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16. Abstract

For this project researchers implemented a systematic approach to identify the domains within TxDOT where Operations Research and Management Science (OR/MS) techniques can lead to substantial improvements. A comprehensive study of TxDOT's operations was conducted based on existing documentation, and complemented by a two-part survey of TxDOT personnel. Researchers used their expertise in OR/MS modeling to define themes, or functional mappings, based on survey responses. Such themes, common across a wide range of TxDOT organizational substructures, consist of applications that share a common set of models and/or methods in the OR/MS literature, and they represent research avenues that have the largest potential to benefit TxDOT operations. Seven key areas of research were identified, including utility accommodation and right of way acquisition, work load and productivity analysis for forecasting future staffing needs, workload analysis for performance-based compensation, right of way acquisition management, management of design and planning processes, project prioritization for financial allocation, and enhancement of internal communications. For each of the key areas identified in this work, researchers developed problem statements, which address a range or family of issues, thus maximizing their potential impacts. Another major outcome of this project involves the detailed documentation of the methodology used to arrive at effective problem statements, which provides TxDOT with a framework to continuously improve its decision support system.

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An Assessment and Framework of Management Science Applications for TxDOT

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Disclaimers

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Acknowledgments

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Chapter 1. Background

Transportation comprises a significant fraction of the U.S. economy. Rising as the second largest state economy in the U.S. in 2010 (U.S. Department of Commerce, 2011), Texas gained 16 percent of its gross national product from transportation-related economic activities in 2008. With the rapid population growth and substantial congestion increase, however, almost all transportation modes and activities in Texas are experiencing problems due to increasing demand with constrained budgets. A recent Texas transportation study estimated that solving the congestion problems in the state's urban regions would generate more than $6.50 in economic benefits for every $1.00 spent (Texas 2030 Committee, 2009). This high impact, though constrained, environment is conducive for the likely success of Operations Research to achieve critical efficiencies.

Operations Research (OR) has provided major benefits to public and private sector organizations since gaining identity as a field in the 1950's. Its capabilities have grown vastly since then as OR knowledge, experience, and technology have grown. A single successful OR application can provide many millions of dollars in benefits through cost savings, revenue increases, or improvements in service quality.

OR achieves improvements by developing and applying mathematical models taking a variety of forms: optimization, simulation, forecasting, statistical analysis, spreadsheet models, etc. OR has had several successes at TXDOT in the last 20 years, due to the efforts of individual personnel and researchers. However, major new opportunities within TxDOT must be explored as budgetary constraints grow increasingly pressing. This proposal describes a thoughtful and structured approach to scoping high impact OR applications within TxDOT and establishing a procedure for continual review.

1.1 Operations Research and Management Science

Operations Research (OR) is a scientific approach to analyze problems and make decisions. It is also called decision science or management science because it arrives at optimal or near-optimal solutions to complex decision-making problems. Operations Research is mostly concerned with the maximization of profit, performance, or yield or the minimization of loss, risk, or cost (HSOP 2011). The major characteristics of operations research are (Turban 1991):

- Focus on managerial decision making.
- Application of scientific approach to decision making.
- Examination of decisions from a broad perspective (application of system approach).
- Use of methods and knowledge from several disciplines.
- Reliance on formal mathematical models.
- Extensive use of electronic computers.

1.1.1 History

The origins of OR date back to the Second World War (1939-1945). During this time, the U.K. and U.S governments created research groups comprised of scientists belonging to different disciplines; the objective was to develop new methodologies so as to allocate scarce resources more effectively in order to create effective strategic, tactical and operational plans (Bose 2005). The success of OR military applications motivated others to develop and apply new tools to

solve similar problems arising in industry starting in the late 1940s. Since the 1950s, OR has expanded rapidly in terms of the application, modeling, and solution approaches. The research community began developing new modeling approaches and tools to solve problems arising in finance, marketing, operations, manufacturing, telecommunications, and government (Sodhi 2010).

1.2 Operations Research Models

The first step in properly defining a mathematical model is to define the *solution structure* of the problem, i.e. the set of decisions that are the outcome of the model. A critical aspect of the development of the solution structure is that it must be useful to the decision maker: the solution must be constructed so that it can be understood and implemented.

Once the solution structure has been defined, the *goals and objectives* must be determined. In particular, it is imperative that goals and objectives are clearly defined, and the metrics necessary to evaluate the aforementioned decisions are consistent with such objectives.

The next step in developing a model is the set of *limitations* placed on the set of possible decisions is critical in obtaining realistic solutions. Accounting for factors such as staff availability, budget, deadlines, etc., is pivotal in obtaining solutions, which are applicable.

It is often found that, while a certain objective or goal may be the primary driving force behind a decision making process, those decisions will be expected to *maintain affected factors under acceptable ranges*. For example, while a capacity expansion project may aim to maximize system performance, there may be environmental justice impacts that must be maintained within acceptable values.

Model Scope: Strategic, Tactical and Operational

OR models are usually categorized based on the scope of the underlying decision process. Traditionally, OR models have been categorized as Strategic, Tactical or Operational Models (see Figure 1).

Figure 1.1: Relationship between Strategic, Operational, and Tactical Planning

Strategic models address decision-making processes at the highest level of an organization. These models are concerned with long-term goals, general direction and organizational philosophies. Because of their nature, strategic models have the potential to shape the entire future of an organization, and as such have tremendous impact. Because of the time

frame and scope of these models, they usually consider big-picture, aggregate level data and forecasts, and are seldom used to generate short-term decisions.

Tactical models deal with short to medium range decisions that support a strategic plan. The objective of a tactical plan is to appropriately allocate resources over the life cycle of the project so as to enable efficient day-to-day operations and achieve previously defined strategic goals.

Operational models deal with day-to-day operations constrained by the strategic and tactical decisions made by the organization. The objective of operational models is to optimize the use of available resources.

1.2.2 OR Methods

In this section we list common OR techniques. Mathematical programming, simulation, and probability and statistics have been recognized as the most frequently used tools in practice in past decades (Gupta, 1997), but the use of Decision Support for Selection Problems has increased significantly in the last decade.

Mathematical Programming and Optimization

In the transportation field, optimization techniques are widely used. Some examples include: Identifying the optimal system configuration, resource allocation and activity scheduling; Estimating the system state and conditions; calibrating the set of parameters of mathematical and statistical models. Mathematical programming models and solution methods may be distinguished by a variety of features of decision variable and model structures.

Simulation

Simulation is used in many contexts, including the modeling of dynamic transportation systems, in order to gain insight into their complex operations and behaviors. Traditionally, the formal modeling of systems has been via a mathematical model, which attempts to find analytical solutions enabling the prediction of the system behavior from a set of parameters and initial conditions. Computer simulation is often used for problems where analytic solutions are not possible. There are a few different types of computer simulation approaches, such as discrete simulation, continuous simulation, and agent-based simulation. The common feature they all share is the attempt to generate a sample of representative scenarios for a model in which a complete enumeration of all possible states would be prohibitive.

Probability and Statistics

An important branch of probability theory is stochastic process, which describes how a random process may evolve over time. Stochastic processes are common in our daily transportation activities and events. The state evolution of many time-dependent transportation systems can be characterized as a stochastic process.

Statistics involves the collection, analysis, interpretation, and presentation of data. Descriptive statistical methods are used to summarize, describe, and analyze a collection of data numerically or graphically. Inferential statistical methods are used to account for randomness and uncertainty in the observations and to draw inferences about the process or population of interest. Inference is a vital tool in analyzing and discovering data-embedded patterns and predicting the data correlation, extrapolation, and interpolation relationships. Econometrics, a

branch of applied statistics, is often used to describe and predict many traffic evolution phenomena and travel choice behaviors as human's economic activities.

Decision support for selection problems

A common use of management science techniques is to help decision makers select among a (potentially large) set of discrete alternatives (Orson, 1996). Unlike traditional optimization problems that seek to determine allocation of a class of resources to service demands (such as allocation of maintenance resources to roadways of varying conditions and travel demands), selection problems typically require choosing among a number of potentially attractive but mutually exclusive alternatives. The common difficulty in this class of problems is that decisions makers have multiple criteria that involve tradeoffs and also face a limited budget. For example, decisions can involve allocation of resources between maintenance and new infrastructure, or allocation of budgets for new infrastructure across different regions that have varying constituencies, travel demands, existing infrastructure, and maintenance needs.

A variety of management science techniques have been developed to address these problems. In general, these techniques build from an understanding of multi-attribute utility theory or a related hierarchy of criteria. Some of the techniques demand extensive detail and calibration , such as the Analytic Hierarchy Process or AHP (Saaty, 1977), while others eschew complexity for relative simplicity such as the AIM or Aspiration-level Interactive Model (Lofti et.al., 1992). All of these techniques require decision makers to express their preference criteria in an ordinal, interval, or (preferably) ratio scale.

There are two main advantages to the application of management science techniques to selection problems. The first comes from the process of formally modeling the problem. The act of expressing complex preferences and applying some level of quantitative measures to preference criteria can help decision makers better understand the problem as well as help groups express a unified preference set – in itself no small feat as individuals will typically have distinct preferences.

The second advantage comes from the application of a specific technique to help arrive at a solution. By definition, a multi-criteria problem will involve tradeoffs so it is generally not possible to arrive at a choice without some drawbacks. However, the technique can provide an explicit and repeatable means to arrive at a choice that seeks to maximize utility for the group within the expressed preference set.

Related to the selection problems is one of allocation or division of resources among multiple recipients (Brams and Taylor, 1996; Robertson and Webb, 1998). The fair division problem generally assumes an infinite potential division of the resource and hence its selection general solution methodology uses the metaphorical description of the moving knife. Solution techniques aim for envy free solutions where recipients do not feel others have an advantage.

1.2.3 Challenges of Management Science

There are many challenges in the development and implementation of OR/MS in practice. the conceptual development of the problem; the mathematical modeling and solution methods chosen; computational infrastructure required for solution of such models; data acquisition and storage; and institutional implementation issues. We describe these issues in detail below.

Problem Development

In the development stage, the biggest challenge is to properly frame the problem or complication that is being addressed so as to be able to formulate it as an OR/MS problem. Objectives must be identified, and metrics to evaluate the achievement of such objectives must be developed. While in some cases the objectives and metrics may be obvious, in many situations these can be the most challenging step of the OR/MS method, especially in the presence of multiple decision makers, dynamic decisions, or multiple competing objectives.

Optimization models can be very computationally expensive, although this problem has eased dramatically in the last decade. Because of this, one must ensure that the level of computational power required to use models that are developed as part of any OR initiative can be matched by the end user. If this is not the case, steps must be taken to procure the appropriate computational resources, or the computational burden must be shifted back to the research team who developed the model as opposed to the end user. In general, modern laptop and desktop computers are adequate, but some applications may require the licensing of the appropriate OR software, or the use of high-powered servers.

Data

Another key factor in the application of OR models is the handling of data. In particular, data handling can be considered as three specific challenges: data acquisition, data storage, and data access.

Availability of appropriate data is crucial in the development and solution of optimization methods. In order to develop realistic models, data requirements must be clearly defined and satisfied. Furthermore, the level of resolution of the chosen OR model must account for the availability of such data or the feasibility of acquiring such data. In certain cases, the acquisition of data may be expensive, difficult, or time consuming. These factors must be accounted for during the development of the modeling stage.

Implementation

To implement an OR model, one must obtain "buy-in" from all key members of the organization, especially when high degrees of communication are required between different groups (i.e. Divisions or Districts), and when new responsibilities need to be defined. Furthermore, incentive structures may need to be updated in order to properly reward and encourage effective implementation of complex strategies.

In the case of TxDOT's District structure, measures must be taken to maintain the autonomy of individual District level decision makers, as they must respond to not only internal pressure, but also to localities they work in. In the case of the Division structure, proper coordination of multiple Divisions within a District must be achieved. Furthermore, at both the Division and District levels, the challenges of communication must be addressed: when decisions affect more than one division or district, steps must be taken sure that the proper communication channels exist, and furthermore that the decision makers involved in the process are aware of such channels.

1.3 TxDOT

TxDOT is one of the state's largest departments in terms of the number of subordinate offices – with 25 geographical districts throughout the state, 22 divisions, and 6 offices. The

multi-functionality is required due to the large size of the state, the widely varying climate and soil conditions affecting public roads, and the differing demands (urban vs. suburban vs. rural). Each district, managed by a district engineer, is responsible for the design, location, construction and maintenance of its area transportation systems. Area offices also exist within districts, and districts also have separate maintenance offices for each county within the district. Divisions and offices headquartered in Austin provide administrative and technical support to the districts.

In an assessment of TxDOT's organizational structure by Deloitte Consulting (2007), TxDOT was found to have a hybrid organizational structure that combined essentially two different types of structures—functional groups and geography—to accomplish its organizational objectives. At the Division-level the organization is structured around functional groups, such as Finance, Design, and Construction. TxDOT uses geography to organize itself at the District level, giving the District engineers the autonomy to plan for and react to District-specific circumstances. As part of its review of TxDOT, Deloitte found that the dual organizational structure had a host of strengths, but also leads to weaknesses at all levels including minimal opportunity for standardization, efficiency, and cross-functional solutions.

1.3.1 How can OR/MS help TxDOT

Generally speaking, TxDOT reviews its operations prior to each legislative session for increased efficiencies in the core functional areas of planning, design, construction, operations and finance. However, past internal and external assessments have not undertaken a comprehensive analysis of TxDOT's divisions, districts and offices with a focus on organization-wide or multifunctional OR/MS models.

To date, OR applications have predominantly consisted of specific problems faced by a particular group within TxDOT; several such isolated implementations of OR/MS methods have been successfully implemented within TxDOT as part of previous research projects.

The Pavement Management Information System (PMIS) is an automated system that TxDOT uses for "storing, retrieving, analyzing, and reporting information to help with pavement related decision making process." It is an analysis tool to support pavement management, the process of "providing, evaluating, and maintaining pavements in a serviceable condition according to the most cost effective strategy." PMIS supports a wide range of activities including planning, highway design, in-service evaluations, maintenance, rehabilitation, research, and extensive detailed reporting to a variety of decision makers. Project 6386: *Evaluation and Development of Pavement Scores, Performance Models and Needs* Estimates aims to develop improvements to the Texas Pavement Management Information System (PMIS) to meet the evolving needs of TxDOT. These improvements include reviews of current practices and pavement maintenance and repair assignments, prioritization, new pavement performance models and condition prediction procedures, decision trees, and improvements to budgeting and impact analysis scenarios. Project 0-6589: *Pavement Repair Strategies for 2R and Routine Maintenance (RMC)* aims to select repair and treatment strategies that address the main cause of failure and are also cost effective.

Project 0-6404:*Accommodating Oversize & Overweight Loads,* aims to develop a statewide *routing* system, with recommended primary and alternate OS/OW route networks for the most common origins and destinations based on historical MCD data. This problem was motivated by an increasing prevalence of reroutes due to maintenance and other district activities, along with potential damage to the highway infrastructure from permit loads.

In project 0-5881, *Quantifying the Effects of Network Improvement Actions on the Value of New and Existing Toll Road Projects,* a system wide analysis is conducted, through the use of optimization modeling tools, to *valuate toll road projects* as a function of the cost, capacity and condition of feeder, complimenting (quasi-feeder) and competing routes. By considering the effects of *network actions*, TxDOT gains tools to judge which network improvements will add the most value to the existing and planned toll road projects. Such analysis will allow TxDOT to properly assess the value of its own non-tolled assets as well as plan for future toll roads in an optimal manner.

