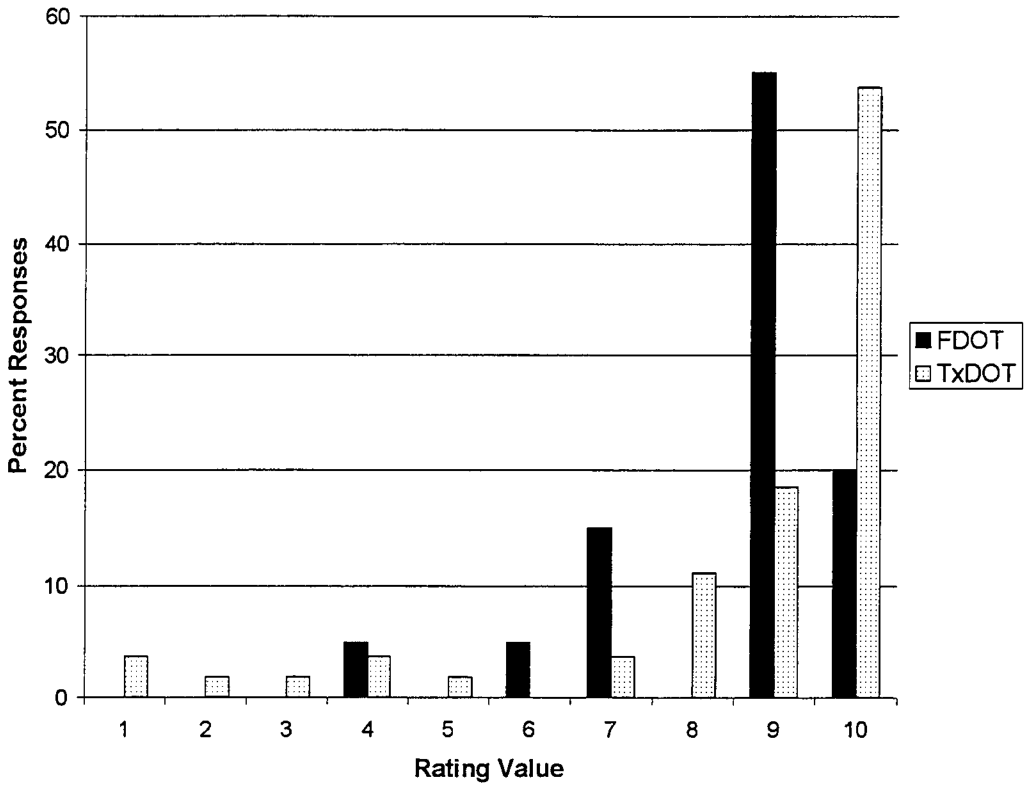

Figure 6.14. Percent Ranking Value Responses for *Quality*, by Agency

Both FDOT and TxDOT respondents clearly felt that ability to manage the contract was very important to the sourcing decision. Figure 6.14 shows that over 70 percent of both agency respondents selected values of either nine or 10. From this information, *ranking* values of nine and 10 were assigned to FDOT and TxDOT, respectively.

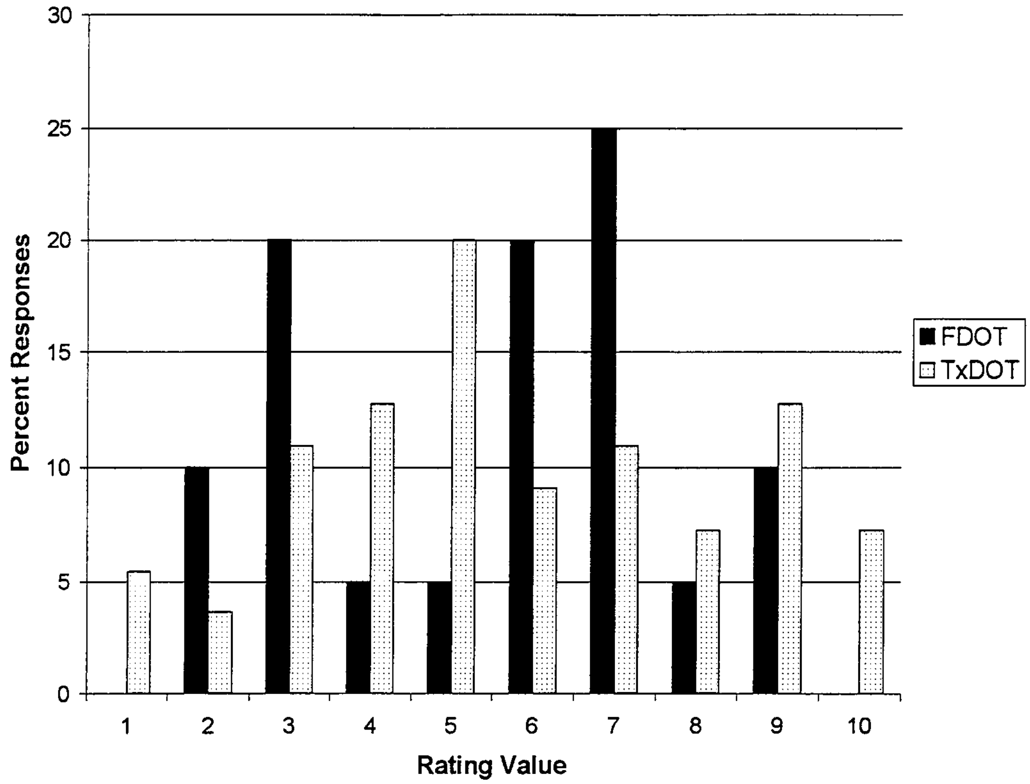

Figure 6.15. Percent Ranking Value Responses for *Strength*, by Agency

From Figure 6.15, both agencies appear to place moderate importance on the issue of *strength*. The mean for TxDOT was 5.7, while the mean for FDOT was 5.5. Based on the measures of central tendency and Figure 6.15, a *ranking* value of six was selected for both agencies.

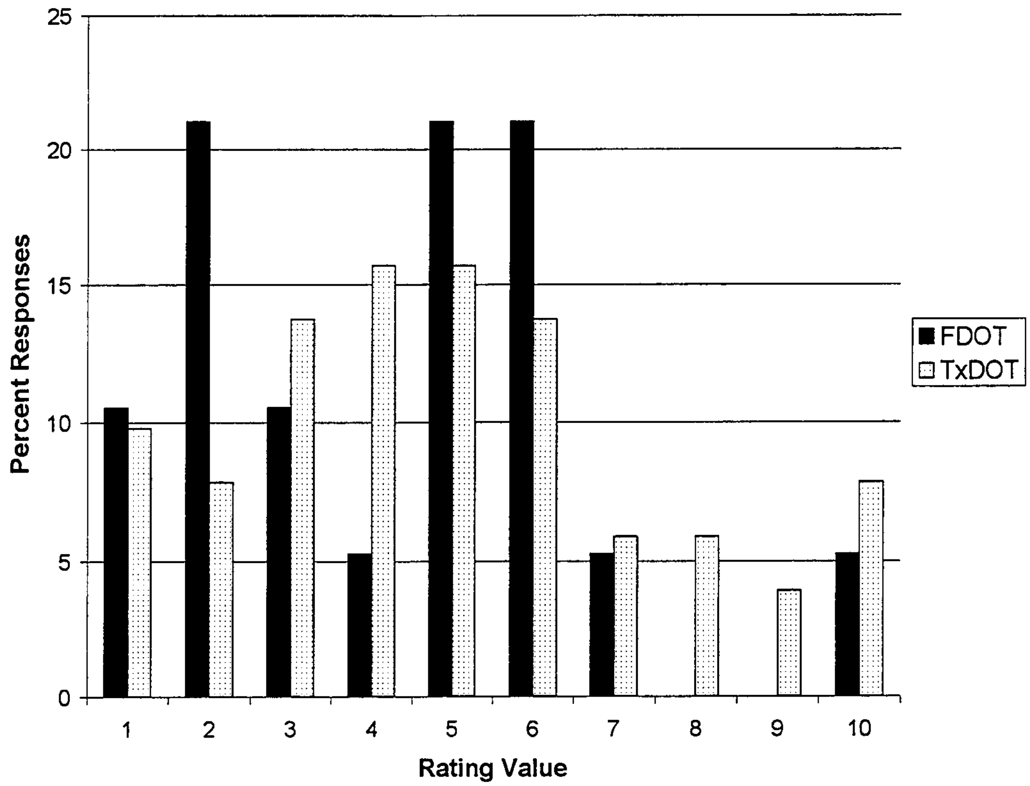

Figure 6.16. Percent Ranking Value Responses for *Legal Barriers*, by Agency

Figure 6.16 indicates a wide dispersion of responses for both agencies. Over 40 percent of FDOT respondents chose *ranking* values of five or six. TxDOT respondents also tended to place moderate importance on the sourcing decision for the issue of *legal barriers*. Based on this information, *ranking* values of four and five were chosen for FDOT and TxDOT, respectively.

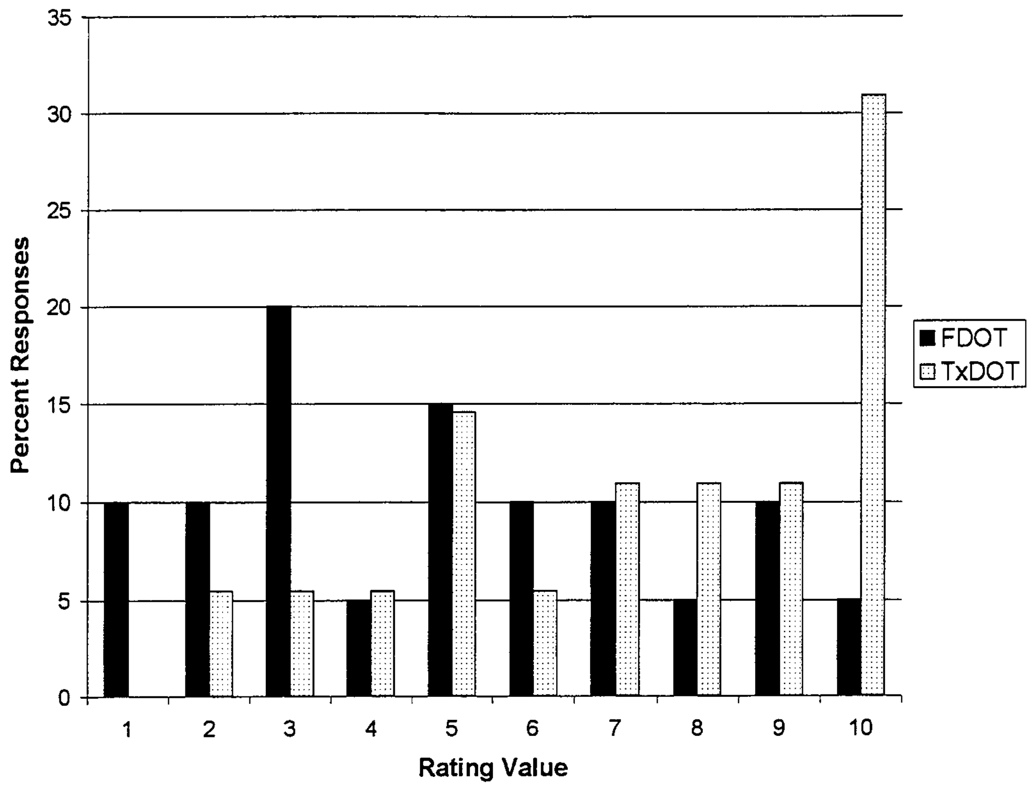

Figure 6.17. Percent Ranking Value Responses for *Employment*, by Agency

FDOT respondents tended to place less importance on the sourcing decision for the issue of *employment*. A large percentage of TxDOT respondents felt that *employment* was very important to the sourcing decision. From the mean, median, mode, and Figure 6.17, *ranking* values of five and eight were assigned to FDOT and TxDOT, respectively.

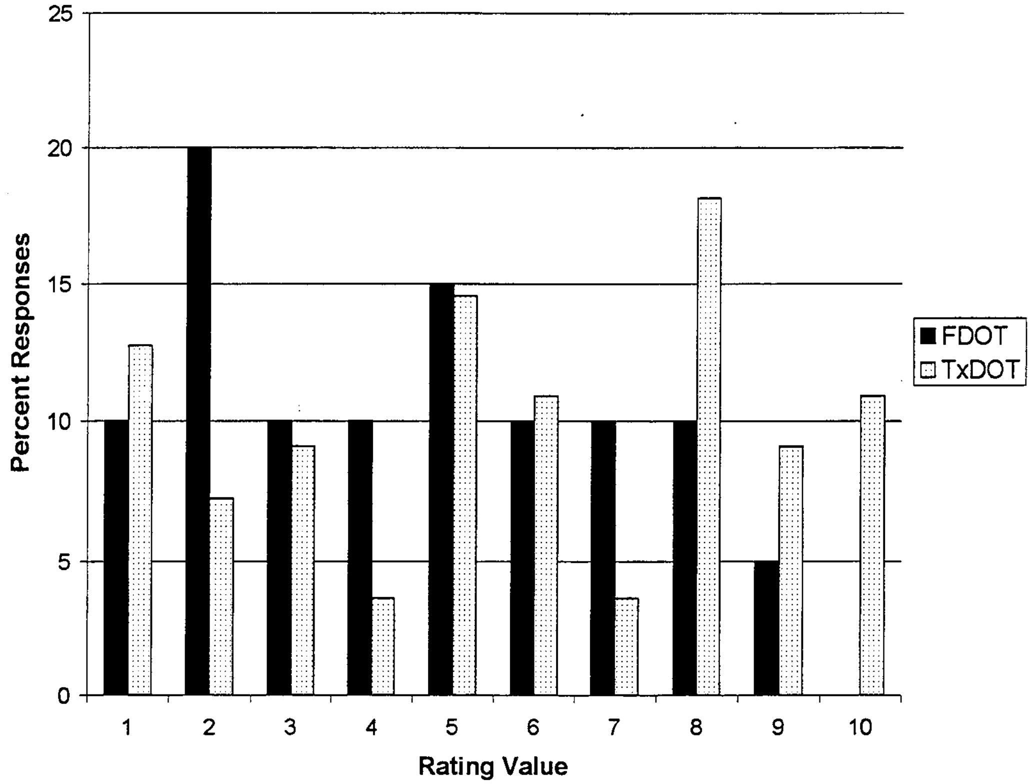

Figure 6.18. Percent Ranking Value Responses for *Political Pressure*, by Agency

Figure 6.18 indicates wide dispersion of responses from both agencies across the range of *ranking* values. No clear preference for the importance of the sourcing decision for *political pressure* is apparent. Based on this information and the measures of central tendency, *ranking* values of five and six were assigned to FDOT and TxDOT, respectively.