Several examples of budget and resource allocation projects are being funded by TxDOT during the current fiscal year. Project 0-6586: *Review of Best Practices for the Selection of Rehab and Preventive Maintenance Projects* aims to make optimal selections of the roadways to receive rehabilitation and preventative maintenance treatments as well as select rehabilitation and preventive maintenance (PM) methods that are structurally sound, capable of being opened to traffic quickly. Project 0-5534: *Asset Management – Texas Style* aimed to develop state-of-the-practice asset management methodologies. These methodologies support current decision-making processes for allocating funds to the different asset categories managed by TxDOT. The specific focus area was resource allocation decisions regarding advance acquisition of right-of-way and the construction of new highway capacity facilities. The research project was conducted in two phases. Phase one of this project explored the potential for beneficial use of simulation, optimization, and decision analysis tools to assist the Texas Department of Transportation (TxDOT) in optimizing strategies for acquiring right-of-way parcels, particularly strategies regarding the timing of parcel purchasing.

Project 0-6412: *Equipment Replacement Optimization* addresses the fleet management issues faced by TxDOT's $500,000,000 fleet. A dynamic programming model is developed with the objective of minimizing the life-cycle sum of maintenance cost and replacement cost by recommending whether to retain or replace a unit of equipment, given that class of equipment's age, mileage, resale value, and the cost of replacement equipment, for the Department to solving the Equipment Replacement Optimization (ERO) problem.

1.4 Overview of research approach

The research effort undertaken as part of this project focused on a systematic view of the different domains within TxDOT where OR/MS techniques an offer substantial improvements. A hybrid approach was taken to identify such domains, as well as specific applications within. A comprehensive study of TxDOT's operations was undertaken based on existing documentation, which was complemented by a two-part survey of TxDOT personnel regarding issues such as efficiency, resource allocation, and need for analytical research.

The objective of these tasks was to identify, through both established references and the experienced opinion of TxDOT personnel, both general themes (communication, resource allocation, etc.) and specific applications (right of way acquisition, forecasting staffing needs) where increased efficiencies are needed.

These responses were then classified according to general themes, or functional mappings, which can be considered to be common across a wide range of TxDOT organizational substructures (districts, divisions). These general themes were developed using the group's expertise in OR/MS modeling, and aimed to group and associate applications that share a common set of models and/or methods in the OR/MS literature. These general themes represent potential research avenues that have the potential to have wider impacts across TxDOT.

Chapter 2. Literature Review

The literature review included operation research applications and current practices of the Texas Department of Transportation (TxDOT). The purpose of this review was to ensure that TxDOT and the research team will benefit from the state-of-the-art concepts and practices for Operations Research methods.

2.1 Application of Operations Research Methods

Currently, Operations Research is used by a variety of organizations; Organizations must deal with choices among alternative activities arising from conflicts of interest among its own components, as well as those arising from other organizations with which it has relations (Bose 2005). Operations Research is rooted in three fields: military operations, economics, and computer science. The military operations have expanded to production planning, distribution planning, and global supply chain planning. The computer platforms have diversified into minicomputers, personal computers, and mobile computing; the economics front has evolved from simple single-firm-single-objective to multi-firm-multi-objective models (Sodhi 2010). The main areas of application of OR techniques include (Turban 1991):

- Inventory control
- Facility design
- Product-mix determination
- Portfolio analysis (of securities)
- Scheduling and sequencing
- Merger-growth analysis
- Transportation planning
- Design of information systems
- Allocation of scarce resources
- Investment decisions (new plants and the like)
- Project Management-planning and control
- New product decisions
- Sales force decisions
- Market research decisions
- Research and development decisions
- Oil and gas exploration decisions
- Pricing decisions
- Competitive bidding decisions
- Quality control decisions
- Machine setup problems in production
- Distribution decisions
- Manpower planning and control decisions
- Credit policy analysis
- Research and development effectiveness

2.1.1 Inventory Control and Transportation Planning

Inventory control includes the supervision of supply in order to guarantee an adequate supply without excessive oversupply. The most recent methods of inventory control include the creation of a dynamic model to compute the parameters of an inventory replenishment and outbound dispatch scheduling policy under dynamic demand (Lee 2003) and the use of linear programming and algorithms to generate itineraries (Adelman 2004). Transportation planning involves the evaluation and design of transportation facilities in order to improve them. Three different case studies were analyzed in this literature review. Teo and Shu (2004) study the distribution network design problem by integrating transportation and infinite horizon multi-echelon inventory cost functions. Bierlaire and Crittin (2004) use a least-square model to estimate and predict Origin-Destination tables. Perakis and Roels (2006) analyze the derivation of an analytical function of travel time based on the theory of kinematics waves to determine the travel time of a traveler and how it is affected by congestion. Top Operations Research applications were identified during the literature review. Selected top reference items are presented in Table 2-1. In our judgment the items listed in Table 2-1 reflect the current state-of-the-art in Operations Research. Inventory control and transportation planning using Operations Research applications are presented in this section.

Table 2.1: Summary of Successful OR Applications in Inventory Control and Transportation Planning.

Item #	Name	Author	Year	Brief Summary
1-001	A Dynamic Model for Inventory Lot Sizing and Outbound Shipment Scheduling at a Third-Party Warehouse	Chung-Yee Lee, Sila Centikaya and Wikrom Jaruphongsa	2003	This paper presents a model for computing the parameters of an integrated inventory replenishment and outbound dispatch scheduling policy under dynamic demand considerations. The optimal policy parameters specify (i) how often and in what quantities to replenish the stock at an upstream supply chain member (e.g., a warehouse), and (ii) how often to release an outbound shipment to a downstream supply- chain member (e.g., a distribution center).
1-002	A Price-Directed Approach to Stochastic Inventory/Routing	Daniel Adelman	2004	This paper presents a linear program that takes into account inventory dynamics and economics in allocating transportation costs for stochastic inventory routing. On test instances it is found that these allocations do not introduce any error in the value function approximations relative to the best approximations that can be achieved without them. An efficient algorithm is developed to both generate and eliminate itineraries during solution of the linear programs and control policy.

Item #	Name	Author	Year	Brief Summary
1-003	Warehouse-Retailer Network Design Problem	Chung-Piaw Teo and Jia Shu	2004	This paper presents a study about the distribution network design problem integrating transportation and infinite horizon multi-echelon inventory cost function. The problem is to determine how many warehouses to set up, where to locate them, how to serve the retailers using these warehouses, and to determine the optimal inventory policies for the warehouses and retailers. The objective is to minimize the total multi-echelon inventory, transportation, and facility location costs.
1-004	An Efficient Algorithm for Real-Time Estimation and Prediction of Dynamic OD Tables	M. Bierlaire and F. Crittin	2004	This paper presents the problem of estimating and predicting Origin-Destination (OD) tables. A least-square modeling approach is considered for solving the OD estimation and prediction problem, which seems to offer convenient and flexible algorithms. The dynamic nature of the problem is represented by an autoregressive process, capturing the serial correlations of the state variables. It is shown that the LSQR algorithm significantly decreases the computation effort needed by the Kalman filter approach for large-scale problems.
1-005	An Analytical Model for Traffic Delays and the Dynamic User Equilibrium Problem	Georgia Perakis and Guillaume Roels	2006	This paper presents that in urban transportation planning, it has become critical (1) to determine the travel time of a traveler and how it is affected by congestion, and (2) to understand how traffic distributes in a transportation network. The first part of this paper shows the derivation of an analytical function of travel time, based on the theory of kinematic waves. The second part shows how the travel-time model is incorporated within a dynamic user equilibrium (DUE) setting. It is proven that the travel-time function is continuous and strictly monotone if the flow varies smoothly.

2.1.2 Resource Allocation

Resource allocation is used to assign available resources in an effective and economical way. Operations Research applications have been used to solve resource allocation problems applied in transportation and reorder cost associated with retailers (Anily and Haviv 2007), revenue management (Cooper 2002), pavement preservation budgeting (Wu et.al. 2008), pavement management systems (Csicsely-Tarpay et.al. 2007), resource investment decision (Bish and Wang 2004), pavement maintenance programming (Tat et.al. 2001), multi-facility location problems (Sherali et.al. 2000), road asset management (Tsunokawa and Hiep 2008), passenger vehicle user-charging (Conway and Walton 2010), heavy vehicle charging system (Dodoo and Thorpe 2004), logistic support resource strategy design (Dillard 2009), optimal risk-based maintenance and rehabilitation policies (Butenko 2009), and the Dynarank decision support system (Davis 2000). The methods used include optimization techniques, sensitivity analysis, excel-based logistics, and hierarchical processes. Table 2-2 list reference items that present the OR applications of resource allocation applied in pavement management systems, asset management, maintenance and rehabilitation, and road infrastructure.

Table 2.2: Summary of Successful OR Applications in Resource Allocation.

Item #	Name	Author	Year	Brief Summary
1-006	The Cost Allocation Problem for the First Order Interaction Joint Replenishment Model	Shoshana Anily and Moshe Haviv	2007	This paper presents an infinite-horizon deterministic joint replenishment problem with first order interaction. Under this model, the setup transportation/reorder cost associated with a group of retailers placing an order at the same time equals some group-independent major setup cost plus retailer-dependent minor setup costs.
1-007	Asymptotic Behavior of an Allocation Policy for Revenue Management	William L. Cooper	2002	This paper presents the concept of how revenue management has become an important tool in the airline, hotel, and rental car industries. Asymptotic properties of revenue management policies derived from the solution of a deterministic optimization problem are described. The primary results state that, within a stochastic and dynamic framework, solutions arising out of a single well-known linear program can be used to generate allocation policies for which the normalized

Item #	Name	Author	Year	Brief Summary
				revenue converges in distribution to a constant upper bound on the optimal value.
1-008	Hybrid Multiobjective Optimization Model for Regional Pavement-Preservation Resource Allocation	Zheng Wu, Gerardo W. Flintsch and Tanveer Chowdhury	2008	This paper presents an alternative method for the central administration to set short-term pavement preservation budgeting under a wider information context, linking budget allocation to multiple criteria and performance targets through structured procedure and interactive communication. The result is a practical decision support model that enables the central administration in a decentralized state DOT to identify optimal maintenance actions and budget allocations across the component districts that are consistent with agency needs and resource limitations and understand the trade-off between the preservation cost and the associated network benefit.
1-009	Using a Pavement Management System for Allocating Resources: Case Study of Hungary	Marianna Csicsely-Tarpay, Raimo Tapio and Antti Talvitie	2007	This paper presents the use of a network-level pavement management system (PMS) for allocating resources to various road maintenance actions and distributing them to a country's different (road management) regions. The case study is set in Hungary, where efforts have been made to apply state-of-the-art techniques in road management.
1-010	Optimal Investment Strategies for Flexible Resources, Considering Pricing and Correlated Demands	Ebru K. Bish and Qiong Wang	2004	This paper presents a study about the optimal resource investment decision faced by a two-product, price-setting firm that operates in a monopolistic setting and employs a postponed pricing scheme. While the resource investment decision is made under demand uncertainty, pricing and resource allocation decisions are postponed to the time when demand curves are realized. The analysis in the report provides the structure of the firm's optimal resource investment strategy as a function of demand parameters and investment costs, and shows that the flexible resource investment decision follows a threshold policy.
1-011	Constraint Handling Methods in Pavement Maintenance	Weng Tat Chan, T.F. Fwa and Kh. Zahidul Hoque	2004	This paper presents a method to solve resource allocation problems. It proposes a more computational method based on prioritized allocation of resources to maintenance activities and the maximum utilization of resources.

Item #	Name	Author	Year	Brief Summary
	Programming			
1-012	Global Optimization Procedures for the Capacitated Euclidean and ℓp Distance Multi-facility Location-Allocation Problems	Hanif D. Sherali, Intesar Al-loughani and Shivaram Subramanian	2000	This paper presents a procedure for determining global minima for the capacitated Euclidean and ℓp distance location-allocation problems. Given the fixed location of m existing facilities, or customers on a plane and their associated demands, this problem seeks the location of n new facilities or sources having known capacities, as well as the allocation of their supplies, to satisfy the demand requirements of customers at a minimum total cost.
1-013	A Unified Optimization Procedure for Road Asset Management	Koji Tsunokawa and Dinh Van Hiep	2008	This paper presents a unified and coherent procedure for optimizing the allocation of a system-wide budget over its constituent subsystems, be it infrastructure components or sub-networks. The net present value (NPV) will be used as the common denominator for measuring the desirability of management programs for all asset subsystems. Using an asset subsystem optimizer (ASSO) the NPVs are first predicted for several budget levels to construct the NPV function of each asset subsystem. For a given system-wide budget, the NPV functions of all subsystems are then used to find the optimal allocation among all subsystems. Once optimal budget allocation has been found, optimal management strategy for each subsystem can be found by running the ASSO with the optimally allocated budget.
1-014	A Road Pricing Methodology for Infrastructure Cost Recovery	Alison J. Conway and C. Michael Walton	2010	The purpose of this research is to provide a theoretical framework for future commercial vehicle user charging, using real-time vehicle weight and configuration information collected using weigh-in-motion (WIM) systems. This work provides an extensive review of both mechanisms and technologies employed for commercial and passenger vehicle user-charging worldwide. The methodology proposed in this study employs highway cost allocation methods for development of an "Axle-Load" toll structure. Some sensitivity analysis is also performed to examine the potential revenue impacts due to uncertainties in different data inputs under existing and proposed structures.

Item #	Name	Author	Year	Brief Summary
1-015	A Pavement Damage Based System for Charging Heavy Good Vehicles for their Use of Road Infrastructure	Nii Amoo Dodoo and Neil Thorpe	2004	This paper describes the development by the authors of a new electronic on-board system for charging HGVs which includes key variables for estimating the amount of pavement damage each HGV causes on the road network.
1-016	An Excel-based Logistics Support Resource Strategy Map to Facilitate Logistics Support Resource Strategy Design	Ford Dillard	2009	The authors note that little attention has been given to the non-cost factors that should be considered in logistics support resource strategy design. Given the multitude of potential drivers of and influences on logistics support, an Excel-based Logistics Support Resource Strategy Map is developed to facilitate logistics support resource strategy design. They also note that the tool is designed primarily for qualitative assessment and the identification of shared and differing impacts of a resource strategy on logistics support. Perceptions and judgments of program team members are the base for these assessments.
1-017	Optimal Risk-Based Maintenance and Rehabilitation Policies	Seyedshohadaie Damnjanovic Butenko	2009	The authors use the Conditional Value at Risk (CVaR) for determining optimal risk-based maintenance and rehabilitation policies. To illustrate the resource allocation under risk, they developed two short-term models and analyzed them in terms of their effectiveness for short-term resource allocation decision making: The MIN–MAX-CVaR model minimizes the highest CVaR over all facilities, and the MIN-SUM-CVaR model minimizes the sum of CVaR of all facilities subject to the budget restrictions. Additionally, they developed a long-term model in the Markov Decision Process (MDP) framework to minimize the cost of network M&R actions such that a certain level for a given performance indicator is guaranteed. They also provided an example of application of the proposed methodology for finding risk-averse rehabilitation policies for networks of transportation infrastructure under deterioration uncertainty.
1-018	The DynaRank Decision Support System	Hillestad Davis	2000	DynaRank is a hierarchical "scorecard" framework designed for the Department of Defense's (DoD's) to assist them with development and updating of

Item #	Name	Author	Year	Brief Summary
				the U.S. defense program in a way that is explicitly consistent with the multiple objectives of the new strategy: shape, respond, and prepare now. DynaRank is intended to high-level resource-allocation decision-making that is guided strongly by a sense of strategy. This decision support system ranks policy options by their cost-effectiveness based on judgments about the relative importance of higher-level objectives and a variety of success criteria.

2.1.3 Research Development Decisions

Research development decisions are the tools used by the decision makers to make a final selection. The application of OR methods in this area are very broad. Krugler et.al. (2010) developed a simulation and optimization model to estimate the right-of-way acquisition information and statistical analysis. Joglekar (2007) used system dynamics to reduce project duration. This model found that resource allocation delay does not produce minimum durations, and increasing uncertainty decreases durations under certain conditions. Howe (2002) describes a linear programming framework developed to help explore the cost and personnel consequences of management decisions that change the structure of the IT workforce. Moore (2000) makes use of performance metrics to outsource management services. Beck (2008) creates a model based on analytical methods to create defense planning. Dreyer (2009) the Portfolio Analysis Tool (PAT) designed for the Department of Defense (DOD) is described. PAT is to help decision makers to balance investments across numerous objectives. The National Research Council (2006) describes where and how DOD can use modeling, simulation, and analysis techniques in the decision making process. Table 2-3 list the reference items that use research development decisions, project management, portfolio analysis, and research development effectiveness applied in several case studies.