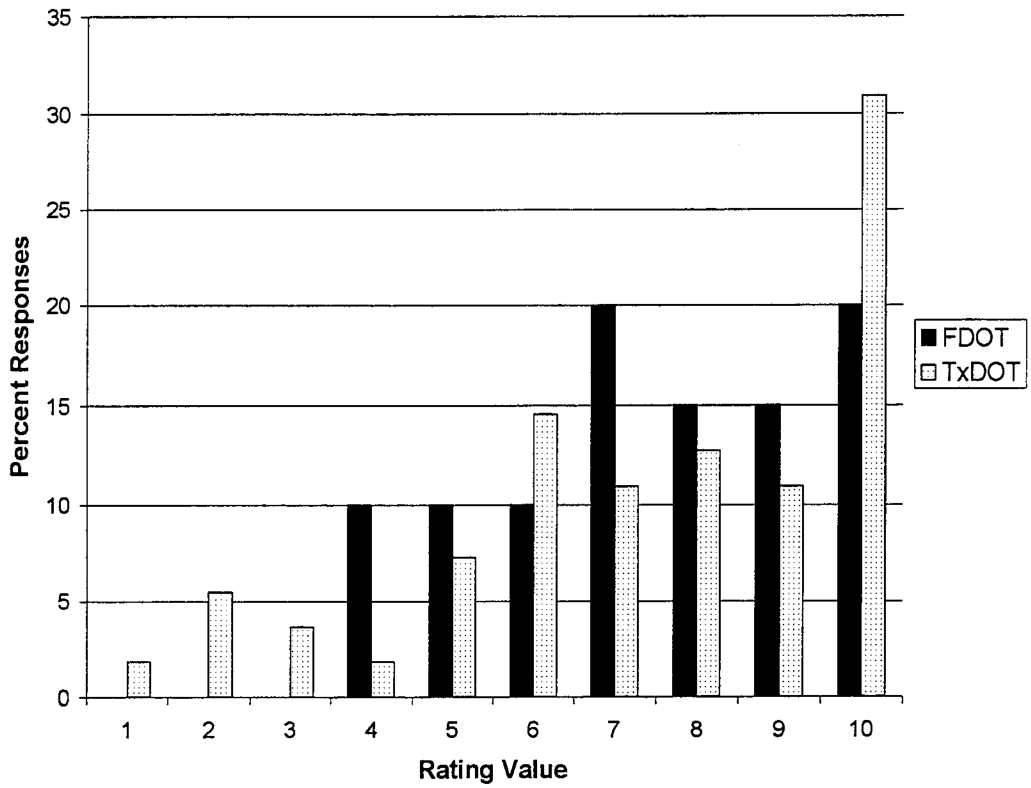

Figure 6.19. Percent Ranking Value Responses for *Resources*, by Agency

Figure 6.19 shows both agencies placing high importance on the sourcing decision for the issue of *resources*. The best utilization of resources was important to both agencies. TxDOT placed higher importance on the issue than did FDOT. Based on this information, a *ranking* value of eight was assigned to both FDOT and TxDOT.

Tables 6.13 and 6.14 summarize the measures of central tendency and selected *ranking* values by agency for use in the Wilcoxon signed rank test.

Table 6.13. Mean, Median, Mode, and Selected Ranking Value for FDOT

Issue	Mean	Median	Mode	Value Selected
Cost	5.8	5.5	3.0	6
Ability	8.6	9.0	10.0	9
Risk	5.5	5.0	5.0	6
Quality	8.5	9.0	9.0	9
Strength	5.5	6.0	7.0	6
Legal Barriers	4.3	5.0	2.0	4
Employment	5.0	5.0	3.0	5
Political Pressure	4.5	4.5	2.0	5
Resources	7.5	7.5	10.0	8

Table 6.14. Mean, Median, Mode, and Selected Ranking Value for TxDOT

Issue	Mean	Median	Mode	Value Selected
Cost	8.1	9.0	10.0	10
Ability	8.1	9.0	10.0	9
Risk	7.0	7.0	8.0	7
Quality	8.6	10.0	10.0	10
Strength	5.7	5.0	5.0	6
Legal Barriers	4.9	5.0	4.0	5
Employment	7.3	8.0	10.0	8
Political Pressure	5.7	6.0	8.0	6
Resources	7.4	8.0	10.0	8

Overall, the *ranking* values for both TxDOT and FDOT were consistent. Disparity on only one issue, *cost*, was observed. Both transportation agencies placed moderate to high importance on all of the issues in the decision-making process. On several issues, TxDOT placed slightly more importance on the decision-making process than did FDOT.

Comparing Levels of Management

Questionnaires received from TxDOT respondents were sorted according to the level of management of the respondents: strategic and operational. With this information, a comparison can be drawn between the level of management and the opportunity for outsourcing of CEI services.

Rating

Figures 6.20 through 6.28 show the graphical representation of percent respondents against the rating values, stratified by level of management. The values of the mean, median, and mode for the various issues are also shown on the figures. In similar fashion as described in the section **Comparing TxDOT to FDOT**, the statistical measures of central tendency and the plots of the percent responses were used to select *rating* values to be used in the Wilcoxon signed rank test.

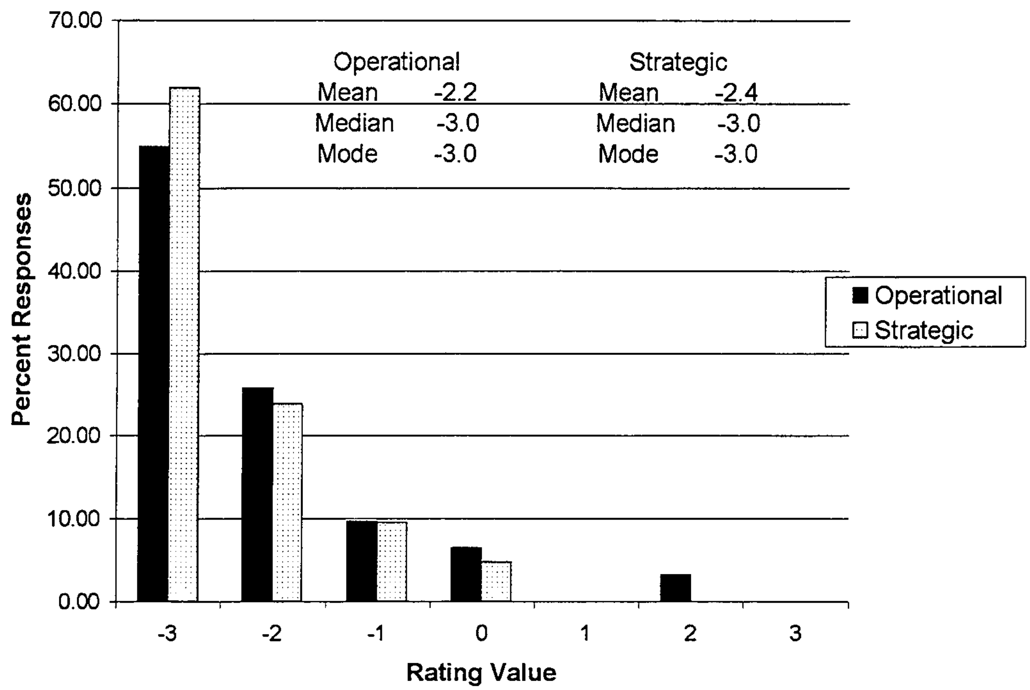

Figure 6.20. Percent Rating Responses for *Cost*, by Level of Management

In Figure 6.20, both strategic and operational managers had approximately the same amount of dispersion, and almost the same mean. Both indicated a preference for the job function being a bad candidate for outsourcing, based upon the issue of *cost*. Based on this information, a *rating* value of –3 (outsourcing 25 percent more expensive than in-house) was chosen for both *operational* and *strategic* management levels.

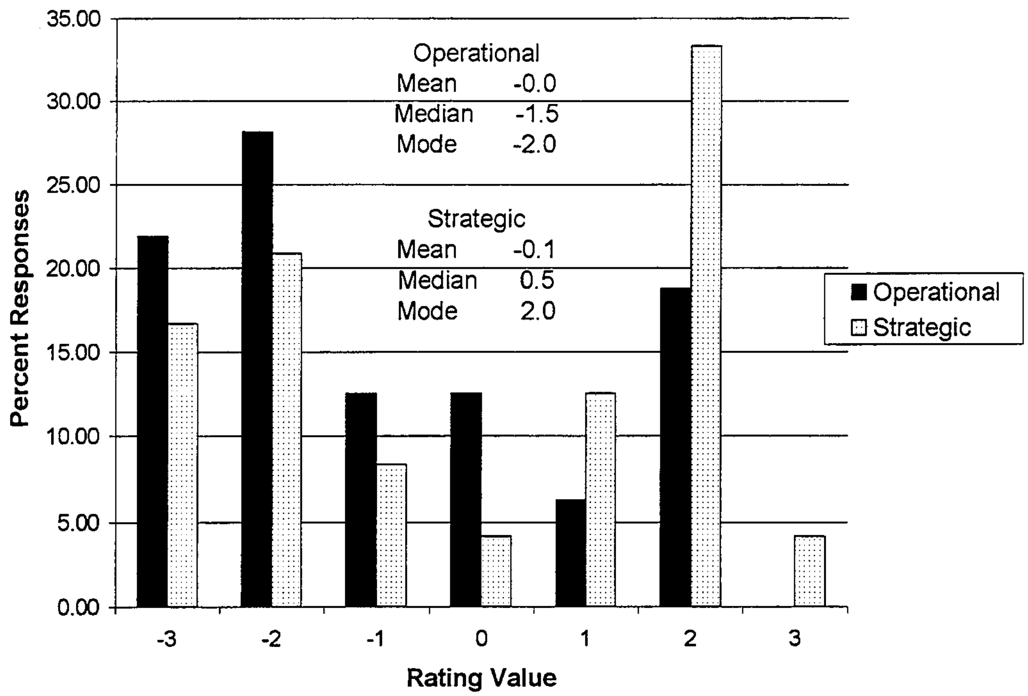

Figure 6.21. Percent Rating Responses for *Ability*, by Level of Management

Figure 6.21 shows wide dispersion for both levels of management and also indicates a difference in the opportunity for outsourcing between the managerial levels. Operational managers tended to rate CEI services a poor candidate for outsourcing based on *ability*, with a mode of –2 (reasonably unacceptable). Strategic managers, on the other hand, saw the job function as a good candidate for outsourcing, with a mode of +2 (reasonably acceptable). From this information, values of –2 and +1 (barely acceptable) were chosen for *operational* and *strategic* management levels, respectively.

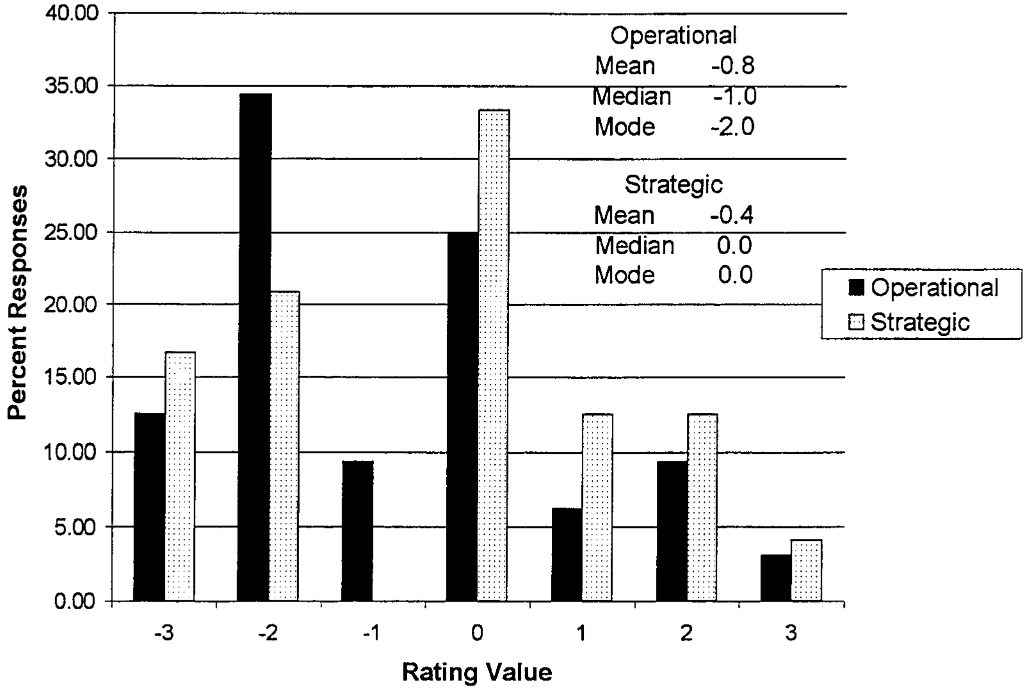

Figure 6.22. Percent Rating Responses for *Risk*, by Level of Management

In Figure 6.22, dispersion of the two levels of management is approximately the same, and the plot of percent responses over the range of rating values is similar. Based on the measures of central tendency and the graphical representation of percent responses, *rating* values of −1 (barely unacceptable) and zero (borderline) were selected for *operational* and *strategic* management levels, respectively, for the issue of *risk*.

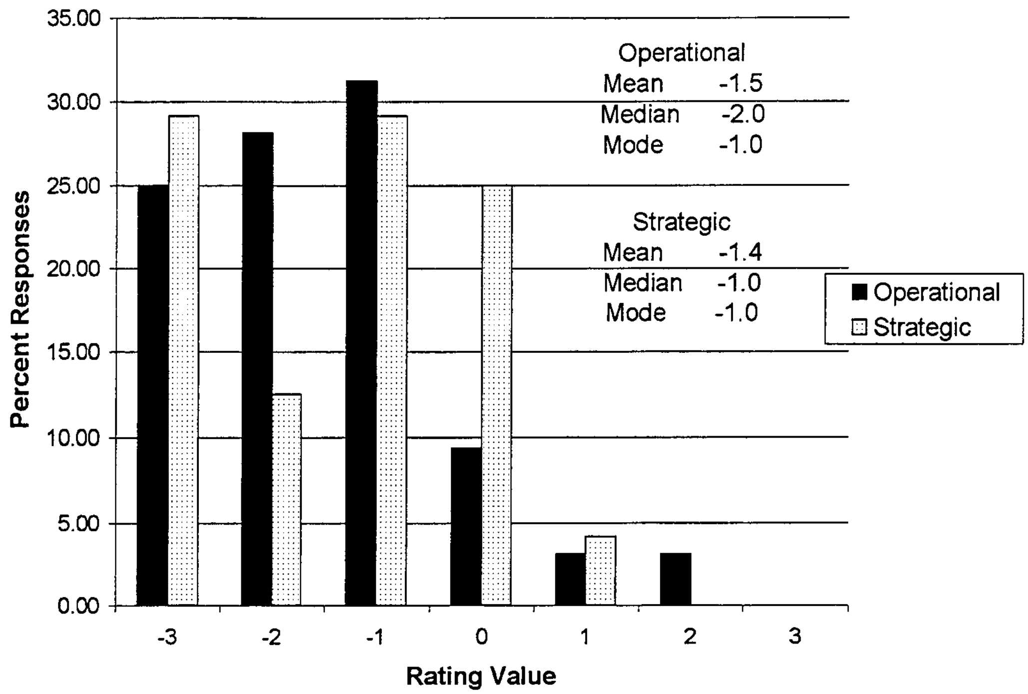

Figure 6.23. Percent Rating Responses for *Quality*, by Level of Management

From Figure 6.23, there appears to be little difference in the responses stratified by level of management. Both operational and strategic managers indicate a tendency to rate CEI services a poor candidate on the basis of *quality*. From Figure 6.14, and the mean, median, and mode, values of –2 (moderately worse) and –1 (marginally worse) were selected for *operational* and *strategic* management levels, respectively.

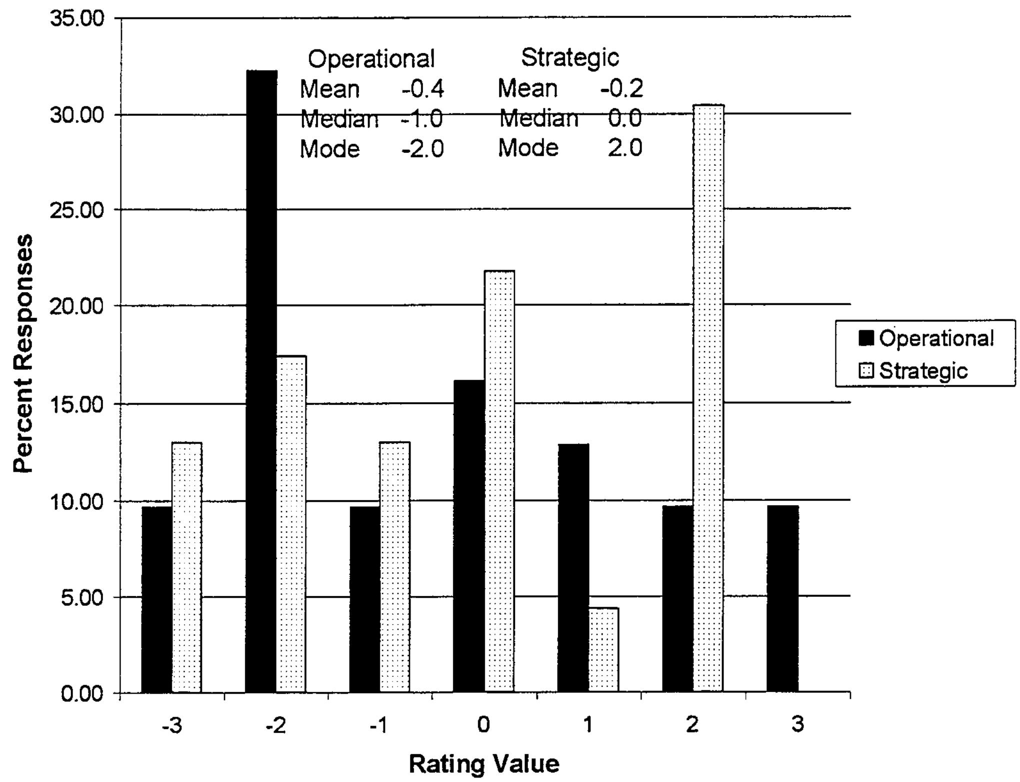

Figure 6.24. Percent Rating Responses for *Strength*, by Level of Management

In Figure 6.24, dispersion of both levels of management is approximately equal, but the modes of the two strata are noticeably different. Over 30 percent of the *operational* managers considered CEI services to be a poor candidate for outsourcing, while approximately the same percentage of *strategic* managers considered it a good candidate, according to variable *strength*. From this information, *rating* values of –2 (very inadequate) and +2 (very adequate) were selected for *operational* and *strategic* management levels, respectively.

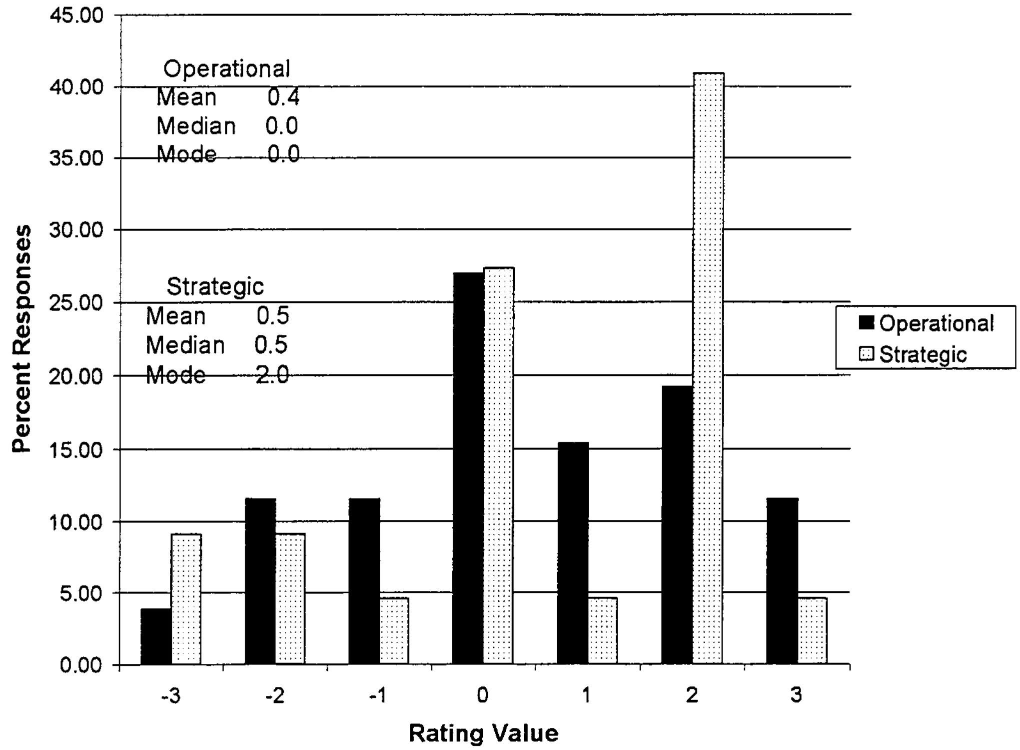

Figure 6.25. Percent Rating Responses for *Legal Barriers*, by Level of Management

Figure 6.25 shows that over 40 percent of the strategic managers felt that CEI services were a good candidate for outsourcing, based on the issue of *legal barriers*. Based on the statistical measures of central tendency and Figure 6.25, *rating* values of zero (borderline) and +2 (reasonably acceptable) were selected for *operational* and *strategic* management levels, respectively.

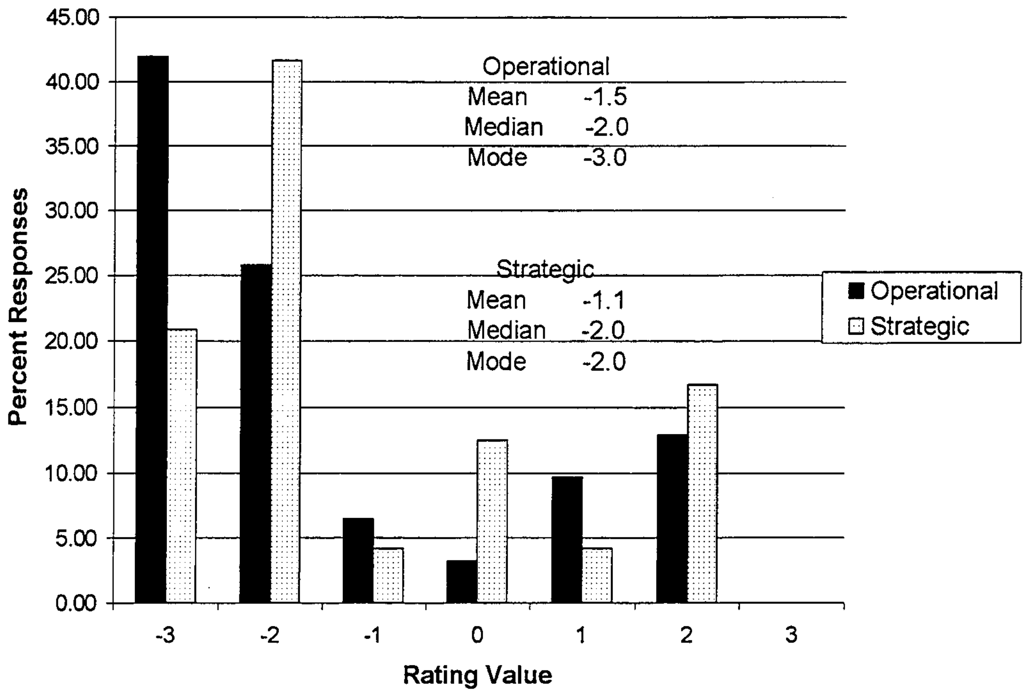

Figure 6.26. Percent Rating Responses for *Employment*, by Level of Management

In Figure 6.26, distributions of both levels of management on the issue of *employment* are similar. Operational managers felt that CEI services were a worse candidate for outsourcing than strategic managers did, with over 40 percent of the responses for operational managers selecting a value of –3. From this information, values of –3 (completely unacceptable) and –2 (reasonably unacceptable) were chosen for *operational* and *strategic* management levels, respectively.

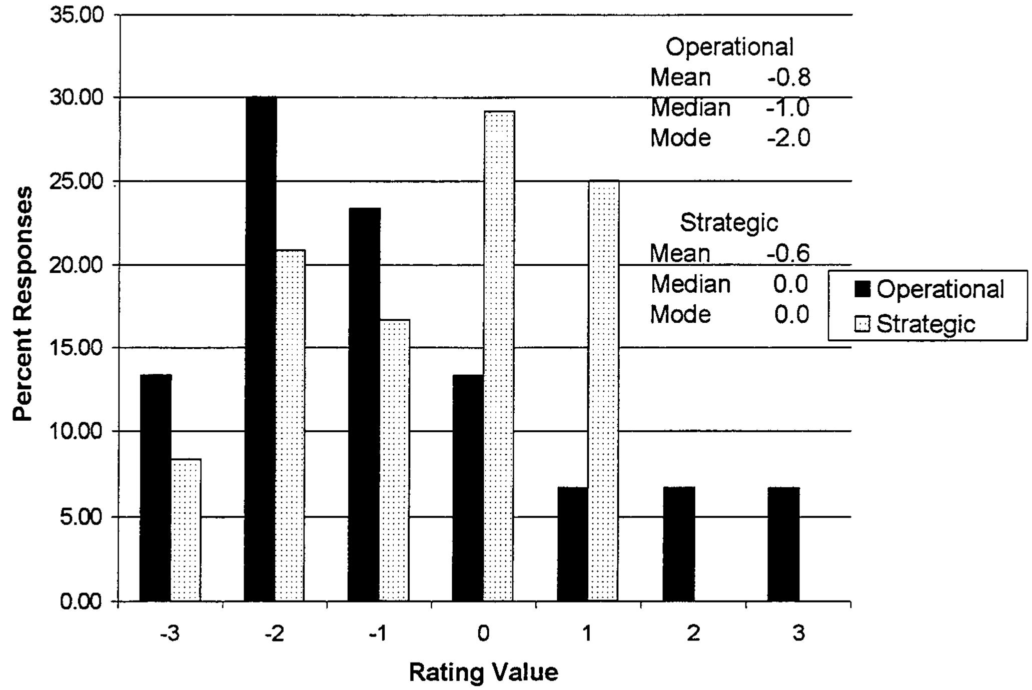

Figure 6.27. Percent Rating Responses for *Political Pressure*, by Level of Management

Figure 6.27 indicates wide dispersion for both strata, with operational managers centered on a median of –1.0, and strategic managers on a median of 0.0. Strategic managers had no noticeable preference on the opportunity for outsourcing of CEI services based on *political pressure*, as evidenced by the mode value of zero. With this information, *rating* values of –1 (marginally worse) and zero (alike) were chosen for *operational* and *strategic* management levels, respectively.