Table 2.3: Summary of Successful OR Applications in Research Development Decisions.

Item #	Name	Author	Year	Brief Description
1-022	Development of Decision-Making Support Tools for Early Right-Of-Way Acquisitions	Paul E. Krugler, Carlos M. Chang-Albitres, Richard M. Feldman, Sergiy Butenko, Dong Hun Kang, and Reza Seyedshohadaie	2010	This report includes historical TxDOT right-of-way acquisition information, analyses statistical information, and then developing simulation and optimization tools for TxDOT right-of-way sections and budget decision makers. This report also includes a review of TxDOT's fleet vehicle replacement strategies and assessment to assist decision makers in the area of operations.

Item #	Name	Author	Year	Brief Description
1-023	Resource Allocation for Decreased Project Duration	Lee, Ford, Joglekar	2007	To perceive and model development projects, the system dynamics approach is applied and allocation policy design was investigated. They focused on how three policy features impact development project durations: (1) whether to base allocations on current or future conditions, (2) how quickly to adjust resources and (3) how much control to exert over resource adjustment speed. Based on model analysis, Lee et. al. found that minimum resource allocation delay does not produce minimum durations, and increasing uncertainty decreases durations under certain conditions. Accordingly, they proposed tuning managerial delays as a potential advancement in project management and investigated the application of tuning these delays to resource allocation policy design.
1-024	A Linear Programming Framework for Management Decisions that Change the Structure of the IT Workforce	Austink, Clemence, Howe	2002	This report describes a linear programming framework developed to help explore the cost and personnel consequences of management decisions that change the structure of the IT workforce. More specifically, the framework will help understand the possible effects of increasing the use of government civilians or of outsourcing IT functions to civilian contractors.
1-025	Using Performance Metrics in Outsourcing Management Services	Baldwin, Camm, Moore	2000	This study is a part of a larger study conducted by Project AIR FORCE, a division of RAND. The long-term research program is sponsored by the Deputy Chief of Staff for Plans and Programs. The use of performance metrics in outsourcing management services is specifically addressed in this report. The research team interviewed a sample group of the customer and provider firms, which represent the innovative leading edge of sourcing practices, to uncover the practices that these firms use to choose and implement performance metrics in their sourcing processes.

Item #	Name	Author	Year	Brief Description
1-026	Portfolio-Analysis Methods for Assessing Capability Options	Davis, Shaver, Beck	2008	This study is part of the work on theory and methods for capability-based planning in the Department of Defense (DoD) and other organizations. In this study, an analytic framework and methodology for defense-wide capability/area reviews, including DoD's experimental Concept Decision Reviews and related evaluations of alternatives is addressed. Two tools for generating and screening preliminary options and then for evaluating those options that pass screening are described. The framework can be used for analysis across capability areas or for strategic-level defense planning (i.e., force planning) to establish the overall mix and balance of capabilities
1-027	RAND's Portfolio Analysis Tool (PAT)	Davis, Dreyer	2009	In this study, RAND's Portfolio Analysis Tool (PAT), designed for the Department of Defense is described. The tool is designed to facilitate strategic portfolio analysis dealing with both uncertainty and differences of perspective,. PAT is an improved version of PAT-MD, which was developed for the U.S. Missile Defense Agency's Program Integration Office (MDA/PI) in 2005. Because strategic planning often involves investing in a mix of capabilities and activities to address a mix of objectives, the main purpose of PAT is to help decision makers to balance investments across numerous objectives.

To do this, PAT generates high-level summary depictions for discussing issues of balance. It uses a spreadsheet-based format with options shown in rows and various measures of option goodness. |
| 1-028 | Defense Modeling, Simulation, and Analysis | National Research Council | 2006 | In this report, the Committee on Modeling and Simulation for Defense Transformation describes where and How DOD can use Modeling, simulation, and analysis (MS&A) techniques. The committee made 14 recommendations and discussed the need for research in numerous promising areas, but has chosen to recommend only five specific areas believed to be the most important ones with respect to the presence of constrained resources: (i) Social behavioral networks, (ii) Game-based training and |

Item #	Name	Author	Year	Brief Description
				simulation, (iii) Cognitive decision making, (iv) Network science, and (v) Embedded systems.

2.1.4 Fair Division

Fair division studies the problem of allocating a set of indivisible goods to a set of people, called players, from an envy-free perspective. An allocation is envy-free if every player likes his own share at least as much as the share of any other player (Lipton 2004). Fair Division methods have been used in a wide range of topics such as the allocation of cabinet ministries to political parties in a parliamentary system (Brams and Kaplan 2002), cake division with minimal cuts using the moving knife technique (Barbanel and Brams 2004), division of a fixed amount of goods among a fixed amount of agents (Varian 1973), allocation of a finite number of indivisible items between 2 players with additive utilities, and the allocation of indivisible goods using a branch-and-bound algorithm. Table 2-4 list the reference items that present the OR applications of fair allocation of goods applied in case studies.

Table 2.4: Summary of Successful OR Applications in Fair Division.

Item #	Name	Author	Year	Brief Description
1-029	On approximately fair allocations of indivisible goods	R.J. lipton, E. Markakis, E. Mossel and A. Saberi	2004	This report uses a case study to fairly allocate a set of indivisible goods to a set of people from an algorithmic perspective. The criterion used in this case study is envy-freeness. This model considers the division of indivisible goods as non-envy-free; therefore, it makes an optimization problem of finding an allocation with minimum possible envy.
1-030	Dividing the Indivisible: Procedures for Allocating Cabinet Ministries to Political Parties in a Parliamentary System	Steven J. Brams and Todd R. Kaplan	2002	In this paper, political parties use a divisor method of apportionment to choose ten cabinet ministries in Northern Ireland. This report studies the consequences of this sophisticated allocation such as Pareto-optimal and nonmonotonicty. This mechanism combines sequential choices with a structured form of trading that result in

Item #	Name	Author	Year	Brief Description
				sincere choices for two parties. This report shows that envy cannot be eliminated, only reduced.
1-031	Cake Division with Minimal Cuts: Envy-Free Procedures for 3 Persons, 4 Persons, and Beyond	Julius B. Barbanel and Steven J. Brams	2004	This report presents a solution to a fair cake division problem. This report shows that the minimal number of parallel cuts required to divide a cake into n pieces is n - 1. A new 3-person procedure, requiring 2 parallel cuts, is given that produces an envy-free division, whereby each person thinks he or she receives at least a tied-for-largest piece. An extension of this procedure leads to a 4-person division, using 3 parallel cuts, that makes at most one person envious. Finally, a 4-person envy-free procedure is given, but it requires up to 5 parallel cuts, and some pieces may be disconnected. All these procedures improve on extant procedures by using fewer moving knives, making fewer people envious or using fewer cuts.
1-032	Equity, Envy, and Efficiency	Hal R. Varian	1973	This paper considers the problem of dividing a fixed amount of goods among a fixed number of agents. This report compares the different theories of normative economics and examines the relationship between envy and efficiency and establishes general results for the existence of fair allocations. In this case it is shown that the only allocations that are coalition-fair in a large economy are competitive equilibrium with equal incomes.
1-033	How to Allocate hard Candies Fairly	Marco Dall'Aglio and Raffaele Mosca	2007	This report considers the problem of allocating a finite number of indivisible items to two players with additive utilities. The solution proposed uses all the maximum allocations and repeated use of an Adjusted Winner, an effective procedure that deals with divisible items, to find new candidate solutions, and to suggest which items should be assigned to the players.

2.2 TxDOT Planning and Programming Practices

TxDOT's current practices and project selection methods were studied in this literature review. Durden (2010) describes the funding process in the state of Texas and provides

information of projected needs from 2010-2030. In Window on State Government (2001), the current planning, programming, and funding of TxDOT is analyzed. It emphasizes the need to eliminate the current funding allocation processes and to establish a new, simpler approach that will provide funds to the strategic priorities and the regional needs in a more predictable, equitable, and understandable manner. Raglan (2010), shows the methods and criteria used in the programming and scheduling of tasks, funding considerations, and project selection criteria of the Unified Transportation Program Categories and the Development and Implementation of the Unified Transportation Program. Table 2-5 list reference items that show the current practices performed by the Texas Department of Transportation (TxDOT). The current planning, programming and funding methods used by TxDOT are presented in this table. Table 2-5 list reference items that show the current practices performed by the Texas Department of Transportation (TxDOT). The current planning, programming and funding methods used by TxDOT are presented in this table.

Table 2.5: Literature Review of Current Planning and Programming Practices.

Item #	Name	Author	Year	Brief Summary
1-019	Funding Texas Highways for the Next 20 Years	Donald J. Durden	2010	This paper describes the funding process in the state of Texas over a 20-year study (2010-2030). It provides information for funding methods, current allocation of funds, and projected needs for the year 2030.
1-020	Establish a New, Simpler Approach to Allocating Funds	Window on State Government	2001	This article describes the current planning, programming and funding approach of the Texas Department of Transportation. It emphasizes the need to eliminate the current funding allocation processes and to establish a new, simple approach that funds both strategic priorities and regional needs in a predictable, equitable and understandable manner.
1-021	Transportation Programming and Scheduling Manual Practices	Brian Ragland	2010	This manual shows the methods and criteria used in the programming and scheduling of tasks, funding considerations, and project selection criteria, elements of the Unified Transportation Program Categories and the Development and Implementation of the Unified Transportation Program.

Chapter 3. Functional Mapping

One of the main objectives of this research project was to determine operations and activities performed by TxDOT where improvement could have the biggest impact in order to identify potential functional classifications and mappings. These functional mapping and classifications can subsequently serve as a basic context for the successful implementation of operations research and management science techniques. For this purpose, the team performed several tasks aimed at gaining a comprehensive understanding of the interests and priorities of TxDOT.

Building off of the literature review, the team identified and collected background material to review and assess TxDOT's organizational structure by functional classifications. A key starting point for this activity was an analysis of TxDOT's organizational structure based upon functionality. Table 3-1 is a listing of TxDOT Divisions that includes recent mission statements for each organization.

TxDOT's previous budget expenditures were assessed and analyzed as to how these align with organization-wide or multifunctional OR/MS models. Using the expenditure data provided by TxDOT, it was possible to identify specific activities which, due to their financial impact, become prime candidates for further analysis. The expenditure data provided by TxDOT is shown in Figure 3-1.

EXPENDITURES

Operational Expenses

PLAN IT _____ **19.1%**

Plan/Design/Manage	4.6%
ROW Acquisition	7.2%
Research	<1%
Contracted Planning and Design	7.0%

BUILD IT _____ **40.4%**

Highway Construction	39.6%
Aviation Services	<1%

MAINTAIN IT _____ **35.5%**

Contracted Maintenance	28.0%
Routine Maintenance	7.1%
Gulf Intracoastal Waterway	<1%
Ferry System	<1%
Gross Weight and Axle Fees	<1%

USE IT _____ **2.8%**

Public Transportation	1.0%
Client Transportation Services	<1%
Registration and Titling	<1%
Vehicle Dealer Regulation	<1%
Traffic Safety	<1%
Travel Information	<1%
Auto Theft Prevention	<1%
Rail Safety	<1%

MANAGE IT _____ **2.2%**

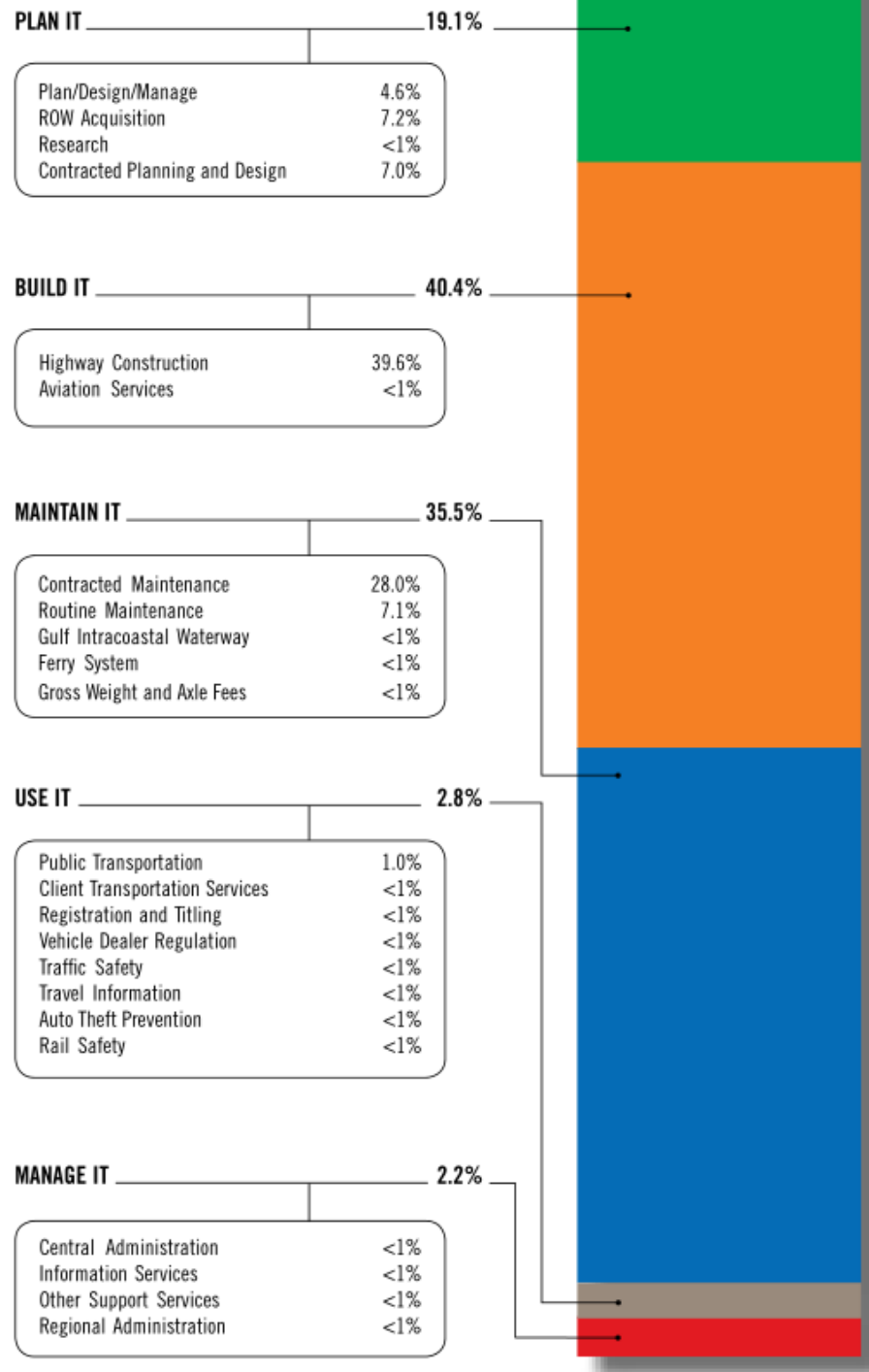|	
Central Administration	<1%
Information Services	<1%
Other Support Services	<1%
Regional Administration	<1%

Figure 3.1: Expenditure Data by Activity Type (Strategic Plan 2009 Through 2013, TxDOT)

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Highway Construction (39.6% of total expenditures) and Contracted Maintenance (28% of total expenditures) were identified as two operations within TxDOT that have several desirable properties from an OR/MS perspective:

- High Impact: Each of these activities represents more dollars spent than any other general category of spending (Planning, Operations and Management).

- Strong OR/MS Literature: Construction and Maintenance are two general fields of OR/MS that, due to their importance in both the private and public world, have been well researched, with a variety of models, methods and tools available.