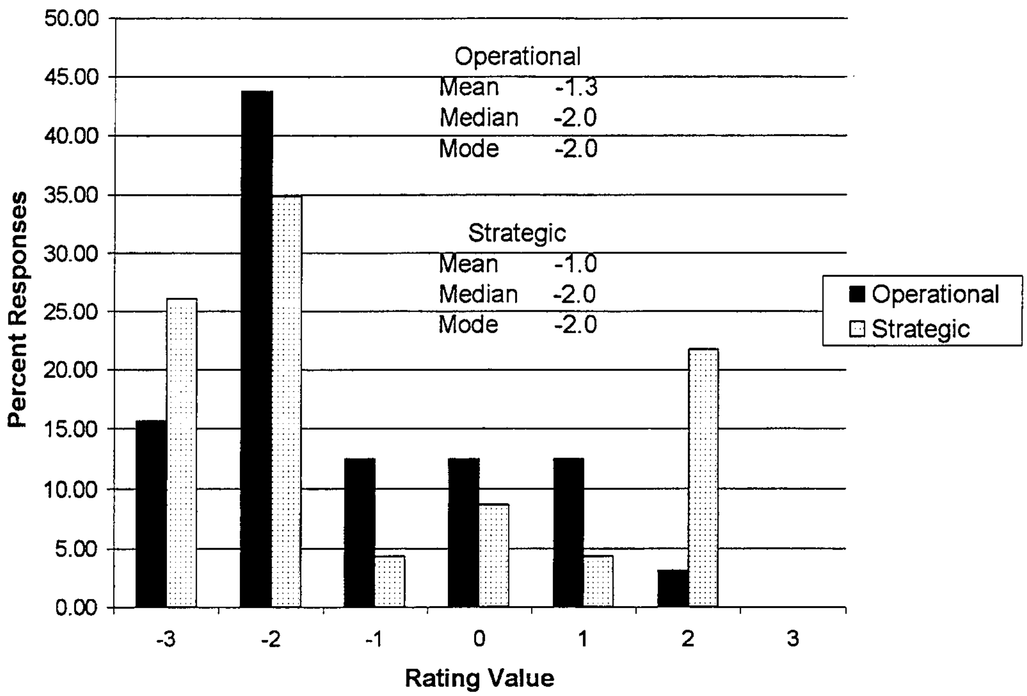

Figure 6.28. Percent Rating Responses for *Resources*, by Level of Management

Figure 6.28 shows no significant difference between the levels of management in terms of dispersion or measures of central tendency. The median and mode values for the strata were the same. The only noticeable characteristic from Figure 6.19 is that over 20 percent of the strategic respondents selected a value of +2 (reasonably acceptable), suggesting that at least a portion of strategic managers considered CEI services a good candidate for outsourcing, based on *resources*. Based on this information, a *rating* value of –2 (reasonably unacceptable) was selected for both *operational* and *strategic* management levels.

Summaries of the measures of central tendency and the values selected for use in the Wilcoxon signed rank test are shown in Tables 6.15 and 6.16. Table 6.15 represents the data reflecting opinions of operational managers, while Table 6.16 represents the opinions of strategic managers.

Table 6.15. Mean, Median, Mode, and Selected Rating Value for Operational Management

Issue	Mean	Median	Mode	Value Selected
Cost	–2.2	–3.0	–3.0	–3
Ability	0.0	–1.5	–2.0	–2
Risk	–0.8	–1.0	–2.0	–1
Quality	–1.5	–2.0	–1.0	–2
Strength	–0.4	–1.0	–2.0	–2
Legal Barriers	0.4	0.0	0.0	0
Employment	–1.5	–2.0	–3.0	–3
Political Pressure	–0.8	–1.0	–2.0	–1
Resources	–1.3	–2.0	–2.0	–2

Table 6.16. Mean, Median, Mode, and Selected Rating Value for Strategic Management

Issue	Mean	Median	Mode	Value Selected
Cost	–2.4	–3.0	–3.0	–3
Ability	–0.1	0.5	2.0	1
Risk	–0.4	0.0	0.0	0
Quality	–1.4	–1.0	–1.0	–1
Strength	–0.2	0.0	2.0	2
Legal Barriers	0.5	0.5	2.0	2
Employment	–1.1	–2.0	–2.0	–2
Political Pressure	–0.6	0.0	0.0	0
Resources	–1.0	–2.0	–2.0	–2

In general, little difference was observed in the *rating* values between operational and strategic management levels. Overall, operational managers considered CEI services a poor candidate to some degree on all of the issues, except for the issue of *legal barriers*, on which no preference was indicated. Strategic managers had a slightly more positive outlook as to the opportunity for outsourcing CEI services based on the *ability, strength,* and *legal barriers* issues.

Ranking

In similar fashion as the comparison between FDOT and TxDOT, Tables 6.17 and 6.18 show the mean, median, mode, and selected *ranking* values for use in the Wilcoxon signed rank test.

Table 6.17. Mean, Median, Mode, and Selected Ranking Value for Operational Managers

Issue	Mean	Median	Mode	Value Selected
Cost	7.5	9.0	10	8
Ability	7.4	8.0	10	8
Risk	6.6	7.0	8	7
Quality	7.9	9.0	10	9
Strength	5.2	5.0	5	5
Legal Barriers	4.2	4.0	3	4
Employment	7.4	7.5	10	8
Political Pressure	5.7	6.0	8	6
Resources	7.2	7.5	10	8

Table 6.18. Mean, Median, Mode, and Selected Ranking Value for Strategic Managers

Issue	Mean	Median	Mode	Value Selected
Cost	9.0	10.0	10	10
Ability	8.9	9.0	10	9
Risk	7.6	8.0	8	8
Quality	9.4	10.0	10	10
Strength	6.5	6.0	3	6
Legal Barriers	5.8	5.5	5	5
Employment	7.0	8.0	10	8
Political Pressure	5.7	6.0	5	6
Resources	7.6	9.0	10	9

Rank Correlation Coefficients

The rank correlation coefficients of the critical issues were the first step in identifying interrelationships among the variables. The values can range from –1 to +1, depending upon the degree of association. A value of one indicates perfect correlation, and a value of zero indicates no correlation. The rank correlation coefficients were calculated by using Equation 6.1 as shown in the **Development of Methodology** section. Table 6.19 is a summary of those rank correlation coefficients for the TxDOT respondents only.

Table 6.19. Rank Correlation Coefficients for Critical Issues

	Cost	Ability	Risk	Quality	Strength	Legal Barriers	Employment	Political Pressure	Resources
Cost	1	0.226	0.042	0.233	0.187	0.331	0.162	0.435	0.361
Ability		1	0.618	0.673	0.427	0.407	0.458	0.279	0.677
Risk			1	0.648	0.516	0.614	0.603	0.210	0.621
Quality				1	0.469	0.564	0.407	0.332	0.661
Strength					1	0.546	0.521	0.153	0.604
Legal Barriers						1	0.467	0.336	0.443
Employment							1	0.065	0.517
Political Pressure								1	0.275
Resources									1

The higher values of the rank correlation coefficients indicate a higher degree of association between the variables. For example, the rank correlation coefficient for the variables *Ability* and *Resources* was 0.677, whereas the rank correlation coefficient for the variables *Political Pressure* and *Employment* was 0.065. This indicated that issues of *Ability* and *Resources* were more closely associated than *Political Pressure* and *Employment*, for this given sample.

The italicized values in Table 6.19 were used to demonstrate the test of significance. The variables required were: sample size *n*, number of variables, and level of confidence α. Table 6.20 shows the steps of the procedure in order to determine the significance of the rank correlation coefficients.

Table 6.20. Rank Correlation Coefficient Significance

Issue X	Issue Y	r	n	$\nu = n - 2$	α	r_{tab}	Is $r > r_{tab}$?	Result
Resources	Ability	0.677	55	53 (50)	0.95	0.273	Yes	Interdependent
Political Pressure	Cost	0.435	50	48 (50)	0.95	0.273	Yes	Interdependent
Political Pressure	Employment	0.065	54	52 (50)	0.95	0.273	No	Independent

The relationship of association between two variables can also be shown graphically. This provides information as to the dispersion of responses. The more dispersed the responses, the less association between the issues. Figures 6.29 through 6.31 show dispersion of the issues. Issue X is shown on the horizontal axis and issue Y is shown on the vertical axis. The location of the circle indicates pairs of responses given for the particular pair of issues. The size of the circle represents the number of times a response was given for that particular response pair. The larger the circle, the more responses given for that particular response pair.

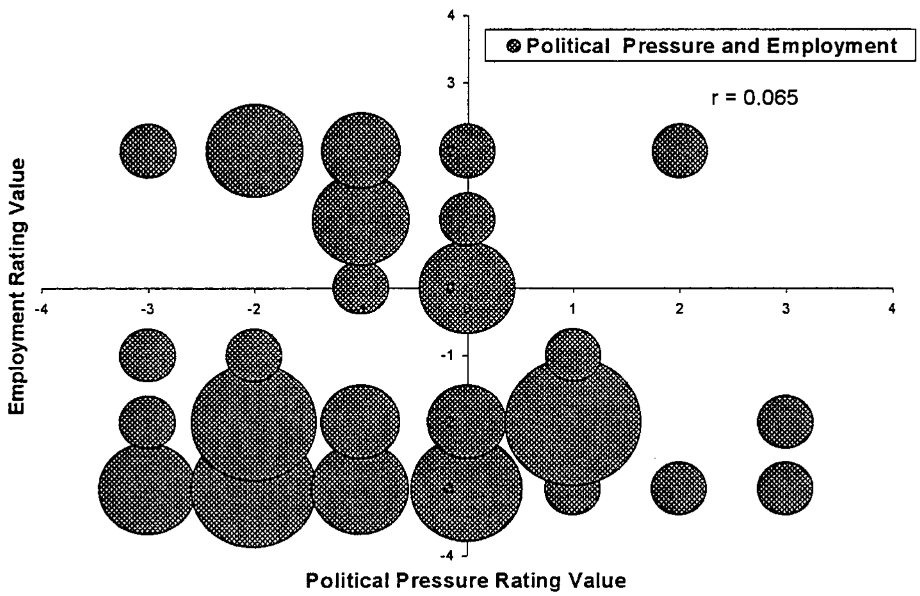

Figure 6.29. Paired Responses for *Political Pressure* and *Employment*

Figure 6.29 shows wide dispersion over the entire plot area with no noticeable linear grouping. The corresponding *r* for this plot was 0.065, indicating almost no association.

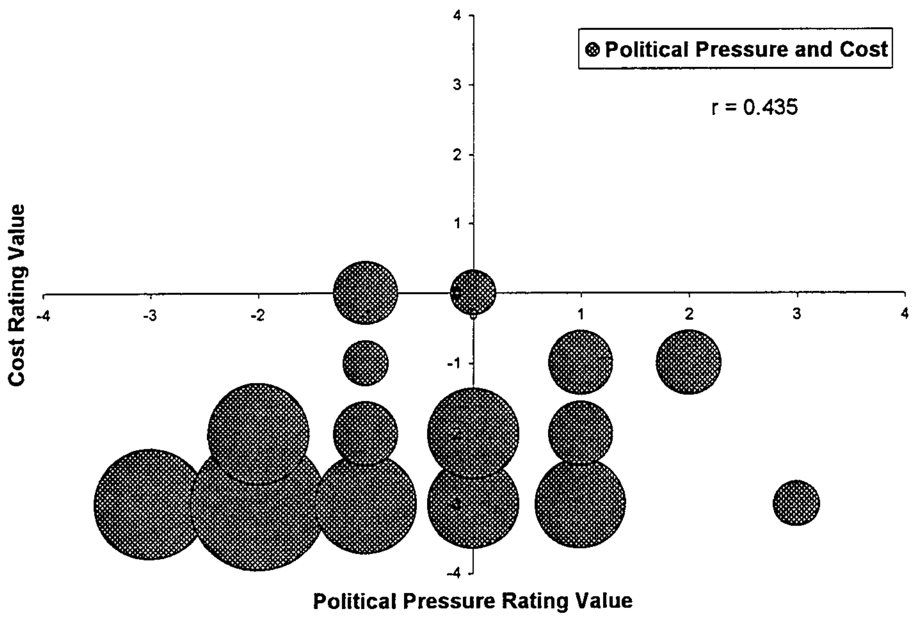

Figure 6.30. Paired Responses for *Political Pressure* and *Cost*

Figure 6.30 shows a concentration of the response pairs in the lower left quadrant of the graph. This indicates that for the pair of issues, respondents generally viewed the job function as a poor candidate for outsourcing. The data was dispersed across the lower portion of the graph, and there appeared to be little correlation between the two issues.

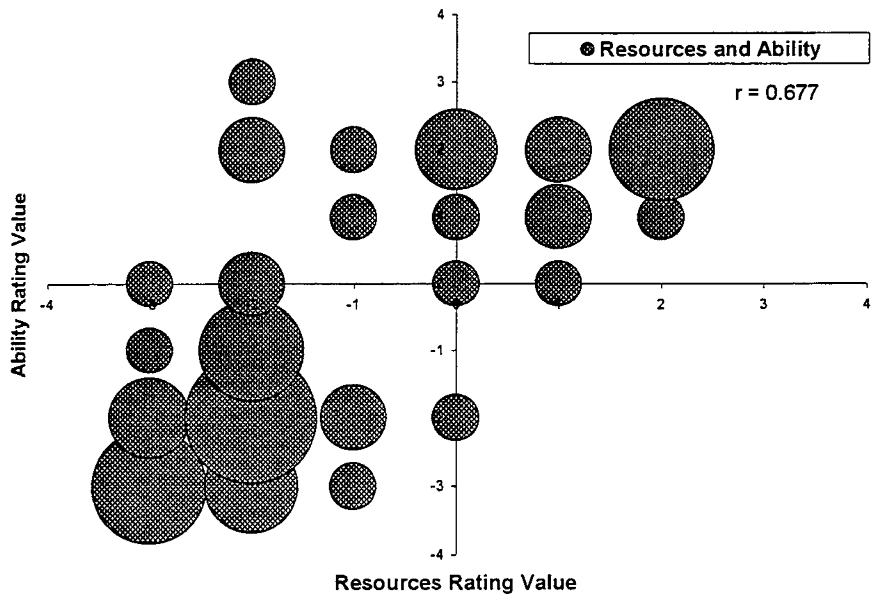

Figure 6.31. Paired Responses for *Resources* and *Ability*

Figure 6.31 is the response pair *resources* and *ability*. The rank correlation coefficient for this pair was 0.677. The data appeared to be closely grouped around an imaginary line running from the coordinates (–3, –3) to (3, 3) on the plot. This grouping corresponded to a higher rank correlation coefficient. Based on the three plots provided, correlation appears to be a relatively conservative measure of the degree of association between two variables. On this basis, any r value under 0.6 is assumed to be uncorrelated. The rank correlation coefficient and the graphs can be used to help the analyst draw conclusions regarding potential relationships between the issues analyzed. Given the qualitative nature of the data, the best method for analyzing the data is to plot the data and visually inspect for association between the variables.

Chi-square Test of Independence

Another test for measuring the significance of association between two variables is the chi-square test of independence. The test was performed on one pair of issues, *political pressure* and *cost*. The initial assumption for the test was that variables were independent. The alternative hypothesis, H_1, was that variables were not independent. This is rewritten as:

H_o: The two criteria of classification are independent

H_1: The two criteria of classification are not independent

The observed cell frequencies are placed in a contingency table. From this table, the expected cell frequencies are calculated using equation 6.6. Table 6.21 summarizes the observed frequencies for the response pairs. Table 6.22 shows the expected cell frequencies calculated using the data in Table 6.21.