- Functional Mapping Potential: As the project structure for both Construction and Maintenance projects share a variety of smaller sub-activities, specific research topics may have far reaching implications due to these commonalities.

In addition to using expenditure breakdown for identifying high impact areas, TxDOT's Strategic Plan for the 2011-2015 period was assessed and the following goals and objectives as determined by TxDOT were reviewed:

Goal 1 - Organizational structure and strategies:
- Performance driven and transportation prioritization and selection process
- Budgetary and non-budgetary performance measures

Goal 2 - Safety: Strategic Highway Safety Plan
- Fatalities and injuries
- Disasters and emergencies
- Work-zone safety
- Budgetary and non-budgetary performance measures

Goal 3 - Maintenance: Pavement Management Maintenance Plan
- Asset management program
- Emergency maintenance
- Budgetary and non-budgetary performance measures

Goal 4 - Congestion reliefs: Congestion Management Plan
- Multimodal infrastructure, technological, operational, and technological solutions
- Congested elements of the transportation system
- Budgetary and non-budgetary performance measures

Goal 5 - System connectivity: Transportation Improvement Program
- Prioritization of connectivity improvements for Texas industries, population, recreational and cultural centers
- Mobility, economic, environmental, and social costs, benefits, and impacts
- Budgetary and non-budgetary performance measures

Goal 6 - Multimodal funding strategies

- Mobility, safety, system condition, economic development, environmental impacts
- Budgetary and non-budgetary performance measures

The six different goals were identified as critical areas of future actions and focus. These goals and specific action items were included in the survey script and used in subsequent questions for classifying management science applications as well as potential problem types.

The research team worked with TxDOT's Office of Strategic Policy and Performance Management to develop a database of all job classifications and this output was assesses focusing on organization-wide or multifunctional OR/MS models. The research team will also anticipated to use these results to potentially identify which organizational units within TxDOT has the highest influence on successful implementation of improvement actions and addressing problem types identified in the previous step. The primary proposed outcome of these tasks is a mapping of potential problem types to impacted areas within TxDOT.

Recommendations made by TxDOT's Restructuring Council were also reviewed and seven major areas of improvement as well as specific improvement recommendations were identified. Table 3-2 highlights improvement areas believed to be useful for the purpose of functional classification.

Table 3.1: Mission and Function of TxDOT Divisions

Division	Mission Statement
Aviation (AVN)	The Aviation Division assists cities and counties applying for, receiving and disbursing federal and state funds for reliever and general aviation airports included in the Texas Airport System Plan (TASP). TASP, which includes 300 airports, is one of the largest aviation systems in the nation. In addition to administering the state grant funds, the aviation division is a participant in the FAA State Block Grant Program through which it has responsibilities for the federal improvement program for general aviation airports. The division also operates a fleet of state owned aircraft for the transportation needs of state officials and employees as well as providing maintenance and repair services to most state-owned aircraft.
Bridge (BRG)	The Bridge Division supports TxDOT's districts by providing in-house expertise in all aspects of structural planning, design, review, construction and inspection of bridges. Division responsibilities include planning assistance, structural plan preparation, construction assistance and reviewing bridge specifications. They are also responsible for inspection the state's 50,000 bridges. In addition, the division develops policies, design standards, manuals, and guidelines for the design, maintenance and construction of a safe and comprehensive state bridge system.
Construction (CST)	The Construction Division performs inspection and testing and provides oversight for contract administration including payment, construction regulatory compliance and inspection and testing for all department construction contracts. The division is responsible for contractor pre-qualification, bid

Division	Mission Statement
	proposal issuance and construction and maintenance contracts letting and provides consultation to districts on project management, administration and inspection and testing from pre-letting to final project acceptance. The division is also responsible for coordinating with the Federal Highway Administration to assure the overall effectiveness of the construction oversight program. It also provides materials quality and testing for construction and maintenance materials as well as a focus in and coordination of pavement design and management and maintains and oversees the department's pavement management information system.
Design (DES)	The Design Division guides the development of construction projects from conception to the release of detailed plans for construction bidding. The division is involved in most areas of highway design, from roadway geometrics to landscape design. Over 800 construction contracts on average per year are bid by contractors. Responsibilities include developing design policies and roadside safety criteria, providing hydraulic design expertise, overseeing the selection of professional services consultants, and managing several landscape programs.
Environmental Affairs (ENV)	The Environmental Affairs Division oversees the department's environmental efforts with the goal of making sure that transportation systems are environmentally sensitive. The division addresses air and water quality, animal and plant ecology, archeology, historic properties, environmental justice, hazardous materials and traffic noise. It also reviews and coordinates environmental documents, develops and delivers environmental training, is liaison to state and federal resource agencies, educates the public, and provides support to TxDOT districts and the Regional Environmental Centers.
Finance (FIN)	Our Finance Division is responsible for the management and control of budget, revenue, disbursements, accounting, and debt management for the agency as well as programming and scheduling and letting management of all transportation projects. TxDOT receives most of its state funds from state and federal motor-fuel taxes and vehicle registration fees.
General Services (GSD)	The General Services Division (GSD) is the central purchasing office for TxDOT. GSD provides oversight authority for negotiated contracts, policies and procedures development and support services for professional services contracts. Contract opportunities with TxDOT and the state of Texas are promoted through GSD's efforts to provide business opportunity information, training and workshops to contractors, TxDOT staff and outside organizations. GSD coordinates statewide efforts in regard to alternative fuels, recycling, records management, mail and surplus property. The management of four Regional Distribution Centers (RDC) located in Austin, Athens, Post and Sequin is handled by GSD. These centers support the supply and material needs of department facilities throughout the state. Other Statewide support services provided by GSD include electronic publishing, reprographics and full-cost recovery offset printing. General Services electronically publishes manuals and highway construction plans on TxDOT's Intranet site, while publishing plans used

Division	Mission Statement
	in the bidding and letting processes on the Internet for the convenience of external customers.
Government and Public Affairs (GPA)	The Government and Public Affairs Division manages TxDOT business before the Texas Legislature and United States Congress, serves as the agency's media spokesperson, analyzes policy questions, studies long-term department challenges and serves as TxDOT liaison to Mexico and other countries. The division focuses on integrating the public and private sectors in the delivery of transportation infrastructure through business development, program marketing, public conferences and internal and external communications.
Human Resources (HRD)	The Human Resources Division administers TxDOT's employment and recruitment programs and employee services. This includes employee training, performance planning and evaluation.
Maintenance (MNT)	The Maintenance Division oversees the preservation, upkeep and restoration of the 177,000 miles of Texas highways. The division also coordinates TxDOT's maintenance contracts, use of herbicides and pesticides, and architectural services for the maintenance of department buildings. Maintenance also oversees Safety Rest Areas, ferry operations, and support and guidance to TxDOT districts during natural disasters and emergencies.
Motor Carrier (MCD)	The Motor Carrier Division is responsible for the safe and efficient routing and issuing of permits for the transport of oversize/overweight loads in Texas. MCD also enforces permit-related administrative rules, conducts investigations, works with customers to ensure compliance and, when necessary, assesses penalties for size/weight violations. In 2009, MCD issued more than 500,000 permits and collected over $95 million in permit fees, which was deposited into the State's Highway Fund and the General Revenue Fund.
Occupational Safety (OCC)	Our Occupational Safety Division is responsible for TxDOT employee safety, tort claims against TxDOT, department worker's compensation, pre-employment physicals and substance abuse testing.
Public Transportation (PTN)	The Public Transportation Division provides financial, technical and coordination assistance to the state's public transit providers. The division also represents public transit in the planning and programming process and prepares funding-needs projections. There are eight large urban, 30 small urban and 39 rural transportation systems in the state. Additionally, there are more than 135 operators in Texas providing transportation services to the elderly and to individuals with disabilities.
Rail (RRD)	TxDOT's Rail Division administers federal and state programs to improve highway-rail grade crossings by partnering with railroads to install and maintain crossing signals and gates, improve crossing surfaces on state highways and consolidate crossings where possible. The division has the authority to implement rail improvements by entering into public-private partnership agreements to provide investments in freight rail relocation projects, rail facility improvements, rail line consolidations or new passenger rail developments. The division participates in the state rail safety participation program in conjunction

Division	Mission Statement
	with the Federal Railroad Administration. State rail safety inspectors coordinate investigative activities with federal authorities in the areas of hazardous materials, motive power and equipment, operating practices, signal and train control and track structures.
Right of Way (ROW)	Once environmental impact studies are complete, land must be acquired to build, widen or enhance roads. The Right of Way Division coordinates the acquisition of land to build highways, providing relocation assistance when needed. There are more than one million acres of right of way on the state system. The division also coordinates utility adjustments, the disposition and leasing of surplus real property owned by TxDOT and regulates outdoor advertising signs and junkyards.
Technology Services (TSD)	Our Technology Services Division supports the business operations of TxDOT with innovative information technology and strategic information resource planning. Division responsibilities include managing microcomputer and mainframe information systems; engineering graphics, photogrammetry and satellite surveying operations; and data and voice telecommunications.
Texas Turnpike Authority (TTA)	The Texas Turnpike Authority aims to improve mobility and safety by developing and operating a safe, reliable and cost-effective system of toll roads using private-sector partners and financing options. The division has the authority to study, design, construct, operate, expand or extend turnpike projects as a part of the state highway system.
Traffic Operations (TRF)	The Traffic Operations Divisions oversees programs in traffic management, engineering and safety. The division is involved in planning and maintaining signs, signals, pavement markings and lighting. The division also manages intelligent transportation systems, crash records, and safety initiatives to improve driver behavior, eliminate roadway hazards and increase traffic law enforcement.
Transportation Planning and Programming (TPP)	The Transportation Planning and Program Division administers planning funds, collects data on the highway system and programs projects. It acts as the central clearinghouse for project selection. This division is responsible for statewide urban and rural multimodal transportation systems planning, long-range programming, Statewide Transportation Improvement Program, analysis and projection of traffic data, collection and storage of roadway data, and preparation and distribution of maps. The division is also responsible for project planning, policy development and operations pertaining to water, bicycle and pedestrian transportation. It serves as the non-federal sponsor of the 423 mile-long Gulf Intracoastal Waterway, which runs along the Texas coastline.
Travel Information (TRV)	The Travel Information Division is responsible for the department's litter-prevention programs, for state-produced travel literature (including Texas Highways, the state's official travel magazine), for the state's 12 Texas Travel Information Centers, and for audiovisual services that provide multimedia support throughout the state. Road conditions reports, traffic cameras and other resources are available online to help plan trips.

Table 3.2: Potential Functional Classification Areas per the Restructuring Council Recommendations

ORGANIZATIONAL STRUCTURE	Aviation and Passenger Rail	Human resource and information technology functions. Innovative financing and debt management activities. Identifying the state's needs in the long- and midterm (economics and future forecasting models, and transportation planning and development specialists).
FINANCIAL MANAGEMENT	Financial Controls and Oversight	Employee accountability and performance measures. Single information technology system that integrates budget and operations data.
INFORMATION TECHNOLOGY	Information Technology as a Strategic Asset	Redefine IT governance objectives, participants, and processes.
HUMAN RESOURCES	Human Resources as a Strategic Function	Define and measure the work, identify skill requirements and salary groups. Position Management process. Results-or outcome-based performance management system.
COMMUNICATIONS	Comprehensive Communications Policy	Ownership, processes and procedures for communications with each stakeholder group.
PLAN, DESIGN, BUILD	Planning Process Improvements Environmental Planning Rural Planning Organizations Right of Way Acquisition Engineering Workforce Analysis Field Operations Staffing	Structured process to establish statewide project priorities to improve transparency and communication with external stakeholders. A clear, transparent and disciplined project planning process. Standardize construction and maintenance project definitions. Track all project data, information and records in a single system. Streamline TxDOT's project planning processes wherever possible (environmental review process and the right of way acquisition processes should be the department's highest priority). Supports the role of rural planning organizations and recommends. Use of in-house engineering services versus the services of outside engineering consultants (Currently under study). Field operations staffing plan (Currently under study).

PROCUREMENT	Centralize Oversight and Develop Consistent Process And Procedures	Historically Underutilized Businesses (HUB) and Disadvantaged Business Enterprises (DBE) management needs significant attention.
		Develop standardized processes and approaches to form a single procurement architecture for all procurement activities.
		Develop a comprehensive procurement database capable of capturing, maintaining, and reporting critical information and data.

3.2 Other Use of the Functional Mapping Process

As noted, the overall purpose of undertaking the functional mapping process was to identify potential areas where OR/MS techniques could make significant improvements. In addition, the process also fed into the development of a systematic series of steps (Project Deliverable P2) to determine actionable research statements (Project Deliverable P1) that could be repeated in order to continue to identify opportunities for improvement in the future. As noted in Project Deliverable P2, this multi-stage procedure is centered on incorporating the knowledge and experience of current TxDOT professionals with the knowledge base of the OR/MS community to identify the areas and activities of TxDOT that could realistically and significantly be improved with the incorporation of OR/MS techniques.

3.3 Conclusions

The information gathered as part of the functional mapping task was valuable in defining a clearer picture with regards to the activities and objectives that are important to TxDOT, which is paramount in identifying applications of OR/MS which can both be actionable, as well as desired from TxDOT's standpoint. By analyzing the problem from a financial, organizational and strategic standpoint, we obtained a better understanding of the problem at hand. Furthermore, this information formed the basis for the survey script as discussed in the following, as well as the contact list to which the survey with be provided. In the end, the objective is to identify the most pressing issues from TxDOT's standpoint that are also high impact, as well as identify any discrepancies between TxDOT's goals and the way they are perceived by TxDOT professionals.

Chapter 4. Communication plan

The purpose of the communication plan was to gain insight into the particular problem types that TxDOT faces, which enabled the research team to develop potential solutions and problem statements. The communication plan was comprised of an online survey of TxDOT personnel, followed by one-on-one telephone interviews with selected TxDOT personnel. The following sections detail the methodology and results of the communication plan.

4.1 Constructing Survey Scripts

The survey was developed around four major sections:
- Demographic and employment information
- Current state of the organization
- Opinions regarding the current state
- Suggestions for managerial improvements

The first part of the survey addressed demographic and descriptive information of survey participants, including their role and position in the organization, education, and factors influencing work experience. This information helped the research team identify the participants and divisions for follow-up interviews.

The next section of the survey focused on the extent to which scientific approaches for decision making are currently being used in the organization. To classify focus areas, this section used the six overall organizational goals that the TxDOT strategic plan for fiscal years 2011-2015 specifies as main areas of future actions.

Prioritizing and identifying improvement areas was the major focus of the third section of the survey. Questions aimed to gather information on specific managerial challenges and capture respondents' evaluations of the organizational effort and efficiency within the context of each of the six major goals.

The last section of the survey focused on participants' recommendations as to what specific managerial solutions might be used to help the organization achieve its long-term goals. Questions asked for suggestions of improvement actions to enhance overall efficiency at division and organizational levels. Several questions addressed the allocation of the organization's financial resources within four main groups of managerial activities: planning, building, maintaining, and other activities. The questions aimed to identify the difference between the current allocation and what respondents think should be allocated. This information helped the research team in prioritizing management solutions identified in the previous tasks of the project.

4.2 Administering Survey

This section describes the process followed to administer the survey, including the development of a contact list, and the method by which the survey was distributed.

4.2.1 Developing Contact List

The research team gathered a list of TxDOT personnel that would be ideal candidates to complete the surveys. An initial list of potential survey recipients was created from an evaluation

of TxDOT's current organization chart using the results from the functional mapping effort. The initial list was reassessed after the creation of a catalog of TxDOT job types related to management functions. The potential list of survey takers was then provided to the Project Monitoring Committee for review and evaluation. The approved list of survey takers is attached at Appendix A. The approximate number and type of participants was determined by evaluating the database of TxDOT job classifications, budget expenditures, and the outcome of literature review. Table 4.1 shows the percentage of participants based on their job title.

Table 4.1: Composition of Survey Participants

Job Title	Percentage of Participants
Director/Officer	44%
Assistant Executive Director	10%
District Engineer	36%
Other	10%

4.2.2 Distributing the Survey

A cover letter was developed to be sent along with an invitation to complete the survey online via Survey Monkey®. Based on the responses gathered from the survey, the research team contacted select personnel for follow-up interviews via telephone to clarify understanding of responses and identify additional potential problem areas.

Online Survey

A member of the Project Monitoring Committee emailed the approved list of potential survey participants, inviting them to complete the survey via Survey Monkey®. In the email invitation was a URL to the survey. A PDF version of the survey was also available for distribution in case the participant wished to complete the survey across an extended length of time. These completed survey responses were then manually entered into the online database. The survey distributed is provided in Appendix B.

Follow-up Interviews

The list of contacts for the follow-up interviews was also provided by a member of the Project Monitoring Committee. The list consisted of a few TxDOT Directors and several Analysts. The research team emailed each potential interviewee inviting them to schedule an interview appointment. Fourteen candidates (6 directors and 8 analysts) agreed to participate in the follow-up interviews. These participants were scheduled for an appointment time and contacted via telephone by the research team for the interview. The interview questions asked are provided in Appendix C.

4.3 Survey Results

This section presents the results of the Online Survey in section 4.3.1, and the follow up surveys in 4.3.2. The focus of the Online Survey results is to depict the general picture of

TxDOT as an organization, while the focus of the follow up surveys was to hone in and further refine the opinions of specific TxDOT decision makers so as to identify clear opportunities for OR/MS applications.

4.3.1 Online Survey

This section presents the results of the online survey responses. Responses were downloaded from the Survey Monkey® database and analyzed using Microsoft Excel when applicable to tabulate results. Open-ended responses were summarized in paragraph or tabular form.

Demographic Summary

The survey was conducted via Survey Monkey online, with the option to complete a PDF version at the respondent's leisure. There were nine participants who completed the survey: seven males, one female, and one blank response. Except for one blank response, participants were split between two age groups: four 40-49 and four 50-59. Education backgrounds were mostly bachelor's, with only one master's and one doctorate. Listed below are all the administrative units that completed the survey (alphabetical order):

- 31 RCN
- AMA
- District office
- Division
- El Paso District
- Laredo District
- TYL
- Tyler District
- (Blank)

Six participants were district engineers, two were directors, and one was a blank response. Of the participants who responded, 100% have worked for TxDOT for more than 10 years. Three participants have been at their current position for 2-5 years, four for 5-10 years, and one for more than 10 years.

Current State of Organization

The purpose of these questions was to ascertain if any management science principles are currently being used at TxDOT. The first question asked participants with respect to the six main TxDOT strategic goals if their division has conducted any efforts in the management sciences. The figure below shows the results of this question
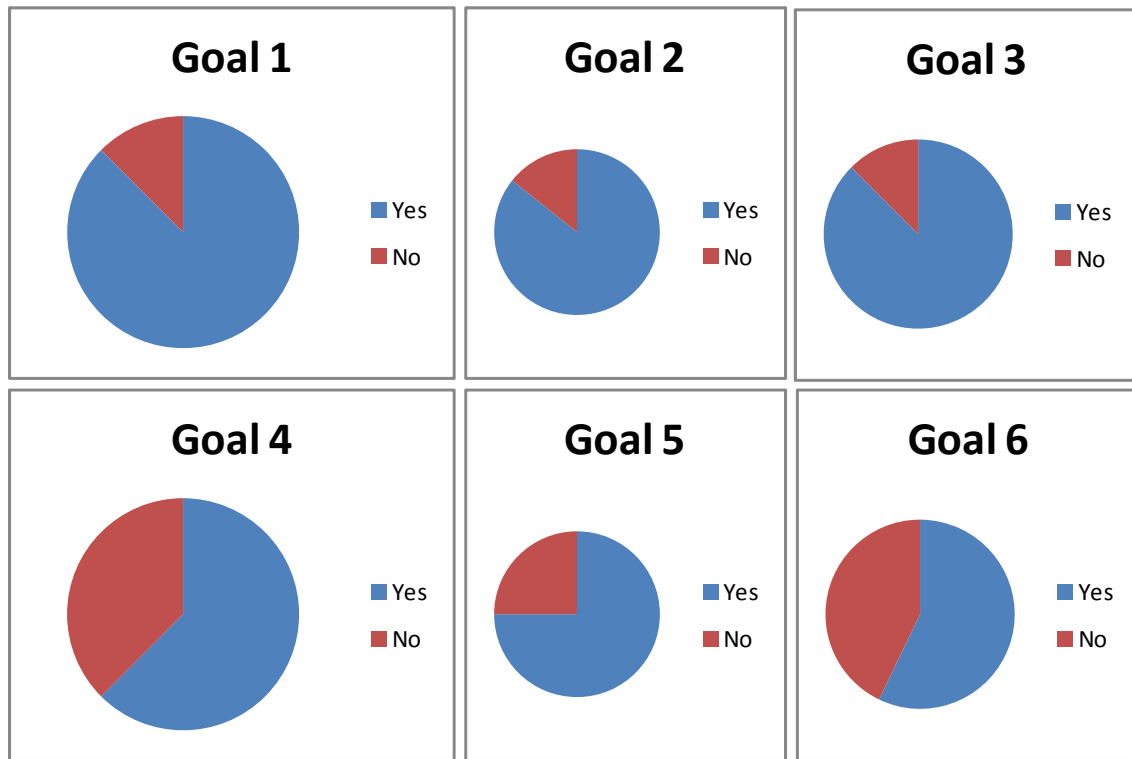
Figure 4.1: Current State of the Organization

Participants were then asked to describe the efforts their division has conducted in the management sciences. With respect to each strategic goal, all raw responses are listed in the table below.

Table 4.2: Efforts of own division

Goal 1	• Annual interaction with elected official. Information sharing meeting every other year • Traffic Safety Programs • One Dot Staffing Plan for District. Quarterly meetings with staffs of major cities within District. Continual involvement and coordination with 2 MPOs in the District. • Decision sciences • One DOT Staffing plan 24 month letting schedule work • PDP-2012 • Surveys and emails Blast
Goal 2	• Fatal/incap accident review team. Hurricane response plan • Traffic Safety Programs, ITS operational strategies, work zone safety programs, and traffic operational strategies • Development and implementation of safety improvement projects utilizing safety bond funds. Establishment of Mission Zero safety initiative for District. • Work with DPS, Texas Forest Service, and utilize CRIS system for safety project selection. • PDP-2012 • Project selection
Goal 3	• Measure pavement condition trends and plan effectiveness • TxTAP and radio and signals operations • Development and implementation of 4-year pavement management plan for each section within the district. Development and implementation of local process of selecting projects to be constructed throughout the District utilizing various funding mechanisms available. • Operations research and decision sciences • Work on 4-year pavement maintenance plan to maximize preventive maintenance work while minimizing major rehab work. • PDP-2012 • Shifting all available funds to pavement
Goal 4	• ITS operational strategies, managed lane strategies, 511 project and traffic operational strategies • Collaborative efforts with 2 local MPOs and other local elected leadership to identify major areas to consider for mobility type projects to relieve congestion. • Decision sciences • PDP-2012 • Extensive research to enhance its use
Goal 5	• ITS operational strategies, CVSN, BSIF and traffic operational strategies • Evaluate system connectivity for as part of the project selection and prioritization process for all major projects. • Operations research and sciences • Work on development of Super 2 roadways throughout the district to improve efficiency on a limited budget. • PDP-2012 • Stakeholders involvement in statewide selection of projects

Goal 6	• Maximize all funding opportunities and effectively perform public outreach in all traffic operational and program areas (ITS earmarks, traffic safety grants, Safety Bond and other safety earmarks • Work with local MPOs and RMA on multimodal project needs as funding opportunities arise. • PDP-2012 • Funds to segments other than highways

When respondents were asked "*Do internal procedures exist to systematically evaluate methods to optimize your division's/office's performance?*" six responded "yes" and three responded "no." If the respondent answered yes, they were asked to describe the procedures. All raw responses are listed below.

- PMIS, Safety records
- We develop manuals and procedures and reporting requirements that we then use to improve our programs.
- Many various performance measures/goals exist and are tracked through many various internal procedures. Example: Goal 1 - One DOT Staffing Plan with staffing level targets. Also Goal 1 - Performance measures within CRAFT that measure District's response time for resolutions to external issues. Goal 2 - District has initiated Safety Mission Zero and associated safety goals. Also is identifying safety projects and utilizing safety bond funds to improve public safety on roadways. Safety of facilities is tracked through Goal 3 - District has implemented 4-year pavement management plan with internal goals for each maintenance section and can be reviewed through internal accounting systems for productivity and efficiencies. Goal 4 - Method in place through working with MPO's and other elected officials to identify locations of high congestion and implement solutions through local contributions in addition to various TxDOT funding programs. Goal 5 - Mobility type project selections are made in which system connectivity is always considered as a major factor in the prioritization process. Goal 6 - District has assisted local MPOs in developing multimodal projects through our collaborative working relationships that have been developed.
- TxDOT Tracker has performance measures in place. Through the RLT information is shared relative to my district's performance.
- Internal in addition to mandated performance measures

Survey participants were asked who is responsible for operational efficiency or change within their division. Common responses included the district engineer, division directors, and themselves (all employees).

The final question of this section asked participants which units within TxDOT (any or all) have the highest influence on the achievement of the six strategic goals. The units listed for consideration were: (1) Finance, (2) Strategic policy and performance management, (3) Field and district operations, (4) Engineering operations, and (5) Support operations. The summary of the results is shown below.

Figure 4.2: Influence on the Achievement of Goals by Division

In summary, respondents identified that there are several efforts currently being made in the management sciences and employees and units within TxDOT are actively moving towards meeting the six goals of the TxDOT strategic plan.

Opinions of Current State

The next section of questions in the survey consisted of prioritizing and identifying improvement areas within TxDOT.

The first question asked respondents what three issues relating to their operations would they have researched if given a highly competent analyst for six months. As open-ended questions, there were a variety of responses as shown below:

- Resource/Materials Management:
  - Surface selection for new pavements
  - 4 year pavement management plan utilization
- Project Effectiveness:
  - Accident reduction (effectiveness of applied solutions)
  - Level of service for snow and ice storms
  - Analyze additional avenues to quantify traffic safety behavioral modification efforts.
  - Is the district optimizing the use of ITS capabilities to manage congestion within the district.
  - Are we as focused on safety and preservation of the system as we should be?
  - Can our performance metrics be expanded to include other functional areas?
  - Internal performance measures and mandated performance measures
- Project Prioritization:
  - How best to establish program priorities
- Financial Allocations/Considerations:
  - Benefit/Cost ratio of expenditures
  - Comparison of in-house versus outsourced services
  - Total cost of owned equipment versus leased
  - Is our 4 year Pavement Management Plan ensuring the greatest return on investment, or is it merely a spending plan to obligate available funding.
  - Budget
- Personnel Workload:
  - Analyze the reduction of technical staff in the districts that have traditionally supported traffic operations while the expectation of service level remains the same.
  - Determination of staffing/FTE levels within each Districts functional areas. (Strategies 101,105,604)
  - How best to determine needed staffing levels
  - How best to evaluate staff performance involved in programs
  - Is our OneDOT staffing plan doing enough to ensure that not only are we meeting the proper staffing goals, but that the numbers ensure we that the needed organizational structure.
  - Do we have the right number of FTE's in each of our operational areas?
- Future Planning:
  - With financial constraints, evolving technology, and communication, a new direction for delivering of intelligent transportation systems needs to be strategically planned (TTI currently working on this).
  - Future staff development needs (cross training)

The next question asked what three issues for TxDOT as a whole most deserve analytical research. Again, there were a variety of responses because it was an open-ended question, but the answers have been categorized below.

- Public Considerations:
  - Public involvement in projects
  - Accident reduction for various applications
  - How best to manage expectations
- Financial Efficiency:
  - Level of transportation funding required to maintain economic growth
  - Dollar amount of projects for advance planning through backlog of plans developed
  - Analyze financial processes and procedures
  - Future funding levels
  - What is the impact to the district's pavement management plans when administration changes project schedules and funding levels to accelerate projects in a rush to obligate funding without properly analyzing the return on investment?
  - Determine our effective costs for doing business in many functional areas, i.e. design, construction, maintenance, planning, operations, etc.
- Project Prioritization:
  - Project selection criteria
  - How best to establish priorities
  - Is the department properly distributing funding based on needs and priorities?
- Staffing:
  - FTE/Staffing levels and distribution
  - Future Staff development
  - A comprehensive staffing analysis is needed to better balance our FTE's with workload
- Internal Efficiency:
  - Improved performance measurements
  - Analyze the legacy systems within TxDOT that cannot provide needed information
  - Analyze solutions to the fact that TxDOT technology resources are well below that of private industry
  - What should the Department's role be in delivering projects
  - Is the department properly using Regional Offices to provide the necessary support to the districts, or are they being used to monitor districts compliance with budgets, lettings, CRAFT issues, etc.
  - A comprehensive risk analysis is needed to make sure we are managing our risks appropriately and not over-managing some risks.

The next question refers to the issue that the respondent felt is generally under-appreciated.

- Cross Training Staff/Passing Knowledge Downstream:
  - Retention of institutional knowledge

- o Staff development. Not just formal training, but time and ability to develop younger/newer personnel on the job.
  - o Succession Planning - while we have developed an organization that can quickly produce plans to obligate any additional funding that becomes available, we have not expended enough of an effort to properly develop and retain quality employees in an effort to encourage them to become future leaders of the department.
- Efficiency Amongst Limited Funding:
  - o Realistic impacts on future system with significantly reduced funding
  - o Provide for increasing traffic volumes with available funding that is remaining constant or decreasing.
  - o Quantification of efficiencies and savings from negotiated professional services contracts
- Consistency Across All of TxDOT:
  - o Standard operating procedures are established throughout the department but are not consistently followed in all districts and division.
  - o Lack of sustainable approach to transportation system development
  - o The need to establish priorities
  - o The need for a required and disciplined approach to project management
  - o The need for strong program oversight
  - o The change in focus as related to the role of the Department in project delivery
  - o The environmental process has become the critical path to project development. Our environmental organization and processes are in need for re-invention, re-tooling and re-prioritizing.

The next question asked participants what specific areas/programs within their division/office would gain the most from an improvement in efficiency. Responses included: automation, fleet maintenance, technology, maintenance field operations, and a comprehensive staffing analysis based on performance metrics. Project prioritization was again mentioned in detail by one respondent:

"The Mobility Project Selection - With our limited resources, the regional offices should step up and prioritize mobility improvement needs for the region, and then based on available funding let the regional DE's determine the project ranking. Then the mobility funding would be allocated based on the projects, in lieu of using formulas that many times do not provide sufficient funding to develop the necessary project to address the congestion issue."