Table 6.21. Chi-square Observed Values, *Political Pressure* and *Cost*

		Cost							
		–3	–2	–1	0	1	2	3	Total
	–3	6	0	0	0	0	0	0	6
	–2	9	5	0	0	0	0	0	14
Political Pressure	–1	5	2	1	2	0	0	0	10
	0	4	4	0	1	0	0	0	9
	1	4	2	2	0	0	0	0	8
	2	0	0	2	0	0	0	0	2
	3	1	0	0	0	0	0	0	1
Total		29	13	5	3	0	0	0	50

Table 6.22. Chi-square Expected Values, *Political Pressure* and *Cost*

		Cost							
		–3	–2	–1	0	1	2	3	Total
	–3	3.48	1.56	0.6	0.36	0	0	0	6
	–2	8.12	3.64	1.4	0.84	0	0	0	14
Political Pressure	–1	5.8	2.6	1	0.6	0	0	0	10
	0	5.22	2.34	0.9	0.54	0	0	0	9
	1	4.64	2.08	0.8	0.48	0	0	0	8
	2	1.16	0.52	0.2	0.12	0	0	0	2
	3	0.58	0.26	0.1	0.06	0	0	0	1
Total		29	13	5	3	0	0	0	50

Before the value of χ^2 can be calculated, it is necessary to reduce the expected frequency table to obtain a minimum expected frequency value of at least 2 in each cell. This reduction is accomplished by adding adjacent rows or columns until the minimum expected cell frequency is obtained. After the expected cell frequency table is reduced, the observed cell frequency table is reduced in the same manner, in order to match the same number of rows and columns in the expected cell frequency table. Table 6.23 shows the reduced table for the observed and the expected cell frequencies for the pair of variables.

Table 6.23. Chi-square Reduced Observed and Expected Cell Frequencies, *Political Pressure* and *Cost*

	Cost							
	Observed				Expected			
		−3	−2	Total		−3	−2	Totals
	−3	6	0	6	−3	3.48	2.52	6
Political Pressure	−2	9	5	14	−2	8.12	5.88	14
	−1	5	5	10	−1	5.8	4.2	10
	0	4	5	9	0	5.22	3.78	9
	1	5	6	11	1	6.38	4.62	11
	Total	29	21	50	Totals	29	21	50

The computed value of the test statistic, χ^2, by equation 6.7 is

$$X^2 = \frac{(6-3.48)^2}{3.48} + \frac{(9-8.12)^2}{8.12} + \ldots + \frac{(6-4.62)^2}{4.62}$$

$$= 10.53$$

The degrees of freedom, ν, are $(5-1)(2-1) = 4$. If the test statistic, χ^2, is greater than the tabulated value $\chi^2_{\alpha,\nu}$, then H_o is rejected. For this test, a level of confidence, α, of 0.95 was chosen. This was done to compare the results from the rank correlation coefficient and the chi-square test at the same level of significance. Because $\chi^2_{0.05,\,4}$ equals 9.488, and 10.53 is greater than 9.488, H_o is rejected at the 0.95 level of significance. The conclusion from the chi-square test is that *political pressure* and *cost* are not independent and that correlation between the two variables does exist. This is consistent with the results from the rank correlation coefficient for the same pair of variables.

The issues of *political pressure* and *cost* were found to be dependent of one another. In this case, the analyst may wish to consider modifying the weight (ranking) values of the two issues, as they pertain to the importance of the decision-making process, and then perform the Wilcoxon signed rank test again.

If H_o were rejected for *political pressure* and *cost*, which had a rank correlation coefficient of 0.435, then it stands to reason that pairs of issues that possess higher rank correlation coefficients will also produce similar results via the chi-square test of independence. For this sourcing study, given its subjective nature, the conservative tendency of the correlation coefficients, and the comparison between the rank correlation coefficients and the chi-square test, an *r* value of 0.600 is recommended for use as the threshold in determining association using rank correlation coefficients.

Wilcoxon Signed Rank Test

The Wilcoxon signed rank test was conducted under the assumption that all of the issues were independent. This was assumed because the critical issues selected were believed to be separate issues that the decision maker would contemplate when analyzing a sourcing option. The issues were thought to be independent, each having a separate impact upon the sourcing decision. Hypothesis H_0 was that the candidate job function was a bad candidate for outsourcing. The alternative hypothesis H_1 was that the candidate job function was not a bad candidate for outsourcing, at a given α level of significance. This can be represented by:

$$H_o: M \leq M_o, \qquad H_1: M > M_o$$

This states that the hypothesized median M_o is less than the actual median. In this study, the hypothesized median was zero. If there was no preference to sourcing of the job function, the value would be zero, since the rating scale is given from –3 to +3. The purpose of the test was to see if the job function was "not a bad candidate"; therefore, the assumption was that the job function was a bad candidate until proven good, hence $M \leq M_o$.

Comparing TxDOT to FDOT

From the values of the *rating* and *ranking* portions of the survey given in Tables 6.9 through 6.12, the process to obtain the test statistic began. To find the difference from the hypothesized median, D_I, the hypothesized median M_o was subtracted from each observation X_i. Since M_o were equal to zero, then D_I equaled the observed value X_i. If any X_I were equal to zero, it should be eliminated from the calculations and the sample size reduced accordingly.

The *rating* value and the *ranking* value were multiplied together. Following this step, the absolute differences were ranked from smallest to largest. In the event of a tie, each tied value was assigned the mean of the rank positions occupied by the differences that were tied. Next, each rank was assigned the sign of the difference of which it was the rank. The sum of the ranks of the negative signs, called T_-, was calculated. Summary of these steps for data reduction of the Wilcoxon signed rank test for TxDOT and FDOT is shown in Tables 6.24 and 6.25.

Table 6.24. Wilcoxon Data Reduction Table for FDOT

Issues	Rating	Ranking	R*R	Rank	Sign (+)	Sign (–)
Cost	–2	6	–12	5		5
Ability	3	9	27	9	9	
Risk	3	6	18	7	7	
Quality	1	9	9	2	2	
Strength	2	6	12	5	5	
Legal Barriers	3	4	12	5	5	
Employment	1	5	5	1	1	
Political Pressure	2	5	10	3	3	
Resources	3	8	24	8	8	
Sum Totals (T)					40	**5**

Table 6.25. Wilcoxon Data Reduction Table for TxDOT

Issues	Rating	Ranking	R*R	Rank	Sign (+)	Sign (–)
Cost	–3	10	–30	7		7
Ability	–1	9	–9	2		2
Risk	0	7	0			
Quality	–1	10	–10	3.5		3.5
Strength	0	6	0			
Legal Barriers	2	5	10	3.5	3.5	
Employment	–1	8	–8	1		1
Political Pressure	–2	7	–14	5.5		5.5
Resources	–2	8	–14	5.5		5.5
Sum Totals (T)					3.5	**24.5**

From the above data, the hypothesis testing for candidacy for the sample job function was performed. Exact probability levels (P) are given for all possible rank totals (T) that yield a different probability level. H_o was rejected at the α level of confidence if T_- was less than or equal to T_{tab} for *n* and the preselected. A level of confidence of 0.80 was used for the hypothesis testing. The steps of the Wilcoxon signed rank test for FDOT and TxDOT are shown in Table 6.26.

The original sample size for all tests was nine. This corresponds to the number of critical issues identified. TxDOT had no preference on two of the issues, *risk* and *strength*, eliminating them from the test and reducing the sample size to seven.

Table 6.26. Wilcoxon Hypothesis Testing for FDOT and TxDOT

Agency	α	Sample Size n	T_-	T_{tab}	Is $T_- \leq T_{tab}$	Reject or Accept H_o	Result
FDOT	0.80	9	5	14	Yes	Reject	Not a bad candidate
TxDOT	0.80	7	24.5	8	No	Accept	Bad candidate

For FDOT, H_o was rejected and the result was that CEI services were considered not a bad candidate for outsourcing. The contrary was determined from TxDOT. This is not unexpected given the initial review of the candidate job function from Figures 6.2 through 6.10. The test confirmed intuition regarding the viability for outsourcing of CEI services. Results from that strata of the sample population considered CEI services a bad candidate for outsourcing. Reasons for the difference in results from FDOT to TxDOT include:

- FDOT outsourced 40 percent of CEI services. FDOT had the political, legal, and contractual mechanisms in place in order to accomplish the task. TxDOT, on the other hand, was still in the infancy of contracting out CEI services and had not clearly identified the procedures required to accomplish the task.
- FDOT had a constrained level of FTEs and a construction budget greater than the available manpower.
- TxDOT's Project Implementation Task Force came to the conclusion that outsourcing CEI services was not a plausible concept.

- TxDOT has not reached the point at which the construction budget is in excess of the restricted manpower available to construct the work.

Comparing Levels of Management

In similar fashion, the Wilcoxon signed rank test of significance was performed on the data, stratified by the level of management. This was to compare level of management to the sourcing decision. Tables 6.27 and 6.28 show the summary of data reduction for operational and strategic management levels, respectively. As mentioned previously, data from the TxDOT sample was used in the comparison between management levels.

Table 6.27. Wilcoxon Data Reduction Table for Operational Managers

Issues	Rating	Ranking	R*R	Rank	Sign (+)	Sign (–)
Cost	–3	8	–24	7.5		7.5
Ability	–2	8	–16	4.5		4.5
Risk	–1	7	–7	2		2
Quality	–2	9	–18	6		6
Strength	–2	5	–10	3		3
Legal Barriers	0	4	0			
Employment	–3	8	–24	7.5		7.5
Political Pressure	–1	6	–6	1		1
Resources	–2	8	–16	4.5		4.5
Sum Totals (T)					0	**36**

Table 6.28. Wilcoxon Data Reduction Table for Strategic Managers

Issues	Rating	Ranking	R*R	Rank	Sign (+)	Sign (–)
Cost	–3	10	–30	7		7
Ability	1	9	9	1	1	
Risk	0	8	0			
Quality	–1	10	–10	2.5		2.5
Strength	2	6	12	4	4	
Legal Barriers	2	5	10	2.5	2.5	
Employment	–2	8	–16	5		5
Political Pressure	0	6	0			
Resources	–2	9	–18	6		6
Sum Totals (T)					7.5	**20.5**

For the operational management level, the issue of *legal barriers* was removed from the calculations because the observed value was equal to the hypothesized value, zero. This reduced the sample size from nine to eight. In similar fashion, the issues of *risk* and *political pressure* were removed from the strategic management level calculations, reducing the sample size to seven. The steps of the Wilcoxon signed rank test for the two levels of management are shown in Table 6.29.

Table 6.29. Wilcoxon Hypothesis Testing for Level of Management

Management Level	α	Sample Size n	T_-	T_{tab}	Is $T_- \leq T_{tab}$	Reject or Accept H_o	Result
Operational	0.80	8	36	11	No	Accept	Bad candidate
Strategic	0.80	7	20.5	9	No	Accept	Bad candidate

For both levels of management, H_o was accepted and the result was that CEI services were considered a bad candidate for outsourcing. Comparison of the degree to which outsourcing CEI services is a bad candidate cannot be explored. The test for significance indicates only the significance of the issue, at a given α, not the degree. This makes it more imperative that the data be disaggregated into levels of management in order to evaluate the opinions of the various levels of decision makers.

Revised Critical Issues

The example of the Wilcoxon signed rank test was performed using the nine critical issues originally identified from Table 6.4. From the rank correlation coefficients, the issue of *ability* appeared to be associated with a number of other variables. The three pairs of issues and their possible relationships are identified below.

- *Ability* and *risk*. The amount of risk exposure can depend upon the agency's ability to manage the contract. Legal risk may be present if the agency is not capable of maintaining control mechanisms over privatized service.
- *Ability* and *quality*. The quality of the service provided can be directly impacted by the agency's ability to monitor the contract and establish measurement of quality and quantity of the service.
- *Ability* and *resources*. The resources available to the agency may or may not be best utilized monitoring the contract. If the resources are not available to monitor the

contract, then the candidate job function becomes a poor candidate for *ability* and *resources*.

Having identified relationships between the variables, the issue *ability* was removed from the data set and the Wilcoxon signed rank test was performed again to see if any difference in the statistical significance of the sourcing decision resulted. For the comparison between agencies, the sample size decreased by one for both TxDOT and FDOT. Following the steps of the statistical test, the same results occurred. No change in the statistical results occurred due to the removal of the issue *ability*.

Summary

Based upon the agencies involved (TxDOT and FDOT) and on the level of management (TxDOT), the opportunity for outsourcing CEI services was compared. From the Wilcoxon signed rank test, FDOT considered the outsourcing of CEI services to be reasonable, at an α of 0.80. TxDOT considered CEI services a bad candidate for outsourcing, at an α of 0.80. Within TxDOT, both strategic and operational managers considered CEI services to be a bad candidate for outsourcing. The rank correlation coefficients helped identify associated issues. Variables with a rank correlation coefficient greater than 0.600 were considered associated. The chi-square test of independence tested a pair of variables that were associated based on the rank correlation coefficients. The result was the chi-square test mirrored the result from the rank correlation coefficients. The chi-square test determined dependence between the pair of issues. When this condition exists, it is recommended that the analyst reduce the *ranking* values from the original data, and rerun the Wilcoxon signed rank test, to determine if any noticeable difference in the statistical test exists. This understanding of associations between the variables is very important to decision making utilizing this methodology, and to multiple criteria decision making.

CONCLUSIONS

Application of Sourcing Methodology

The sourcing methodology was designed to be an evaluation tool for decisions regarding sourcing of job functions. The sourcing methodology provides an organized method to analyze opinions of decision makers as to sourcing decisions. Results from the methodology should be used as a tool rather than as policy in the sourcing of job functions. The final determination as to sourcing decisions must be made by the decision makers.

If the Wilcoxon signed rank test returns a result of the job function being a bad candidate for outsourcing, and the ultimate decision is to not outsource the job function, the decision maker has elected to concur with the opinions of various managers surveyed. This maintains the status quo in the agency and can avoid potential problems associated with implementing an organizational change inconsistent with the opinions of staff involved with the change. Conversely, if the Wilcoxon signed rank test returns a result of the job function being a good candidate for outsourcing, and the ultimate decision is to outsource the job function, then there will be minimal opposition and barriers to the implementation of such an action.

If the decision maker elects to outsource a particular job function when the results of the survey indicate a different preference, there may be some opposition within the organization to the implementation of such actions. The evaluation methodology provides the decision maker with opinions of the managers regarding sourcing of a particular job function. If the preference of the managers is to not outsource the job function and the decision maker elects to do the contrary, then the decision maker has a compilation of the potential problem issues that will need to be addressed in order to successfully outsource the job function. This gives the decision maker advance knowledge of sourcing preferences of the managers closest to the job function, prior to the actual outsourcing implementation. Petitioning information from agencies that have performed the candidate job function with private forces may help identify problems and possible solutions to overcome those problems. This information can be used to consider the impact on managers and an entire agency if a particular job function were to be performed by private forces versus agency staff.