The next question asked respondents to rate the current work practices of their division/office in achieving each of the six TxDOT strategic goals. The charts below summarize the responses.
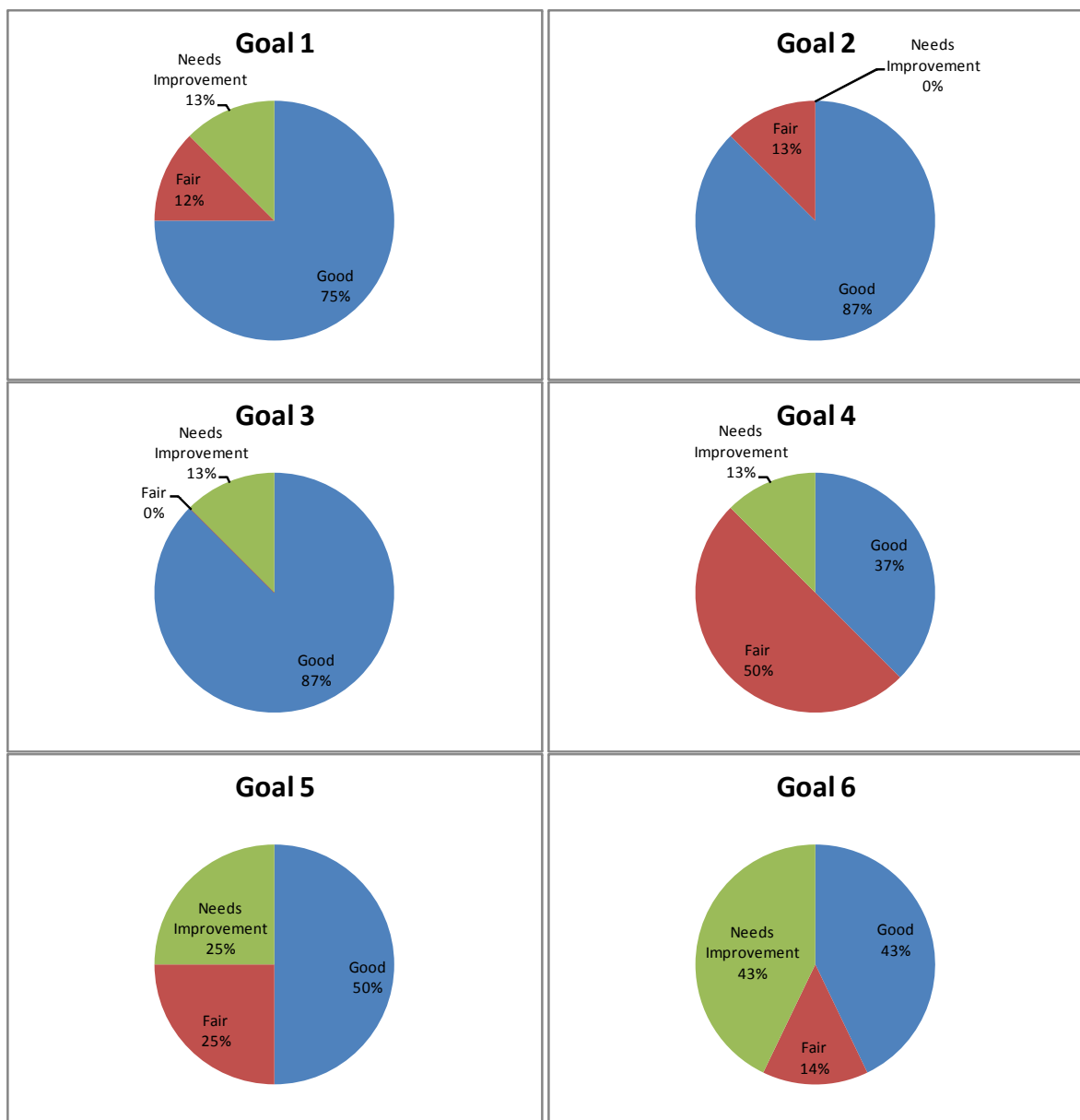
Figure 4.3: Current Work Practices

The next two questions relate to the financial efficiency of the participants' division/office and TxDOT as a whole. The first of these two questions rated the respondent's division's financial efficiency within the context of the six strategic goals. The second question simply asked how the participant would rate TxDOT's overall financial efficiency.
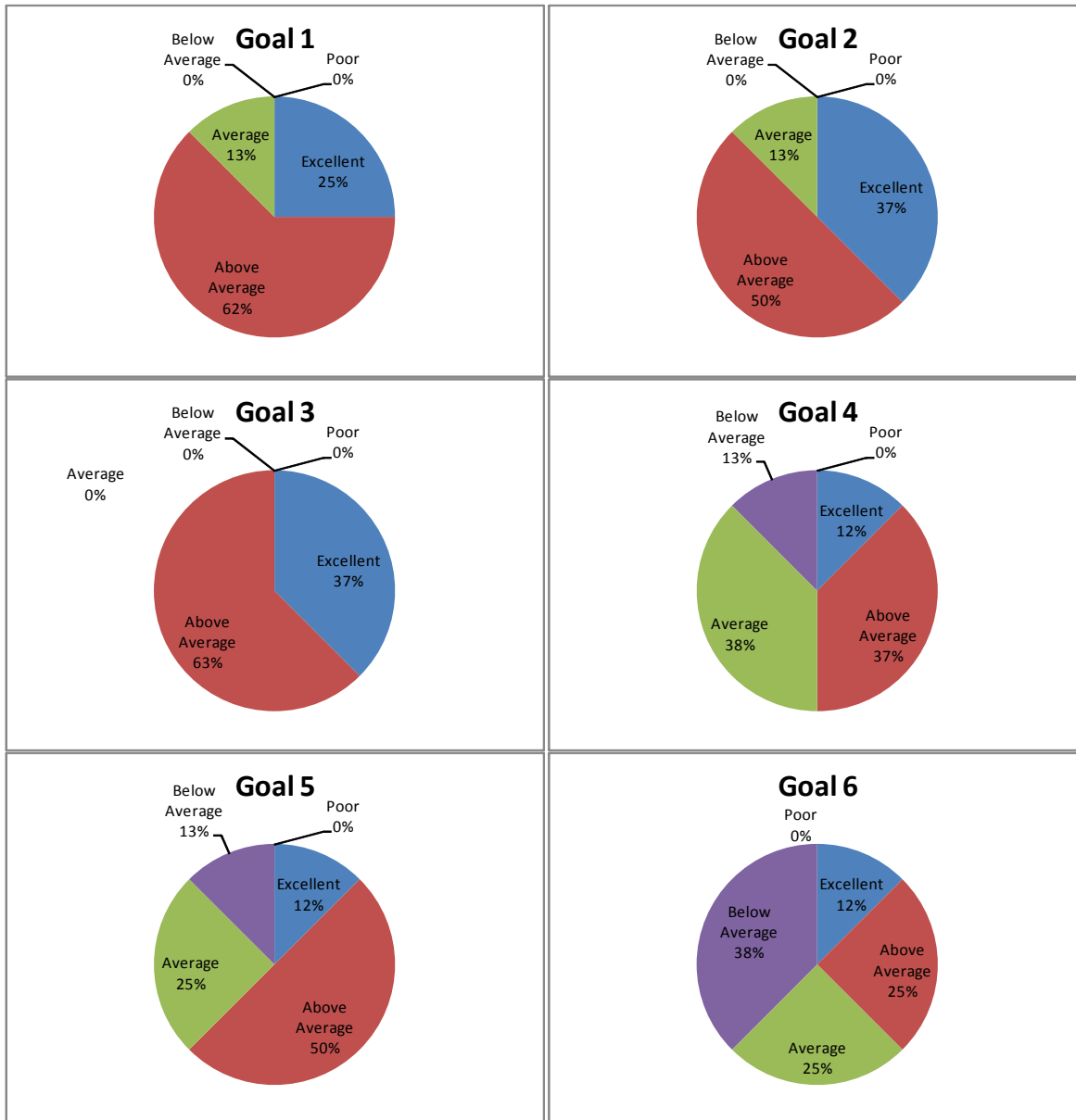
Figure 4.4: Overall Financial Efficiency

Of all respondents, 63% rated TxDOT's overall financial efficiency as "Good," 25% rated it "Fair," and 13% rated it as "Poor." When asked to explain why they provided such a rating, respondents said:

- Rated "Good":
  - Has seen significant improvement in recent years due to planning, sharing best practices and cost saving initiatives
  - There are some processes that are limited by funding/purchasing restrictions and could be significantly improved.

- o TxDOT has led the way with innovative financial partnerships in the U.S., but our antiquated financial system makes it difficult to answer all questions without significant manual labor.
    - o Optimum utilization of our funding resources that resulted in improved pavement scores when models predicted otherwise
- Rated "Fair":
    - o Lack of focus on priorities
- Rated "Poor":
    - o A project was renegotiated after construction letting that realized a $ 50 Million savings to TxDOT, after the original agreement was rushed.

The next question asked participants to rate TxDOT's overall organizational efficiency (as opposed to financial efficiency). Of all respondents, 25% rated TxDOT's overall organizational efficiency as "Excellent," 38% rated it "Good," and 38% rated it as "Fair." When asked to explain why they provided such a rating, respondents said:

- Rated "Excellent":
    - o Every process is open to streamlining and improvements
    - o Proven results
- Rated "Good":
    - o Has seen significant improvement in recent years due to planning, sharing best practices and cost saving initiatives
    - o We are a great organization made up of excellent employees, but we seem to be out of balance with our priorities and risks
- Rated "Fair":
    - o Based on recent reports and audits related to the department's modernization efforts.
    - o Lack of focus on priorities
    - o TxDOT has right sized the number of employees, but has a big need to improve on placing the employees into the proper positions within the organizational structure. Just because we have the correct number of design personnel, does not mean that we have the proper design supervision and management levels.

The last question asked what part of the TxDOT organization needs to be improved the most in terms of efficiency and why. Open-ended responses consisted of:

- Automation--unresponsive to users and resists early adoption of improvements
- Turnpike
- Financial and technical areas - based on recent reports and audits related to the department's modernization efforts.
- Purchasing - The limitations of purchasing various things in order to achieve our goals are limited and restricted. Road materials are an example.
- Need to focus on sustainability and establishing priorities then being disciplined and expending money based on priorities

- In terms of efficiency, the part of TxDOT organization that most needs improvement is funding allocation and obligation scheduling. The administration seems to be in a constant rush to obligate any available funding, without taking the time to ensure that the funding is being used to provide the greatest return on investment, so district are sometimes forced to let projects just to obligate the funds, even when those projects would not provide the greatest bang for the buck.
- All engineering divisions need to be combined into one Project Development Division to better manage the process, enhance communication and coordination and increase efficiency.
- HR hiring, firing, compensation, succession planning as it is a key to future development and success

In summary, respondents feel that TxDOT in general operates with above average efficiency, but there are several areas that could be improved upon. Recurring ideas consisted of improving the project prioritization process so that projects are funded based on need and are using TxDOT's financial resources in an effective and optimal way. Personnel cross-training was mentioned several times. With significant staff turnover and expertise within a job function, the need to pass along that knowledge is vital to the on-going success of the organization in the future. Job-sharing functions could be considered as part of employee training or exodus. Financial and material resource allocation should be carefully scrutinized to ensure appropriate projects and maintenance are being addressed across the state as a whole. Consistent and clear communication from a top-down chain of command is necessary to keep all employees moving forward towards the same strategic goals.

Recommendations

The last section of the survey focused on participants' recommendations as to what specific managerial solutions might be used to help the organization achieve its long-term goals. The first question asked for suggestions on efforts or programs the participant's division should conduct in the management sciences. The responses were given in general and then with respect to each of the six strategic goals.

In general, improving communication in a cost-effective way was one effort mentioned, especially since managers are located remotely from subordinate personnel. A desire for increased flexibility to make better business decisions was also mentioned. Improving the way in which staff within a division spend their time was addressed. A recurrent theme throughout the survey, project prioritization was brought up again in the context of developing a way to analyze the return on investment during the project selection process. More specifically, in order "to better evaluate that we are not only obligating the available funding, but that we are also using the funding to obtain the greatest return on our investment."

Table 4.3: Recommendations with respect to each of the six strategic goals

Goal 1	• More flexibility with distribution of FTEs. • Most important • Better utilization of information systems to minimize internal meetings and travel time to allow greater time for communication and coordination with external partners and stakeholders. • Have a statewide succession plan; hiring to be centralized
Goal 2	• Develop a programmatic approach for the review of safety projects • Enhance the internal records documentation of collisions on the CRIS system to differentiate between collisions that are due to driver issues versus the need for pavement improvements. • Enhanced partnership with internal and external stakeholders
Goal 3	• Develop an asset management system • In addition to the Annual Pavement Condition Scoring and Reporting, provide information on how well the district performed on letting projects and completing work noted on their 4 Yr PMP. • Improved performance measures that are relevant and useful
Goal 4	• Secure additional mobility funding • On mobility projects, require documentation showing how the project will impact the overall congestion index within the district, so that we are not building 5 overpasses through a town with 1 signal light.
Goal 5	• Enhance Macro-level approach to planning
Goal 6	• Develop a method for assessing based on sustainability criteria • Provide districts with greater flexibility on development of annual funding caps, in lieu of development of project letting schedule to match funding provided by division. • Training and communication to promote the multi-modal approach in the planning process

The next two questions asked what suggestions would the participant make to improve the financial performance of (1) their division/office and then (2) TxDOT as a whole.

Division/Office Suggestions:
• Better performance measurement
• We would ask the department to provide better financial resources, technologies and systems.
• Need to have accurate CSJs for charging to projects and need to have program charge numbers.
• In order to improve the financial performance of the district, I would suggest the development of an office of risk analysis which would calculate rates of return on project,

analyze risk associated with accelerated letting of projects on project creep and delay due to incomplete ROW acquisition or utility adjustments. Further, in addition to the current Budget Information System, would add forecasting capabilities so that districts could provide projected monthly expenditures to enhance budget tracking.

- More flexible contracting and procurement policies that allow for and encourage innovation. We are very rigid with Comptroller and DIR requirements.
- Performance measures that are relevant and that rely on updated data

TxDOT as a Whole: Suggestions:
- Place more emphasis on improving financial resources, technology and systems.
- More flexibility across all functional areas through revised policies that constrain making the best business decisions.
- Need to focus on total project cost. Need to develop priorities and focus limited money on priorities. Need to require a more disciplined approach of capturing staff time spent of projects (by project) and program work.
- As a part of the letting process, in addition to providing an anticipated construction schedule for the project, require districts to submit a payout schedule for the work being performed to better assist the finance division in projecting monthly expenditures.
- Better prediction and forecasting models for revenue and budgeting.

The next two questions related to TxDOT's expenditure categories and the resource allocations. The first question asked participants how they guess resources are currently allocated within each expenditure category, so that the total allocation totaled 100%. The second question first showed the actual current allocation percentages, and then asked participants how they recommend allocating resources within each category. All responses were averaged and are summarized in the table below.

Table 4.4: Estimates of Resource Allocation by Respondent

	Planning	Building	Maintaining	Other Categories
Guess	13.6%	40.7%	37.9%	7.9%
Actual	19.1%	40.4%	35.5%	5.0%
Recommendation	20.0%	35.0%	40.0%	5.0%

The next question continued with the same expenditure categories and asked what amounts of financial resources should come for each category for the execution of each of the six strategic goals. The legend of choices was:
- LOW: I think a LOW amount of financial resources should come from this expenditure category for the execution of this goal
- MEDIUM: I think a MEDIUM amount of financial resources should come from this expenditure category for the execution of this goal

- HIGH: I think a HIGH amount of financial resources should come from this expenditure category for the execution of this goal

Table 4.5: Respondent Suggestion for Allocation of Financial Resources

	Planning			Building			Maintaining			Other Categories		
	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
Goal 1	29%	29%	43%	57%	14%	29%	43%	29%	29%	29%	29%	43%
Goal 2	14%	43%	43%	0%	29%	71%	0%	14%	86%	57%	14%	29%
Goal 3	14%	57%	29%	14%	43%	43%	0%	14%	86%	57%	29%	14%
Goal 4	14%	14%	71%	14%	14%	71%	57%	0%	43%	71%	14%	14%
Goal 5	14%	0%	86%	14%	29%	57%	43%	29%	29%	71%	29%	0%
Goal 6	29%	0%	71%	57%	14%	29%	57%	14%	29%	43%	43%	14%

The last question was similar in nature, but asked what specific units within TxDOT should be in charge of each of the six strategic goals. The choices for each unit were:

- LOW: I think this organizational unit should have LOW influence/control over the execution of this goal
- MEDIUM: I think this organizational unit should have MEDIUM influence/control over the execution of this goal
- HIGH: I think this organizational unit should have HIGH influence/control over the execution of this goal

Table 4.6: Responsibility for Strategic Goals by Unit

	Finance			Strategic Policy and Performance Management			Field and District Operations			Engineering Operations			Support Operations		
	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
Goal 1	29%	29%	43%	29%	29%	43%	14%	14%	71%	14%	57%	29%	14%	43%	43%
Goal 2	29%	57%	14%	57%	14%	29%	0%	14%	86%	14%	29%	57%	29%	57%	14%
Goal 3	29%	57%	14%	71%	0%	29%	0%	14%	86%	29%	14%	57%	43%	29%	29%
Goal 4	43%	29%	29%	43%	14%	43%	0%	29%	71%	14%	29%	57%	57%	43%	0%
Goal 5	43%	14%	43%	43%	29%	29%	0%	29%	71%	29%	14%	57%	71%	29%	0%
Goal 6	14%	57%	29%	71%	0%	29%	57%	29%	14%	43%	29%	29%	71%	29%	0%

In conclusion, the way in which TxDOT currently allocates financial resources should be checked for optimality. On average, respondents were fairly close in guessing how TxDOT currently allocates its funds, but their recommendations for financial allocation are different and should be considered. With regards to the six strategic goals, careful consideration should be made about how to achieve them. The four expenditure categories all play a part in achieving these goals, but are they properly proportioned? Similarly, where does the responsibility lie for achieving these goals within the organizational units of TxDOT? The previous two tables indicate the participant recommendations for these two questions, and should be taken into consideration.

4.4 Follow-up Survey Results

The responses to the follow-up surveys were summarized and subsequently grouped based on OR/MS general themes. These results are shown below.

Table 4.7: Follow-up Survey Results

Title	Index	Interview Notes	Summary statement	Problem type
Utility accommodation and right of way acquisition	1.1	Analyze and quantify potential savings through improved procedures regarding eligible utility accommodations. Prepare best practice recommendations to assure utility conflict analysis is performed and captured, that independent agency estimates of cost and duration of utility installations are developed and establish procedures for point of delivery inspection of utility accommodations completed to certify legitimate costs incurred.	Utility accommodations	Planning/design/project management methods
	1.2	Utility costs when it comes to ROW - those costs are in the millions of dollars, they don't hit at one time; I know they're working on that, but they need to come up with a plan	Right of way acquisition services	

Title	Index	Interview Notes	Summary statement	Problem type
	1.3	Utility costs-TxDOT goes out and wants to build a road on a certain piece of land, and utilities need to be rerouted around it; they don't get us a bill in the same year the work was done, charges end up being more than the original agreement; forecasting needs to be done	Utility cost contract agreements	
Work load and productivity analysis for forecasting future staffing needs	2.1	Study to determine what productivity/production metrics are the most important. Will soon be working with smaller management staff – need to determine how to assess manager performance and what factors matter. Current performance metrics not developed in-house. Current model is to run to failure.	Forecasting staffing needs at the managerial level based on productivity	HR forecasting methods
	2.2	Ability to look at current staffing needs and forecast based on projected budgets and rate of turnover/retirements, etc.	Forecasting staffing needs	
	2.3	Develop staffing plans for engineers 2014and out – currently use People Solve to ID current slots but no way to assess/forecast future needs using hypothetical info, etc.	Forecasting staffing needs	

Title	Index	Interview Notes	Summary statement	Problem type
	2.4	Manpower analysis of core activities (construction, maintenance, design) to understand how many hours each task needs.	Workload analysis	
Work load analysis for performance-based compensation	3.1	Work load analysis or work function analysis. Down to the level of MBA-ish, how much productivity does each person have and how does that play into the whole system? Big goal is aligning the number of people to the functions they perform.	Work load analysis - Staff efficiency	Workload imbalances
	3.2	Statistical model to identify pay discrepancies (gender and under-represented workers for equity adjustments – no current process to analyze	Pay discrepancies	
	3.3	Organization as a whole would benefit from a whole organization performance assessment – for some jobs classifications (engineers for example) no defined levels of performance. Anecdotal evidence is that some districts and individuals outperform others. What is average, what is acceptable? Goes to shared services – how to t track and define. What metrics do you use? Are there industry standards?	Whole organization performance assessment	

Title	Index	Interview Notes	Summary statement	Problem type
Right of way acquisition management (time/cost)	4.1	Calculate the average time in-process for components of right of way acquisition services delivery to analyze the correlation if any with the extent and length of time given to right of way considerations in advance project planning, scoping and development.	Right of way acquisition services	Planning/design/project management methods
	4.2	Utility costs when it comes to ROW - those costs are in the millions of dollars, they don't hit at one time; I know they're working on that, but they need to come up with a plan	Right of way acquisition services	
Management of design and planning processes	5.1	TxDOT knows how much time needed for detailed design but does not have a process for schematic design and advanced planning, etc.	schematic design and advanced planning	Planning/design/project management methods
	5.2	Lack of control over determination of a defined scope before going into detailed design (or other sequential phases?) Need assistance in scope definition process.	Detailed design	

Title	Index	Interview Notes	Summary statement	Problem type
	5.3	Do not consider long-term/ultimate impacts of specific projects. Widen once and then might come back in a few years and widen again. Is there a better way to tie long range advanced planning with corridor to project level decisions? Could we optimize at each project to make determinations on what it ultimately could be within a given future timeframe	Right of way acng-tern/ultimate impacts of specific projects.quisition services	
Project prioritizing for financial allocation	6.1	Our method of allocating transportation dollars – making sure that we're allocating in areas that really need it as opposed to just political needs	Funding strategies	Financial allocation and cost tracking
	6.2	Definitely see portfolio management on an enterprise level – I know efforts are being done to optimize funding, but finding optimal projects to go with that funding is not being done. Asking "are these really most important projects that we're spending money on?"	Funding strategies	

Title	Index	Interview Notes	Summary statement	Problem type
	6.3	Maintenance on the front side (in first question, it was maintenance from the back end) – putting more emphasis into which projects, making sure we're getting those right projects, kind of back to portfolio maintenance, there is more road maintenance. Asking, "are we maintaining the most important things?"	Funding strategies	
	6.4	Project prioritization – what is the best use of the limited funding we have, that goes into not only construction projects, (the focus of TxDOT is construction), but we also have multi-million dollar IT projects and many of them. And we have little bitty ones too.	Funding strategies	
Enhancing internal communication by using IT tools and improving processes by reducing unnecessary paper work	7.1	Use of technology for reduction of unnecessary paper work to increase efficiency. For example, using economical hand-held devices in this project helped inspectors measure and record placements in the field. This increased efficiency of inspectors and people above them who had to review their work.	Collaborative project management solutions	Communication (internal)

Title	Index	Interview Notes	Summary statement	Problem type
	7.2	Reduce the unnecessary paperwork and bureaucracy by streamlining work processes as well as adopting new technologies	Collaborative project management solutions	
	7.3	Establish better statewide communication strategies (e.g., using Skype, instant messaging, texting)	Collaborative project management solutions	
	7.4	It all starts from administration. There needs to be more of a collaborative effort versus a dictatorial effort, making sure that you are including all the affected parties and possible affected parties. Give people opportunity to say, "nope that won't work," before making sweeping policy changes.		
	7.5	Severe lack of communication, and there's a trust issue. You can send messages 24/7, but if people don't trust who or from what the information is coming down – it does nothing. You can have a lack of communication, but if people don't trust who it's coming from, they're not going to listen. Respect is earned – people have to maintain it and earn it.		

Chapter 5. Development of Problem Statements

This section aims at describing the systematic process developed to identify and frame potential OR/MS research statements. Section 5.1 focuses on the development process itself, while section 5.2 introduces a case study used to illustrate the process. Finally, section 5.3 presents the problem statements that resulted from this project, developed using the process presented in this section.

5.1 Problem Statement Development Process

Once the results from the survey are obtained, the objective is to group concerns raised by different respondents into a more manageable number of categories, where each category represents one general group of organizational challenges that can benefit from improved OR/MS analysis. The categories developed as part of this research project, which can be used or improved upon in future endeavors, are:

- Planning/design/project management methods
- Financial allocation control and cost tracking
- Planning/design methods
- Workload imbalances
- Project prioritization and financial allocation
- Communication (internal)
- HR forecasting methods
- Equipment forecasting methods
- Communication (external)
- Cross-training

The goal of categorizing the issues identified in the surveys is to develop a general idea of which general set of problems are considered important, in hopes that methods can be developed which address multiple issues simultaneously, thus guaranteeing higher impact of proposed research problem statements.

The general set of problems considered was identified based on the responses to the follow up survey, summarized in Table 4-7. Once a general issue is identified, the following set of questions must be answered in order to identify problems which can produce high impact, actionable research problem statements:

- ***Can the benefits of addressing the issue at hand be easily quantified?***
- ***Will the benefits of addressing the issue at hand affect multiple areas in TxDOT?***
- ***Will the benefits of addressing the issue at hand have positive effects for a long period of time?***
- ***Is there evidence of successful implementations of OR/MS within TxDOT to address the issue at hand?***
- ***Is there evidence of situations where the issue at hand has had a negative impact?***

As an example, we provide a case study detailing the process followed to create one of the Problem Research Statements developed for deliverable P1.

5.2 Case study: Internal Communication

As answers to the question "What three issues or questions relating to your area must need (more) analytical research?" and "Likewise, for the Department as a whole, what three issues/questions most deserve analytical research?" yielded the following questions which can be identified as issues of internal communication, i.e. communication within the organization.

Use of technology for reduction of **unnecessary paper work** to increase efficiency. For example, using economical hand-held devices in this project helped inspectors measure and record placements in the field. This increased efficiency of inspectors and people above them who had to review their work.

Reduce **the unnecessary paperwork** and bureaucracy by streamlining work processes as well as adopting new technologies

Establish better statewide communication strategies (e.g., using **Skype, instant messaging, texting**)

It all starts from administration. There needs to be more of a collaborative effort versus a dictatorial effort, making sure that you are including all the affected parties and possible affected parties. **Give people opportunity to say, "nope that won't work," before making sweeping policy changes.**

Severe lack of communication, and there's a trust issue. You can send messages 24/7, but if people don't trust who or from what the information is coming down – it does nothing. You can have a lack of communication, but if people don't trust who it's coming from, they're not going to listen. Respect is earned – people have to maintain it and earn it.

While the 4 statements don't all necessarily tackle the same communication issue, it is clear that a focus on more streamlined, updated communication strategies is considered important by several important decision makers. Once an issue has been identified, we must identify the possibility that addressing such an issue will result in significant improvements for TxDOT.

Can the benefits of addressing the issue at hand be easily quantified?

In the case of internal communication issues, it is not clear how to quantify the benefits of improvement.

Will the benefits of addressing the issue at hand affect multiple areas in TxDOT?

Improving internal communication has the potential to affect every area of TxDOT, as all activities within the organization hinge on efficient and timely communication.

Will the benefits of addressing the issue at hand have positive effects for a long period of time?

It is clear that improved internal communications would have a long lasting positive effect in the organization.

Is there evidence of successful implementations of OR/MS within TxDOT to address the issue at hand?

As mentioned by one of the respondents, although at a smaller scale, successful implementation of handheld devices for more efficient communication had very positive results.

Is there evidence of situations where the issue at hand has had a negative impact?

While individual events could be pinpointed, it is not necessary as internal communication issues can have a part in a great number of operational issues.

Having answered these questions, it becomes clear that the problem of streamlining and improving internal communications can have far reaching and significant implications, and as such, should be considered as a potential research problem statement. Appendix D shows the RPSs developed as part of deliverable P1.

5.3 Resulting Problem Statement From Case Study

<table>
<tr><td rowspan="4">**Texas Department of Transportation**</td><td rowspan="4" align="center">Research Problem Statement</td><td align="center">Form ProbStat</td></tr>
<tr><td align="center">(Rev. 2/2009)</td></tr>
<tr><td align="center">(RTI)</td></tr>
</table>

RMC:	2	OPR: (for RTI use)		Project #: (for RTI use)	
Date:				Research Program Year:	

Project Title:	Improved Internal Communication
RMC Priority:	What RMC research priority will this project address? Planning and Environment (RMC 2)
Project Description:	What is the problem? As an organization consisting of 25 districts, 21 divisions and over 12,000 employees, internal communication is critical in the achievement TxDOT's goals. Communication problems can lead to poor efficiency, workplace problems, unbalanced workloads, etc. New technologies ranging from online networking tools to communication enabled hardware have an opportunity to increase the efficiency of specific activities. It is an important question, then, to identify which such tools can provide the right combination of implementability, cost and operational benefit. Ideally, an assessment of potential technologies, the communication challenges they could solve and a benefit vs. cost analysis would provide an invaluable resource for TxDOT when considering internal communication issues. Who is impacted by the problem? Streamlining internal communication protocols and reducing unnecessary bureaucracy has the potential to affect every division, district and employee in TxDOT. What is the significance / scope of the problem? The TxDOT staff is clearly its biggest asset, and making more efficient use of its workforce by minimizing the amount of time and effort wasted can result in incredible time savings and increases in productivity. What are the technical objectives of this project? The main objective of this project is to identify communication technologies that can improve and streamline the internal communications within TxDOT. What benefits would this project deliver, and how would the results be used within TxDOT? Communication technologies that are identified as beneficial for implementation, if adopted by TxDOT, could improve workforce efficiency and reduce bureaucracy.

RMC:	2	OPR: (for RTI use)		Project #: (for RTI use)	
		What specific deliverables would help TxDOT implement the findings / results from this project? An evaluation of commercially available communication technologies and an assessment of their efficacy, and the challenges they can help solve under different circumstances, would allow TxDOT to address internal communication issues and, as such, provide a low cost opportunity for operational improvements. Which District, Division, or Office would be responsible for implementing the results from this project? Technology Services.			
Developed By:		0-6637 Research Team			

Chapter 6. Conclusions

The purpose of this project was to identify high-impact and actionable applications of Operations Research and Management Science, and to document the systematic method used to identify such applications. The method focused on close collaboration with TxDOT personnel, and utilizing the research team's research expertise to generate functional mappings, i.e. general themes that encompass a range of TxDOT activities which share common modeling characteristics

The main objective of such a functional mapping focuses on the ability to find modeling and solution methods which are common to as wide a range of problems as possible, thereby maximizing their impact. These functional mappings were developed using TxDOT's strategic goals, organizational structure, and documented expenditures so as to develop preliminary functional classifications.

These functional classifications were then refined using a two-part survey distributed to selected TxDOT personnel. The first survey was distributed to a list of 67 contacts developed in conjunction with the Project Director. The focus of this survey was to identify the perception of the current state of scientific analysis of decision making procedure in TxDOT; specific areas in which opportunity for improvement exists; and suggestions on managerial improvements which can aid TxDOT in achieving its strategic goals. The second survey was meant to allow specific respondents to provide further information on specific opportunities and issues within the organization.

Using the results from the survey, the most prevalent and important issues were identified, and classified according to the preliminary functional classifications, which were refined based on the results from the surveys.

The research team found consistency across both the documented data reviewed and the results from the survey: right of way acquisition, project management and resource allocation were identified as important issues within the organization, consistent with expenditure figures.

On the other hand, several issues raised by TxDOT personnel which relate more to the management of the organization's staff: workload balancing, productivity-based compensation, and internal communication were identified as important issues that could have a wide spread impact on TxDOT. Furthermore, these are all established areas of research in the OR/MS community; this in turn suggests that OR/MS techniques have a high potential to be actionable in the context of TxDOT operations.

Finally, a systematic procedure for evaluating the feasibility of specific managerial issues as OR/MS research problem statements was developed in section 5. The focus of the procedure was on simplicity; as the focus of the research project is to identify high-impact opportunities, the focus should be less on the specifics of the impacts, but rather the order of magnitude of the expected benefit of implementation of advanced mathematical analysis techniques. By evaluating the history of practices, the number of affected parties, and the time period over which the benefits will be reaped, it is possible to develop a picture of the potential impact of OR/MS applications.

6.1 Education and Training

The process developed and followed as part of this project can and should be used in the future, as continued monitoring and improvement are critical in ensuring proper analysis and

implementation of OR/MS. Furthermore, it is critical to involve decision makers when identifying and implementing decision making support tools. As such, continued education and training of TxDOT personnel is critical.