If the managers believe the candidate job function is a good candidate for outsourcing, but the decision maker elects to keep the job in-house, then potential benefits which might have been identified by the managers could be missed, and performing an action contrary may not be the best use of available resources.

Comparing TxDOT to FDOT

Results from the tests indicated FDOT was comfortable having CEI services outsourced. Conversely, TxDOT decision makers considered CEI services a bad candidate for outsourcing. Based on conflicting results from FDOT, further investigation into the plausibility of outsourcing CEI services may be warranted, prior to considering outsourcing of the job function. Some of the issues presenting the largest opposition, such as *employment* and *risk,* should be investigated.

Comparing Levels of Management

The results indicated that both operational and strategic managers within TxDOT perceive CEI services to be a bad candidate for outsourcing. Information from this type of comparison may be used to draw conclusions about the degree to which levels of management indicate their preference to sourcing options on the various issues.

Technical Comments on Sourcing Methodology

Rank Correlation Coefficients

The rank correlation coefficients provide a method to identify association between pairs of variables (issues). Association between variables is assumed for an r of 0.600 or greater. This test identified several pairs of variables with association. The conclusion of association between variables gives the decision maker additional information to help identify potential relationships between variables that could explain the association. Plots of frequency of response pairs for the *rating* values provide graphical representation of the dispersion of responses. Examples given in the report were between *cost* and *quality*, and *resources* and *ability*.

Chi-square Test of Independence

The chi-square test of independence provides another method to identify dependency between two variables. This test was used to confirm results from the rank correlation coefficients and to assist in identifying a threshold for the identification between association and no association. Both the rank correlation coefficients and the chi-square test of independence provide a measure of the association between variables. If association is found between variables, then the decision maker should consider revisiting the original ranking values and adjust them to reflect dependence, and rerun the Wilcoxon signed rank test.

Wilcoxon Signed Rank Test

The Wilcoxon signed rank test is an appropriate test for analysis of qualitative and subjective data. The test provides a relatively quick analysis of data gathered from the surveys. The results provide a statistical method to analyze opinions of managers closest to the job function. However, the decision as to whether to follow the result of the statistical test is left to the decision maker.

RECOMMENDATIONS AND AREAS FOR FURTHER RESEARCH

Recommendations from this research and development of a quantitative evaluation methodology for the sourcing of public-sector job functions are listed below.

- The methodology presented in this report should be used as a proactive decision tool to help decision makers in their sourcing decision for particular job functions. The methodology can be adapted to analyze a variety of job functions.
- The methodology should be used as a quick, initial investigation into the plausibility of outsourcing a particular job function. If a more detailed systems approach is desired, then one should consider the decision process tool developed by the Construction Industry Institute (13), as it is described in the implementation section.
- The list of critical issues to the sourcing decision is a generic list compatible with a variety of job functions. The list is not inclusive, and conditions present when analyzing a particular job function may necessitate the development of additional issues.

- When analyzing a particular job function, one should attempt to gather opinions of decision makers outside the candidate agency, selecting agencies with experience in utilizing private forces for the candidate job function. This provides an additional point of reference for the various issues included in the sourcing study.
- One should select those individuals closest to the candidate job function: individuals from both operational and strategic managerial levels.
- Comparison between agencies and between levels of management provides insight into how the agencies and managers perceive the opportunity for outsourcing a particular job function.
- The calculation of rank correlation coefficients provides a measure of association between the variables. Based upon this sourcing study an r of 0.400 indicates association between the variables.
- If association is established between two variables, then the preferred method is to revisit the critical issues and rebuild the questionnaire. A time-saving method is to identify possible relationships between the variables and remove the associated variable from the data set prior to performing the Wilcoxon signed rank test.
- The chi-square test of independence may be used on selected pairs of variables identified from the rank correlation coefficients. This test confirms the results of the rank correlation coefficients.
- When association is found between variables, the decision maker should analyze the relationship between variables and consider modifying the original sourcing study. The critical issues selected should reflect the associated issue in the definition. Another alternative is to remove the associated issue from the list of critical issues, prior to performing the Wilcoxon signed rank test.

If further investigation into the degree of difference between levels of management or between agencies is desired, then statistical comparison between the two means of the various issues may provide additional insight. While this is outside the scope of this report, it may prove beneficial in identifying the degree of difference between the compared classifications.

Based on the results from comparison between FDOT and TxDOT regarding outsourcing of CEI services, further investigation into how FDOT utilizes private forces to accomplish the work is required. Issues such as contract development, contract management, risk sharing, and performance standards should be addressed, prior to outsourcing CEI services. Given the political mandates by the Texas legislature regarding engineering services, the level of FTEs and the agency's budget, TxDOT will eventually have to consider other job functions for outsourcing. In efforts to utilize resources in the most efficient manner possible, TxDOT should analyze its current job functions, define job functions as core and non-core as they relate to the success of its mission and vision, and consider the most viable candidates for outsourcing

IMPLEMENTATION

A strong and efficient TxDOT staff is fundamental to the fulfillment of the agency's mission as delineated in the Texas Constitution and subsequent legislative actions. Implementation of this research study will enhance TxDOT's ability to conduct comprehensive outsourcing policy assessments. These assessments will produce better public policy for the people and a more sound operating agency for TxDOT management. The techniques developed by the research study will also facilitate an objective, quantitative analysis of various legislative mandates for outsourcing TxDOT's functional activities. These legislative requirements are not always framed in a manner that solicits a fully documented impact analysis, and the results of the research study will fill that gap. Also, the products of the research study will enhance TxDOT management's ability to conduct accurate and timely agencywide and district-level analyses of individual outsourcing options. Since the outsourcing impacts and potentialities may vary from management level and within geographic districts, this research is important to support differentiated decisions about outsourcing which will lead to better and more effective overall resource utilization. Finally, the implementation of the research results will facilitate TxDOT's development of an objective, systematic rationale for incorporating outsourcing into the agency's strategic planning and management.

The sourcing methodology developed in this study should be used as a quick and initial investigation into the plausibility of outsourcing a particular job function. If a more detailed, systems approach is desired, then consider integrating this methodology (TTI model) with the sourcing model developed by the Construction Industry Institute (CII). Each model must be adapted, validated, and then applied in practice to ensure that the general model needed by

TxDOT performs as expected. The final product may provide the necessary substantiation for translating the decision into a policy, and for explaining related issues to the key decision makers and the legislature. A conceptual illustration of the possible adaptation and integration of the TTI and CII models is presented, using the Construction Engineering and Inspection (CEI) job function. For simplicity, two main components of the CII process are addressed and include: 1) Determine Key Job Functions; and 2) Evaluate Sourcing of Job Functions.

Determine Key Job Functions

Under this action, key job functions considered for outsourcing are first identified by the decision maker (e.g., district engineer). Some specific reasons for such consideration could be legislative mandates, TxDOT policy, the magnitude of resources associated with the function, or simply a recommendation from TxDOT for assessing the feasibility of outsourcing a job function. Construction Engineering and Inspection is identified as a function that can be outsourced. The next step is to describe the function in terms of sub-functions and critical capabilities. For example, several sub-functions for CEI could include:

- Staking,
- Conducting or attending pre-construction meetings,
- Performing filed sampling and testing of materials,
- Inspecting, documenting, and preparing progress reports and final estimates,
- Computing final quantities and costs,
- Preparing change orders, and
- Claims investigation.

Several critical capabilities are listed next and might include the following for CEI:

- Surveying of knowledge and expertise,
- Understanding of material properties,
- Testing of requirements related for different materials,
- Ability to interpret drawings and specifications,
- Ability to administer TxDOT procedures, and
- Good communication skills.

It may be necessary or more efficient to carry out some of these sub-functions in-house, and some may be better outsourced. Thus, in the next step, the decision maker would prioritize the sub-functions in the order of the most to the least important. This could aid in deciding which functions should remain in-house and which are considered best for outsourcing. Selection of issues critical to the sourcing decision will also be based upon factors described in Table 6.6 (**Issues Critical to the Sourcing Decision of Job Functions**), and interviews with agency managers and engineers familiar with the function. For the purpose of conducting the sourcing study, the issues will be clearly defined, and additional points that need to be considered for each of those issues shall be explained to the respondent. For example, the additional points to be considered in the context of the critical issue of *risk* are:

- Ability of the contractor(s) to complete the contract of the service,
- Consequences of any service interruptions,
- Legal implications of outsourcing,
- Risk of corruption,
- Responsibility for inability to meet the schedule or budget, and
- Possibility of collusion among contractors.

The sourcing decision will primarily depend upon whether the function is core or otherwise. If its existence is intrinsically intertwined with the long-term viability of the organization, a function would generally be classified as core. Thus, a function identified as a core function would, by virtue of the definition, have to be conducted in-house. The quantitative evaluation methodology for the sourcing of public-sector job functions developed by TTI is a tool that can be used to arrive at a decision regarding whether a job function is core or non-core. Based on the conclusions of this study, the construction engineering and inspection function was considered a function that should be performed in-house most of the time. Thus, for purposes of this illustration, CEI is considered a core job function.

Evaluate Sourcing of Job Functions

Evaluating the sourcing of job functions considers both agency and contractor capabilities and resource availability. The decision maker wants to ensure that any job function performed by a contractor (or consultant) can be performed successfully. Further, if the job function is outsourced, the agency will still remain involved in the function in some capacity such as providing oversight or input. This assessment should be made as part of the sourcing decision. The first step in evaluating the sourcing of a job function depends upon whether the function is core or non-core. If it is considered core, such as the CEI function, then the decision maker must determine if available staff has the critical capabilities needed to perform the job function. If the answer is yes, then the decision maker determines the type of work relationship the agency might have with a contractor. The feasibility of using any one of several different possible agency/contractor work relationships will be assessed, for each of the sub-functions. The possible relations are listed in Table 6.30 below as identified in the CII model (these work relationships may be different for TxDOT).

Table 6.30. Owner/Contractor Work Relationships

Relationship Descriptor	Description of Five Possible Work Relationships
OP	Strictly performed by the owner (agency)
OP/CI	Owner performed using owner's work process, with contractor input
OL/CP	Owner led using owner's work process, with the contractor performing the work
CP/OI	Contractor performed using contractor's work process, with input from the owner
CP	Strictly performed by the contractor (The owner/agency provides project management oversight)

In the case of the CEI job function, the decision maker may decide that all sub-functions should be performed by agency personnel only (OP). Thus, no contractor involvement is required. Alternatively, the agency may want the contractor to perform quality control (QC) functions while the agency performs quality assurance (QA). A work relationship like an owner-lead/contractor-performed(OL/CP) might be used, for example. As another illustration, the decision maker might decide that construction staking should be the purview of the contractor and the agency may check only contractor staking. This would be a contractor-performed/owner-input (CP/OI) relationship. In making these decisions, a number of factors, such as risk, legal issues, and quality requirements should be considered and incorporated into the decision-making process.

After the work relationship is selected, the agency must determine whether the resources are available to perform the job functions. This may depend upon project size. When a contractor is involved in any job function, the decision maker should evaluate the contractor's ability to perform his/her portion of the job function. Important considerations should be whether or not contractors have the critical capabilities and resources available to perform the function consistent with agency standards. For example, construction staking should not be a problem for most contractors. However, a contractor's ability to perform QC functions may not be as high, especially if statistical sampling is required.

This sourcing evaluation process is repeated for all key functions. Finally, a review for alignment will serve as a check for examining whether or not the sourcing decisions are consistent with the agency policy. Some or all steps of the process may have to be revisited after the review.

A preliminary list of functions and activities that may be considered for outsourcing or in-house analysis is given below:

1. Administration
    - training
    - staff programs
    - database management

2. Accounting
    - record-keeping
    - database management

3. Information Resources
    - material printing
    - graphic development
    - media development

4. Human Resources
    - administrative, clerical, and receptionist functions (filing and paperwork)
    - telecommunication services (phone answering and message taking)
    - employee benefits area (insurance and data handling)
    - maintenance of employee records
    - payroll functions
    - data entry (102 function and related forms)
    - hiring processes (pre-employment screening)

5. Planning
   - non-highway studies
   - traffic surveys
   - traffic studies
   - research projects
   - ramp studies
   - corridor studies
   - environmental impact studies
   - schematics
   - plan preparation

6. Design
   - surveying and mapping
   - location studies
   - plans and specifications
   - environmental clearance reports
   - design/build (turnkey)

7. Construction Inspection
   - inspecting, documenting, and preparing progress reports and final estimates
   - field sampling and testing of materials
   - computing final quantities and costs
   - preparing change orders
   - investigating claims

8. Traffic Operations
   - traffic circulation studies
   - speed zone studies
   - speed zone maps
   - traffic signal analysis
   - traffic signal design
   - normal vehicle counts and turning movements
   - engineering studies and analysis
   - equipment maintenance and repair
   - striping, signal, and drafting operations

REFERENCES

1. *Outsourcing of State Highway Facilities and Services.* NCHRP Synthesis 246. Transportation Research Board, Washington D.C., 1997.

2. State of Texas. House Bill 9, Chapter 7, 72nd Legislature – First Called Session, 1991.

3. Ward, W.V., C. Lee, and C. Bradley. *Utilization of Consultants by State Department of Highways and Public Transportation.* Center for Transportation Research, The University of Texas, Austin, Texas, January 1987.

4. *Utilization of Consulting Engineers for Highway Project Development.* Ernst & Whitney, Austin, Texas, May 1987.

5. Burke, D., R. Cavazos, A. Garcia-Diaz, and K. Tenah. *Utilization of Consultants by SDHPT.* Texas Transportation Institute Research Report 1100-1F, Texas Transportation Institute, Texas A&M University System, College Station, Texas, May 1987.

6. State of Texas. Senate Bill 370, Section 1.23, 75th Legislature – Regular Session, 1997.

7. *Report on District Operation Review.* TxDOT, Austin, Texas, January 1995.

8. *Introduction and Informative Outline.* State Council on Competitive Government, State of Texas, March 1997.

9. State of Texas. Civil Statues, Article 601b, Article 15, Part XVI, Chapter 401, November 1993.

10. Warren, D.R. *Defense Outsourcing: Challenges Facing DOD As It Attempts to Save Billions in Infrastructure Costs.* Testimony before the Subcommittee on Readiness, Committee on National Security, House of Representatives, Washington, D.C., 1997

11. *Evaluation of Candidate Services.* Arizona Department of Transportation, Competitive Government Committee, Phoenix, Arizona, May 1996.

12. *Pavement Maintenance and Rehabilitation: Workshop.* California Transportation Commission, July 1996.

13. Anderson, S. *CII Implementation Resource 111-2: Owner/Contractor Work Structure Process Handbook.* Construction Industry Institute, Austin, Texas, 1997.

14. Meister, D. *Behavioral Analysis and Measurement Methods.* John Wiley and Sons, Inc., New York, 1985.

15. Bendig, A.W. A Statistical Report on a Revision of the Miami Instructor Rating Sheet. *Journal of Educational Psychology*, Vol. 43, 1952, pp. 423-429.

16. Bendig, A.W. The Use of Student Rating Scales in the Evaluation of Instructors in Introductory Psychology. *Journal of Educational Psychology*, Vol. 43, 1952, pp. 167-175.

17. Bendig, A.W. The Reliability of Self-Ratings as a Function of the Amount of Verbal Anchoring and of the Number of Categories on the Scale. *Journal of Applied Psychology*, Vol. 37, 1953, pp. 38-41.

18. Bendig, A.W. Reliability and Number of Rating Scale Categories. *Journal of Applied Psychology*, Vol. 38, 1954, pp. 38-40.

19. Finn, R.H. Effects of Some Variations in Rating Scale Characteristics on the Means and Reliabilities of Ratings. *Educational and Psychological Measurement*, Vol. 32, 1972, pp. 255-265.

20. Jenkins, G.D., and T.A. Taber. A Monte Carlo Study of Factors Affecting Three Indicies of Composite Scale Reliability. *Journal of Applied Psychology*, Vol. 62, 1977, pp. 392-298.

21. Daniel, W.W. *Applied Nonparametric Statistics*, 2nd ed. PWS-KENT Publishing, Boston, Massachusetts, 1990.

22. Hamburg, M. *Statistical Analysis for Decision Making*, 2nd ed. Harcourt Brace Jovanovich, Inc., New York City, New York, 1977.

23. Dixon, W.J., and A.M. Mood. The Statistical Sign Test. *Journal of the American Statistical Association*, Vol. 41, 1946, pp. 557-566.

24. Conover, W.J. *Practical Nonparametric Statistics*, 2nd ed. John Wiley & Sons Inc., New York, 1980.

25. Thomas, C. *Sundown on Big Government*, The Texas Public Policy Foundation, San Antonio, Texas, 1997.

APPENDIX A
FUNCTIONS DELEGATED BY DIVISIONS TO DISTRICTS

Functions Delegated by Human Resources Division to Districts

1. Employment Opportunities • Districts process recruiting information. • Districts may have own recruiters. • Districts accept and process applications, and interview applicants.
2. Employee Relations • Management Team and District Engineer approve emergency leave requests for immediate family funerals, via policy revision. • Division works in conjunction with Districts.
3. Personnel Records Branch • Input of personnel status changes, also known as 102. • Districts responsible for entry, editing and accountability. • Via senior management team memorandum of agreement.
4. Personnel Administration • Basic data entry for: new hires on payroll, change in employee status, health insurance. • Via procedural changes.

Functions Delegated by Materials and Test Division to Districts

1. Evaluation of commercial lab equipment and personnel.
2. Measurement of concrete pavement cores to determine pay factors.

Functions Delegated by Occupational Safety Division to Districts

1. Administers following programs:
• Worker's Compensation Act.
• Tort Claims Act.
• Vehicle and equipment operator's liability insurance.
• Contractors' insurance requirements.
• Employees' exposure to hazardous materials.
• Employees' safety program.

Functions Delegated by Public Transportation Division to Districts

1. Contract preparation.
2. Development and maintenance of program of projects/updates to FAMS.
3. Annual application review and approval.
4. Review of transit element of all planning documents.
5. Maintenance of PTMS and related inventories DBE/HUB tracking and reporting.
6. Oversight/Reporting of contractor's drug and alcohol testing.
7. Grant and contract administration.

Functions Delegated by Traffic Operations Division to Districts

1.	Traffic safety grants.
2.	Engineer review of plans, specifications, and estimates.
3.	Signature of certain types of engineer agreements.
4.	Via policy issue statement (half decided on by senior management and half from Divisions).

Functions Delegated by Transportation Planning and Program Division to Districts

1.	Highway Performance Monitoring System (HPMS) - data gathering and validation.
2.	Texas Reference Marker System (TRM) - data gathering and evaluation installation of.
3.	Traffic control for data gathering equipment and activities.
4.	Districts organize public meetings/hearings for Statewide Plan or Corridor Studies.

Functions Delegated by Vehicle Titles and Registration to Districts

1.	Human resource support - job vacancy notices, attending training at district office locations, attending employee forums.
2.	Automation support.
3.	Vehicle maintenance.
4.	Procurement of furniture and office supplies.
5.	Miscellaneous needs (signs, framework, etc.).

Environmental Tasks for Natural Resources

		Tasks																	District
	District Name	1.0	1.1	1.2	1.3	1.4	1.5	2.0	3.0	4.0	4.1	5.0	6.0	7.0	8.0	9.0	10.0	11.0	Classification
1	Paris	D	D	D	D	ENV	D	D	ENV	D	ENV	D	D	D	ENV	D	D	NA	Rural
2	Fort Worth	D	ENV	D	D	ENV	D	ENV	ENV	D	ENV	ENV	D	ENV	ENV	D	D	NA	Metropolitan
3	Wichita Falls	D	ENV	D	D	ENV	D	NA	ENV	D	ENV	D	D	ENV	ENV	D	D	NA	Rural
4	Amarillo	D	ENV	E/D	D	ENV	ENV	NA	ENV	D	ENV	D	D	D	ENV	D	D	NA	Rural
5	Lubbock	D	D	D	D	E/D	D	NA	ENV	D	ENV	D	D	D	ENV	D	D	NA	Urban
6	Odessa	D	ENV	ENV	ENV	NA	ENV	NA	ENV	ENV	ENV	ENV	ENV	ENV	ENV	D	D	NA	Rural
7	San Angelo	D	D	D	ENV	ENV	ENV	NA	ENV	D	D	D	D	D	ENV	D	E/D	NA	Rural
8	Abilene	D	ENV	D	D	ENV	ENV	NA	ENV	D	ENV	D	D	D	ENV	D	E/D	NA	Rural
9	Waco	D	ENV	D	D	ENV	ENV	ENV	ENV	D	D	D	D	D	ENV	D	D	NA	Urban
10	Tyler	D	D	D	D	ENV	D	D	D	D	ENV	D	D	D	D	D	D	NA	Urban
11	Lufkin	D	D	D	D	ENV	D	D	ENV	D	D	D	D	D	ENV	D	D	NA	Rural
12	Houston	D	D	D	D	ENV	D	D	D	D	ENV	D	D	D	D	D	D	D	Metropolitan
13	Yoakum	D	ENV	D	D	ENV	D	D	ENV	ENV	ENV	ENV	D	D	ENV	D	D	D	Rural
14	Austin	D	D	D	ENV	ENV	ENV	NA	D	D	ENV	D	D	D	D	D	D	NA	Metropolitan
15	San Antonio	D	D	D	D	ENV	D	NA	ENV	D	ENV	D	D	ENV	ENV	D	E/D	NA	Metropolitan
16	Corpus Christi	D	E/D	ENV	ENV	ENV	ENV	ENV	ENV	D	ENV	E/D	ENV	D	ENV	D	E/D	E/D	Urban
17	Bryan	D	ENV	D	ENV	ENV	ENV	ENV	ENV	D	ENV	D	D	ENV	ENV	D	D	NA	Rural
18	Dallas	D	D	D	D	ENV	D	D	ENV	D	ENV	ENV	D	ENV	D	D	D	NA	Metropolitan
19	Atlanta	D	D	ENV	D	D	ENV	ENV	E/D	D	ENV	ENV	ENV	D	ENV	D	D	NA	Rural
20	Beaumont	D	D	ENV	ENV	ENV	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	D	Urban
21	Pharr	D	E/D	D	E/D	E/D	E/D	ENV	ENV	ENV	ENV	ENV	D	D	ENV	D	E/D	D	Urban
22	Laredo	D	D	D	D	ENV	ENV	ENV	ENV	D	ENV	D	D	D	ENV	D	D	NA	Rural
23	Brownwood	D	ENV	D	D	ENV	ENV	NA	ENV	D	ENV	ENV	ENV	D	ENV	ENV	D	E/D	Rural
24	El Paso	D	D	D	D	ENV	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	D	D	NA	Urban
25	Childress	D	ENV	D	D	ENV	E/D	NA	ENV	D	ENV	D	D	E/D	ENV	E/D	E/D	NA	Rural

Environmental Tasks for Natural Resources

1.0 - 1.5 Wetland
2.0 Navigable Waterways
3.0 Coordination with Texas Natural Resource Conservation Commission
4.0 - 4.1 Protected Species
5.0 Biological Surveys
6.0 Fish and Wildlife Coordination Act
7.0 Migratory Birds
8.0 Texas Parks and Wildlife Department Coordination
9.0 Section 4(f)/Section 6(f)
10.0 Coastal Management Plan
11.0 Farmland Coordination

Office of Primary Responsibility:
D = District
ENV = Environmental Affairs Division
E/D = Environmental Affairs Division and Districts
NA = Not Applicable

Environmental Tasks for Pollution Prevention and Abatement: Noise and Air Quality

		Tasks			District
	District Name	12.0	13.0	13.1	Classification
1	Paris	D	D	ENV	Rural
2	Fort Worth	D	D	ENV	Metropolitan
3	Wichita Falls	D	D	ENV	Rural
4	Amarillo	D	D	ENV	Rural
5	Lubbock	D	D	ENV	Urban
6	Odessa	D	D	ENV	Rural
7	San Angelo	D	D	ENV	Rural
8	Abilene	D	D	ENV	Rural
9	Waco	D	D	ENV	Urban
10	Tyler	D	D	D	Urban
11	Lufkin	D	D	ENV	Rural
12	Houston	D	D	D	Metropolitan
13	Yoakum	D	D	ENV	Rural
14	Austin	D	D	D	Metropolitan
15	San Antonio	D	D	ENV	Metropolitan
16	Corpus Christi	D	D	ENV	Urban
17	Bryan	D	D	ENV	Rural
18	Dallas	D	D	ENV	Metropolitan
19	Atlanta	D	D	ENV	Rural
20	Beaumont	D	D	ENV	Urban
21	Pharr	D	D	ENV	Urban
22	Laredo	D	D	ENV	Rural
23	Brownwood	NA	D	D	Rural
24	El Paso	D	D	ENV	Urban
25	Childress	D	D	ENV	Rural

Tasks for Pollution Prevention and Abatement: Noise and Air Quality

12.0 Noise Analysis and Abatement

13.0 Air Quality Analysis

13.1 Coordination of Environmental Reviews with Texas Natural Resource Conservation Commission (TNRCC)

Environmental Tasks for Pollution and Abatement: Hazardous Materials

		Tasks						District
	District Name	14.0	14.1	14.2	14.3	14.4	14.5	Classification
1	Paris	D	D	NA	D	D	D	Rural
2	Fort Worth	D	D	D	D	D	D	Metropolitan
3	Wichita Falls	D	D	NA	D	D	D	Rural
4	Amarillo	D	D	NA	D	D	D	Rural
5	Lubbock	D	D	D	D	D	D	Urban
6	Odessa	ENV	ENV	NA	D	D	D	Rural
7	San Angelo	D	D	D	D	E/D	D	Rural
8	Abilene	D	D	NA	D	D	D	Rural
9	Waco	D	D	NA	D	D	D	Urban
10	Tyler	D	D	NA	D	D	D	Urban
11	Lufkin	D	D	D	D	D	D	Rural
12	Houston	D	D	D	D	D	D	Metropolitan
13	Yoakum	D	D	NA	ENV	ENV	D	Rural
14	Austin	D	D	NA	D	D	D	Metropolitan
15	San Antonio	D	D	D	D	D	D	Metropolitan
16	Corpus Christi	D	D	D	D	D	D	Urban
17	Bryan	D	D	NA	D	D	D	Rural
18	Dallas	D	D	D	D	D	D	Metropolitan
19	Atlanta	D	D	NA	D	D	D	Rural
20	Beaumont	ENV	ENV	NA	ENV	ENV	ENV	Urban
21	Pharr	D	D	NA	D	D	D	Urban
22	Laredo	D	D	NA	D	D	D	Rural
23	Brownwood	ENV	D	D	NA	D	D	Rural
24	El Paso	D	D	NA	E/D	E/D	E/D	Urban
25	Childress	D	D	D	D	D	D	Rural

Environmental Tasks for Pollution Prevention and Abatement: Hazardous Materials

14.0 Perform preliminary Hazardous Materials Survey/ASTM 1528

14.1 Determine whether Phase I Environmental Site Assessment (ESA) or further investigation should be performed

14.2 Perform Phase I ESA (In-House)

14.3 Coordinate, manage, and monitor consultant services for Phase I ESA

14.4 Coordinate, manage, and monitor consultant services for further investigation

14.5 Review internal and consultant-derived reports

Environmental Tasks for Cultural Resources: Archeology

	District Name	Environmental Tasks													District Classification
		15.0	15.1	15.2	15.3	15.4	15.5	15.6	15.7	15.8	15.9	15.10	15.11	15.12	
1	Paris	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Rural
2	Fort Worth	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Metropolitan
3	Wichita Falls	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Rural
4	Amarillo	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Rural
5	Lubbock	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Urban
6	Odessa	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Rural
7	San Angelo	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Rural
8	Abilene	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Rural
9	Waco	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Urban
10	Tyler	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Urban
11	Lufkin	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Rural
12	Houston	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Metropolitan
13	Yoakum	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Rural
14	Austin	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Metropolitan
15	San Antonio	E/D	E/D	E/D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Metropolitan
16	Corpus Christi	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Urban
17	Bryan	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Rural
18	Dallas	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Metropolitan
19	Atlanta	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Rural
20	Beaumont	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Urban
21	Pharr	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Urban
22	Laredo	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Rural
23	Brownwood	D	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Rural
24	El Paso	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Urban
25	Childress	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Rural

Environmental Tasks for Cultural Resources: Archeology

15.0 Determine whether proposed project or activity constitutes an *undertaking* as defined by 36 CFR Part 800
15.1 Identify the Area of Potential Effects of the determined *undertaking*
15.2 Conduct Reconnaissance Survey of the project area
15.3 Conduct Intensive Surveys
15.4 Complete a professional Archeological Resources Survey Report
15.5 Conduct a systematic and detailed examination of subsurface archeological and geoarcheological deposits
15.6 Provide a technical report of testing and evaluation of site significance
15.7 Initiate coordination process and establish formal consultation with State Historic Preservation Office (SHPO)
15.8 Develop and implement an appropriate data recovery plan for archeological properties found in project area
15.9 Coordinate data recovery design with regional cultural resources management plans
15.10 Develop and coordinate contractual series to implement data recovery plan
15.11 Manage and monitor contractual services and coordinate data recovery measures with SHPO
15.12 Coordinate the permanent disposition of archeological materials for curation and conservation

Environmental Tasks for Cultural Resources: Buildings/Structures

	District Name	Tasks											District Classification
		16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	16.9	16.10	
1	Paris	D	ENV	D	D	ENV	ENV	ENV	ENV	ENV	ENV	D	Rural
2	Fort Worth	D	ENV	D	D	ENV	ENV	ENV	ENV	ENV	ENV	D	Metropolitan
3	Wichita Falls	D	ENV	D	D	ENV	ENV	ENV	ENV	ENV	ENV	D	Rural
4	Amarillo	D	ENV	D	D	ENV	ENV	ENV	ENV	ENV	ENV	E/D	Rural
5	Lubbock	D	ENV	D	D	ENV	ENV	ENV	ENV	ENV	ENV	E/D	Urban
6	Odessa	D	ENV	D	D	ENV	ENV	ENV	ENV	ENV	ENV	E/D	Rural
7	San Angelo	D	ENV	D	D	ENV	ENV	ENV	ENV	ENV	ENV	E/D	Rural
8	Abilene	D	ENV	D	D	ENV	ENV	ENV	ENV	ENV	ENV	E/D	Rural
9	Waco	D	ENV	D	D	ENV	ENV	ENV	ENV	ENV	ENV	E/D	Urban
10	Tyler	D	ENV	D	D	ENV	NA	NA	NA	NA	NA	ENV	Urban
11	Lufkin	D	ENV	D	D	ENV	ENV	ENV	ENV	ENV	ENV	E/D	Rural
12	Houston	D	D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Metropolitan
13	Yoakum	D	ENV	D	D	ENV	ENV	ENV	ENV	ENV	ENV	D	Rural
14	Austin	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Metropolitan
15	San Antonio	ENV	ENV	E/D	E/D	ENV	ENV	ENV	ENV	ENV	ENV	E/D	Metropolitan
16	Corpus Christi	D	ENV	ENV	D	ENV	ENV	ENV	ENV	ENV	ENV	E/D	Urban
17	Bryan	D	ENV	D	D	ENV	ENV	ENV	ENV	ENV	ENV	D	Rural
18	Dallas	ENV	ENV	ENV	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Metropolitan
19	Atlanta	D	ENV	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Rural
20	Beaumont	ENV	ENV	ENV	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Urban
21	Pharr	D	ENV	D	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	Urban
22	Laredo	D	ENV	D	D	ENV	ENV	ENV	ENV	ENV	ENV	D	Rural
23	Brownwood	D	E/D	D	D	ENV	ENV	ENV	ENV	ENV	ENV	E/D	Rural
24	El Paso	D	ENV	D	ENV	ENV	ENV	ENV	ENV	ENV	ENV	D	Urban
25	Childress	D	ENV	D	D	ENV	ENV	ENV	ENV	ENV	ENV	E/D	Rural

NA = No Available

Environmental Tasks for Cultural Resources: Building/Structures

16.0 Determine if project or activity constitutes an *undertaking* as defined by 36 CFR Part 800

16.1 Delineate project's area of potential effects and determine further course of action

16.2 Assess information needs: Review existing records and archival material

16.3 Perform Reconnaissance Survey of project area

16.4 Perform Intensive Surveys

16.5 Provide architectural description of historic properties

16.6 Review schematic and other design documents

16.7 Consult with State Historic Preservation Office (SHPO) to seek ways to avoid or reduce effects on historic properties

16.8 Prepare required agreement document for the SHPO

16.9 Carry out mitigation stipulated in agreement document

16.10 Prepare and coordinate Section 4(f) evaluations for historic sites

Environmental Tasks for Cultural Resources: Social End Economic Analyses/Environmental Justice

		Tasks		District
	District Name	17.0	18.0	Classification
1	Paris	D	D	Rural
2	Fort Worth	D	D	Metropolitan
3	Wichita Falls	D	D	Rural
4	Amarillo	D	D	Rural
5	Lubbock	D	D	Urban
6	Odessa	D	D	Rural
7	San Angelo	D	D	Rural
8	Abilene	D	D	Rural
9	Waco	E/D	E/D	Urban
10	Tyler	D	D	Urban
11	Lufkin	D	D	Rural
12	Houston	D	D	Metropolitan
13	Yoakum	D	D	Rural
14	Austin	D	D	Metropolitan
15	San Antonio	E/D	E/D	Metropolitan
16	Corpus Christi	D	D	Urban
17	Bryan	D	D	Rural
18	Dallas	D	D	Metropolitan
19	Atlanta	D	D	Rural
20	Beaumont	ENV	ENV	Urban
21	Pharr	ENV	E/D	Urban
22	Laredo	D	D	Rural
23	Brownwood	ENV	E/D	Rural
24	El Paso	ENV	ENV	Urban
25	Childress	D	D	Rural

Environmental Tasks for Cultural Resources: Social and Economic Analyses/Environmental Justice

17.0 Assess social and economic impact of proposed transportation projects

18.0 Identify and address any disproportionately high and adverse impacts to minority and low-income populations

Priority Training Needs at the District Level:

18.0 Environmental Justice

APPENDIX B

SAMPLE SURVEY USED FOR THE OUTSOURCING STUDY

Texas Transportation Institute Research Project 0-1730

Sourcing of Construction Engineering Services

Questionnaire A

BACKGROUND

The Texas Department of Transportation sponsors this Texas Transportation Institute project with one purpose being the development of an evaluation methodology to support the sourcing of job functions for public agencies. This will include **identifying critical issues** to the specific job function**, rating and ranking** them, and **evaluating the results** from a small survey of decision makers. Finally, **implementation procedures** will be suggested to help agencies apply the process to their particular sourcing needs. To test the proposed methodology, we are performing a survey of decision makers closest to one particular job function – construction engineering management. **PLEASE NOTE: The questions for you and your colleagues relate to the potentiality for construction engineering to be outsourced, and do not imply support for a given level of outsourcing, or the entire privatization of the job function.**

DEFINITIONS

Sourcing of a job function
The decision by a manger or management as to who provides the given job function. The options for the sourcing of a job function consist of keeping the work in-house and providing manpower to accomplish the task, or to outsource the job function and have private entities provide the service or function.

Construction Engineering Services
This is often referred to as construction engineering and inspection (CEI). Typically, construction engineers administer highway construction projects. Their work includes:

- Staking or checking contractor staking
- Conducting or attending preconstruction meetings
- Performing field sampling and testing of materials
- Inspecting work, documenting, and preparing progress and final estimates
- Computing final quantities and costs
- Preparing change orders
- Investigating claims

SURVEY

PART 1: RATING - Complete the scale given after each issue by circling a phrase that best describes your position to the viability or opportunity for using private forces to complete the job functions related to construction engineering services. Space has been provided for any explanation you may feel is necessary for your answers.

PART 2: RANKING - The numeric scale (1-10) ranks the importance that the issue is to the consideration of the job function. Please circle the value that best corresponds to your opinion of the importance that the particular issues play in the decision to the sourcing of construction engineering inspection services.

Please complete the attached questionnaire and return it to Mr. ____________ by ___________. Please use the stamped, addressed envelope provided or FAX to ______________.

Texas Transportation Institute Research Project 0-1730
Sourcing of Construction Engineering Services
Questionnaire A – State Transportation Agency

Name / Address____

__________________________________Phone Number ____________

E-mail address ____

PART 1. RATING

1. Cost

The estimated cost of construction engineering management services, as defined by direct labor, and indirect labor costs. When evaluating this issue, please assume a comparable level of quality.

What is the cost difference between performing construction engineering management services with private forces and keeping the job function in-house? (Private-Public)

25 % More than in-house	*15% More than in-house*	*10% More than in-house*	*No Difference*	*10% Less than in-house*	*15% Less than in-house*	*25% Less than in-house*

2. Ability to Manage the Contract

The ability of the government to oversee, monitor, measure, and control the delivery of the activity.

- Monitoring of the delivery of services by the public agency.
- Ability of public agency to develop and maintain control mechanisms over privatized service.
- Measurement of the quality and quantity of the service.

Based on the ability to manage the contract, are construction engineering management services an acceptable job function to consider for outsourcing?

Completely Unacceptable	*Reasonably Unacceptable*	*Barely Unacceptable*	*Borderline*	*Barely Acceptable*	*Reasonably Acceptable*	*Completely Acceptable*

3. Risk

The degree to which contracting out exposes the government to additional hazards, including legal and/or financial exposure, service disruption, or corruption.

- Ability of the contractor(s) to complete the contract of the service.
- Consequences of any service interruptions.
- Consideration of any effect to legal exposure as a result of contracting out.
- Consideration of any effect to risk of corruption.
- Consideration of any effect to risk sharing with the contractor.
- Responsibility to party for any and all cost overruns.

Based on the risk to the organization, is this job function acceptable to consider for out-sourcing?

Completely Unacceptable	Reasonably Unacceptable	Barely Unacceptable	Borderline	Barely Acceptable	Reasonably Acceptable	Completely Acceptable

____

____

4. Quality of service

This describes the performance, effectiveness, timeliness, and thoroughness of the provided service.

- Quality of the service if construction engineering management services are contracted out.
- Impacts on accountability and responsiveness by the public agency.
- Ability of well-defined quality objectives to be included in a contract.

If construction engineering management services are performed with private forces, how will the quality compare to similar services provided by public forces? (Private-Public)

Undoubtedly Worse	Moderately Worse	Marginally Worse	Alike	Marginally Better	Moderately Better	Undoubtedly Better

____

____

5. Future strength of competitive market

This describes the private-sector interest and ability to provide construction engineering management services in the future. Please circle if you evaluated this issue on an _Agency-wide_ or _Geographical_ basis.

- Consider the future quantity of interested contractors (if private forces were to be utilized) (i.e., would the market for the services be sustainable?).
- Consider the size of the financial commitment required.

Will the strength of the competitive market be adequate to support construction engineering management services being performed with private forces in the future?

Totally Inadequate	Very Inadequate	Barely Inadequate	Borderline	Barely Adequate	Very Adequate	Totally Adequate

____

____

6. Legal Barriers

The legal implications of attempting to perform construction engineering management services with private forces.

- Does law, statue, or ordinances mandate the mode of service delivery, public or private?
- Must laws, statues, or ordinances be changed to permit contracting out of the service or activity?
- Is contracting out compatible with the legislative, commission, or council intent that created the service or activity?

Based upon the legal implications of attempting to perform construction engineering management services with private forces, are construction engineering management services a viable candidate for outsourcing?

Completely Unacceptable	Reasonably Unacceptable	Barely Unacceptable	Borderline	Barely Acceptable	Reasonably Acceptable	Completely Acceptable

____

____

7. Impact on Public Agency Employment

The effect on public agency employment by using outside forces to complete construction engineering management services previously done by public employees.

- How will contracting out impact public employees?
- How many employees are affected?
- Will the contractors be required to hire displaced public employees?
- Consider the current state wages, compared to the private sector, and the effect on personnel turnover.
- Will any public employees be involuntarily terminated?

Based upon the impact on public employees, are construction engineering management services a viable candidate for outsourcing?

Completely Unacceptable	Reasonably Unacceptable	Barely Unacceptable	Borderline	Barely Acceptable	Reasonably Acceptable	Completely Acceptable

____

____

8. Political Pressure

This describes the amount of opposition to change in whom provides the service. Resistance can come from the public, users, interest groups, or public officials.

- What are the various groups' (concerned citizens, users of the service, interest groups, or public/elected officials) positions to change?
- Is there a preference by these groups as to who provides the service (in-house, private)?
- Consider the overall political support for this service.

Based on the political pressures in the external environment, is it better or worse to perform construction engineering management services with private forces?

Undoubtedly Worse	*Moderately Worse*	*Marginally Worse*	*Alike*	*Marginally Better*	*Moderately Better*	*Undoubtedly Better*

9. Resources (future)

The efficient and effective use of government assets (e.g., personnel, funding) is reflected within this criterion. This includes in-house or private-sector advantages in terms of professional expertise, facilities or equipment, time constraints, and state revenue or expenditure restrictions.

- How would the private sector's expertise in this area compare to the government's (over time)?
- Do time constraints exist that preclude in-house government delivery?
- Will contracting out reduce required completion times?

Based on the resources required for construction engineering management services, are construction engineering management services an acceptable candidate for outsourcing?

Completely Unacceptable	*Reasonably Unacceptable*	*Barely Unacceptable*	*Borderline*	*Barely Acceptable*	*Reasonably Acceptable*	*Completely Acceptable*

PART 2. RANKING

Assign a value to each issue to indicate the importance of the decision for the sourcing of construction engineering management services. Highest rank = 10; Lowest rank = 1. Please note that different issues may be assigned the same value.

Issue	Ranking									
Cost	1	2	3	4	5	6	7	8	9	10
Ability to Manage the Contract	1	2	3	4	5	6	7	8	9	10
Risk	1	2	3	4	5	6	7	8	9	10
Quality of Service	1	2	3	4	5	6	7	8	9	10
Strength of Competitive Market (future)	1	2	3	4	5	6	7	8	9	10
Legal Barriers	1	2	3	4	5	6	7	8	9	10
Impact on Public Agency Employment	1	2	3	4	5	6	7	8	9	10
Political Pressure	1	2	3	4	5	6	7	8	9	10
Resources (future)	1	2	3	4	5	6	7	8	9	10

Additional comments: ____________________

____

____

____

____

____

Thank you for completing this survey. Please return it to:
Please return by: ____________________

Mr. ____________________
Texas Transportation Institute
The Texas A&M University System
College Station, Texas 77843-3135
TEL: ____________________
FAX: ____________________