Advanced understanding of research methods and existing literature is necessary for the development and refinement of solutions to some of the complex problems encountered by TxDOT. However, the ability to identify an existing problem which can be approached from an OR perspective requires only basic understanding of what OR/MS is. As such, TxDOT could greatly benefit from increased exposure of personnel to OR/MS methods. Workshops, tutorials, presentations, and informal classes can all be used as avenues for developing a general conscience within the organization of the possible improvements that can be achieved through the implementation of analytical decision-making models. A significant number of TxDOT personnel do have a background in OR related fields, but a more ubiquitous understanding could greatly benefit the organization.

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Appendix B: Online Survey

Project No. 0-6637
Management Science Applications for TxDOT – Scoping Study
Task 4: Survey and Selectively Interview TxDOT Professionals

<u>Survey Script</u>

Thank you for your willingness to participate in this survey about resource usage within your division at the Texas Department of Transportation (TxDOT). Your participation in this survey is entirely voluntary. You may choose not to answer a question if you feel uncomfortable. This survey will take approximately one hour of your time to complete. This research study has been reviewed by the Human Subjects' Protection Program and/or the Institutional Review Board at Texas A&M University. For research-related problems or questions regarding your rights as a research participant, you can contact these offices at (979)458-4067 or irb@tamu.edu. For questions about this survey specifically, please call NAME at NUMBER.

Please click OK when you are ready to begin the survey.

Demographic Questions (1-10)

1. Please specify the administration unit, division, or office in which you work: _____

2. What is your current job title? _____

3. What is your gender?

   Female
   Male

4. What is your age?

   19 or under
   20-29
   30-39
   40-49
   50-59
   60 or over

5. What is your highest level of education?

        High school or equivalent

        Certificate or training program

        Associate

        Bachelors

        Masters

        Doctorate

        Other

6. How long have you been working for TxDOT?

        Less than a year

        1 - 2 years

        2 - 5 years

        5 - 10 years

        More than 10 years

7. How many years have you been at your current position?

        Less than a year

        1 - 2 years

        2 - 5 years

        5 - 10 years

        More than 10 years

8. What is your current job function? (Mark all that apply.)

        Executive Director

        Deputy Executive Director

        Assistant Executive Director

        Manager

        Supervisor

        Coordinator

        Analyst

        Technician

        Specialist

        Engineer

        Auditor

        Inspector

9. Did you have any experience in the private sector prior to joining TxDOT?

        Yes
        No

10. Before joining TxDOT, how many years of experience relevant to your current position did you have from non-TxDOT organizations or the private sector?

        Less than a year
        1 - 2 years
        2 - 5 years
        5 - 10 years
        More than 10 years

For the purposes of this survey, **management sciences** (also known as operations research or decision sciences) is defined as "***A scientific approach to decision making, which seeks to determine how best to design and operate a system, usually under conditions requiring the allocation of scarce resources***."

[*This information will be available for reference during survey participation.*]
According to the TxDOT strategic plan for the fiscal years 2011-2015 periods, the following goals are specified to be main areas of future actions and focus:

Goal 1 – Organizational structure and strategies:
- Develop a proactive internal and external communication plan that fosters transparency

- Develop a comprehensive performance management program to enhance program evaluation, decision making, resource utilization, and product delivery

- Develop and nurture partnerships with communities, agencies and other transportation stakeholders

- Enhance workforce recruitment, retention, and leadership development efforts

Goal 2 – Enhance safety for all Texas transportation system users:
- Reduce fatalities and serious injuries on the Texas transportation system

- Partner with public and private entities to plan for, coordinate, and respond to disasters and emergencies

- Promote work zone safety to protect roadway workers and the traveling public

- Measure, monitor, and report performance in improving safety

Goal 3 – Maintain the existing Texas transportation system:
- Develop optimal asset management programs to protect existing infrastructure investments

- Ensure timely and effective emergency maintenance response and damage repair

- Measure, monitor, and report performance in maintaining the existing transportation system

Goal 4 – Promote congestion relief strategies:
- Implement multimodal infrastructure, operational and technological solutions to address congestion and mobility needs

- Focus congestion relief efforts on the most severely congested elements of the state transportation system

- Measure, monitor, and report performance in providing congestion relief

Goal 5 – Enhance system connectivity:
- Ensure Texas industries can efficiently access statewide, regional, national, and international markets and gateways

- Provide coordinated, multimodal transportation facilities and networks to connect all statewide population, economic, recreational, and cultural centers

- Measure, monitor, and report performance in enhancing system connectivity

Goal 6 – Multimodal funding strategies:
- Assess and document transportation system needs and available revenues in periodic updates of the long-range Texas Transportation Plan

- Explore all available multimodal financing options while not recommending any particular strategy

- Regularly communicate with the Texas public about the program results that come from maximizing existing funding levels as well as the consequences of alternative future funding levels

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Current State Questions (11-16) ("What's been/being done right now?")

11. Has your division/office conducted any efforts or programs in the management sciences toward any of these goals? Please specify your answers in the table below:

	Go al 1	Go al 2	Go al 3	Go al 4	Go al 5	Go al 6
Yes						
No						
I don't know						

12. <mark>If "Yes"</mark>…Please describe the efforts or programs your division/office has conducted in the management sciences (operations research, decision sciences).

       Goal 1:
       Goal 2:
       Goal 3:
       Goal 4:
       Goal 5:
       Goal 6:

13. Do internal procedures exist to systematically evaluate methods to optimize your division's/office's performance?

14. <mark>If "Yes"</mark>…Please describe the internal procedures that exist to systematically evaluate methods to optimize your division's/office's performance.

15. Who is responsible for operational efficiency/change within your division/office?

16. Please review the following list of organizational units within TxDOT.

- **Finance**

- **Strategic policy and performance management**

- **Field and district operations (25 Districts)**

  o Construction

  o Maintenance

  o Traffic operations

- **Engineering operations (Divisions)**

  o Aviation

  o Bridge

  o Design

  o Environmental affairs

  o Rail

  o Research and technology implementation

  o Right of way

  o Transportation planning and programming

  o Turnpike authority

- **Support operations**

  o Civil rights

  o General services

  o Human resources

  o Motor carriers

  o Occupational safety

  o Public transportation

  o Technology Services

  o Travel information

What specific units within TxDOT do you think have the highest influence on the achievement of the six goals (Mark all that apply)?

	Finance	Strategic policy and performance management	Field and district operations	Engineering operations	Support operations
Goal 1					
Goal 2					
Goal 3					
Goal 4					
Goal 5					
Goal 6					

Opinions of Current State Questions (17-25) ("What's working well? What's working not so well?")

17. What specific areas/programs within your division/office are the most efficient?

18. What specific areas/programs within your division/office need to be improved most in terms of efficiency?

19. Regarding the six goals from the strategic plan, please rate the effectiveness of the current work practices of your division/office in achieving each goal. Please specify your answers in the table below:

> **Needs Improvement:** current work practices of your division/office are poorly in line with the specified goal and needs improvement to achieve the specified goal
>
> **Fair:** current work practices of your division/office are somewhat in line with the specified goal

Good: current work practices of your division/office are in line with the specified goal

	Go al 1	Go al 2	Go al 3	Go al 4	Go al 5	Go al 6
Good						
Fair						
Needs Improvement						

20. How would you rate your division's/office's *financial efficiency* within the context of the six goals?

	Go al 1	Go al 2	Go al 3	Go al 4	Go al 5	Go al 6
Excelle nt						
Above Average						
Averag e						
Below Average						
Poor						

21. How would you rate TxDOT's overall organizational efficiency?

    a. Excellent

    b. Above Average

    c. Average

    d. Below Average

    e. Poor

22. Why do you think TxDOT's overall organizational efficiency is [*answer to previous question*]?

23. How would you rate TxDOT's overall financial efficiency?

    a. Excellent

    b. Above Average

    c. Average

    d. Below Average

    e. Poor

24. Why do you think TxDOT's overall financial efficiency is [*answer to previous question*]?

25. What part of the TxDOT organization needs to be improved most in terms of efficiency? Why?

Recommendation Questions (26-END) ("What do you think should be done?")

26. What suggestions do you have for efforts or programs your division/office should conduct in the management sciences in general and also within the context of the six goals? (You may draw from any past experience you have, whether from private sector or experience at TxDOT.)

    In General:
    Goal 1:
    Goal 2:
    Goal 3:
    Goal 4:
    Goal 5:
    Goal 6:

27. What suggestions would you make to improve the financial performance of your division/office?

28. What suggestions would you make to improve the financial performance of <u>TxDOT as a whole</u>?

29. How do you think resources for the following TxDOT expenditure categories are currently allocated? (Please specify the percentage of resource allocation.)

> Planning:
> Building:
> Maintaining:
> Others categories:

30. How do you recommend allocating resources for the following TxDOT expenditure categories? (Please specify the percentage of resource allocation.)

Category	Current allocation (% of operating expenses)	Recommended allocation (% of operating expenses)
Planning	19.1	
Building	40.4	
Maintaining	35.5	
Other categories	5.0	
TOTAL	**100%**	**100%**

31. How much financial resources within each expenditure category do you think should deal with each of the six goals for TxDOT? (Check all that apply)

> **L:** I think a **<u>low</u>** amount of financial resources should come from this expenditure category for the execution of this goal
>
> **M:** I think a **<u>medium</u>** amount of financial resources should come from this expenditure category for the execution of this goal
>
> **H:** I think a **<u>high</u>** amount of financial resources should come from this expenditure category for the execution of this goal

	P lanning	B uilding	M aintaining	Oth er categories

Goal 1											
Goal 2											
Goal 3											
Goal 4											
Goal 5											
Goal 6											

32. What specific units within TxDOT do you think should be in charge of the six goals?

       L: I think this organizational unit should have **<u>low</u>** influence/control over the execution of this goal

       M: I think this organizational unit should have **<u>medium</u>** influence/control over the execution of this goal

       H: I think this organizational unit should have **<u>high</u>** influence/control over the execution of this goal

	Finance			Strategic policy and performance management			Field and district operations			Engineering operations			Support operations		
Goal 1															
Goal 2															
Goal 3															
Goal 4															
Goal 5															
Goal 6															

33. Do you have any other comments, suggestions, or questions related to any of the topics from this survey?

Appendix C: Interview Questions

Research Project 0-6637 Management Science Applications for TxDOT – Scoping Study

>**Structured Interview Questions**
>**August 2011**
>
>**Name:** _____
>**Title:**_____
>**Office:**_____

1. What three issues or questions relating to your area must need (more) analytical research?

2. Likewise, for the Department as a whole, what three issues/questions most deserve analytical research?

3. What specific areas within your division/office would gain the most from an improvement in operational efficiency?

4. What part of the TxDOT organization at large needs to be improved the most in terms of efficiency? Why?

5. What are some of the expenditures that TxDOT is making that could be more optimally allocated?

6. Anything else you would suggest to improve your own and/or TxDOT's performance?

Appendix D: Research Problem Statements

Texas
Department
of Transportation

Research Problem Statement

RMC:	P	OPR: (for RTI use)		Project #: (for RTI use)	0-6637
Date:	08/28/2011			Research Program Year:	2012
Project Title:	Development of Performance Metrics to Assess Productivity and Forecast Staffing Needs				
RMC Priority:	What RMC research priority will this project address? Policies and practices to enhance organizational performance (RMCP)				
Project Description:	What is the problem? TxDOT manages many resources with a small management staff and there are not productivity metrics to assess manager performance in order to forecast staffing needs. There is not an organized data structure to support a model based on performance metrics useful to develop staffing plans. The model will include manpower analysis of TxDOT core activities including design, construction, and maintenance, This research project will look at management science methods to forecast staffing needs and enhance productivity. Who is impacted by the problem? TxDOT Administration, Divisions and Offices, and Districts What is the significance / scope of the problem? All TxDOT Administration, Divisions and Offices, and Districts that are involved with making decisions in allocating resources and engaged in maintaining and preserving Texas's pavement infrastructure. What are the technical objectives of this project? Develop performance metrics to monitor manager performance, forecast staffing needs, and develop action plans and budgets. What benefits would this project deliver, and how would the results be used within TxDOT? It will significantly help TxDOT in best allocating resources and forecasting staffing needs based on performance metrics for productivity. What specific deliverables would help TxDOT implement the findings / results from this project? Complete documentation of work performed, methods used, and results achieved. Includes a model based on productivity performance metrics to assess staffing needs and develop				

RMC:	P	OPR: (for RTI use)		Project #: (for RTI use)	0-6637
		plans and budgets. Which District, Division, or Office would be responsible for implementing the results from this project? TxDOT Administration			
Developed By:		0-6637 Research Team For TxDOT employees only – Would you be willing to serve as the Project Director or as a Project Advisor, or can you suggest someone else knowledgeable about the problem / issue?			
Submission:		Email completed Problem Statements, as MS Word files, to **rtimain@txdot.gov**			

Research Problem Statement

RMC:	P	OPR: (for RTI use)		Project #: (for RTI use)	0-6637
Date:		08/29/2011		Research Program Year:	2012
Project Title:		Development of a Methodology for Performance-based Compensation			
RMC Priority:		What RMC research priority will this project address? Policies and practices to enhance organizational performance (RMCP)			
Project Description:		What is the problem? TxDOT manages a limited budget and there is a need to allocate financial resources in a more effective manner. An analysis on staff efficiency and productivity should be conducted to develop an analytical method to determine staff compensations based on performance. This research project will look at work load and functions, staff productivity to develop a methodology to formulate a payment compensation system. Who is impacted by the problem? TxDOT Administration, Divisions and Offices, and Districts What is the significance / scope of the problem? All TxDOT Administration, Divisions and Offices, and Districts that are involved with making decisions in allocating resources and engaged in management of personnel. What are the technical objectives of this project? Develop an organization performance assessment methodology to track work load and staff efficiency to pay compensations based on performance. What benefits would this project deliver, and how would the results be used within TxDOT? It will significantly help TxDOT in best allocating resources based on an organization performance assessment minimizing pay discrepancies among workers. What specific deliverables would help TxDOT implement the findings / results from this project? Complete documentation of work performed, methods used, and results achieved. Includes a model to pay compensations based on work load, efficiency, and productivity. Which District, Division, or Office would be responsible for implementing the results from this project? TxDOT Administration			

RMC:	P	OPR: (for RTI use)		Project #: (for RTI use)	0-6637
Developed By:		0-6637 Research Team For TxDOT employees only – Would you be willing to serve as the Project Director or as a Project Advisor, or can you suggest someone else knowledgeable about the problem / issue?			
Submission:		Email completed Problem Statements, as MS Word files, to **rtimain@txdot.gov**			

Research Problem Statement

RMC:	2	OPR: (for RTI use)		Project #: (for RTI use)	
Date:				Research Program Year:	
Project Title:	Improved Internal Communication				
RMC Priority:	What RMC research priority will this project address? Planning and Environment (RMC 2)				
Project Description:	**What is the problem?** As an organization consisting of 25 districts, 21 divisions and over 12,000 employees, internal communication is critical in the achievement TxDOT's goals. Communication problems can lead to poor efficiency, workplace problems, unbalanced workloads, etc. New technologies ranging from online networking tools to communication enabled hardware have an opportunity to increase the efficiency of specific activities. It is an important question, then, to identify which such tools can provide the right combination of implementability, cost and operational benefit. Ideally, an assessment of potential technologies, the communication challenges they could solve and a benefit vs. cost analysis would provide an invaluable resource for TxDOT when considering internal communication issues. **Who is impacted by the problem?** Streamlining internal communication protocols and reducing unnecessary bureaucracy has the potential to affect every division, district and employee in TxDOT. **What is the significance / scope of the problem?** The TxDOT staff is clearly its biggest asset, and making more efficient use of its workforce by minimizing the amount of time and effort wasted can result in incredible time savings and increases in productivity. **What are the technical objectives of this project?** The main objective of this project is to identify communication technologies that can improve and streamline the internal communications within TxDOT. **What benefits would this project deliver, and how would the results be used within TxDOT?** Communication technologies that are identified as beneficial for implementation, if adopted by TxDOT, could improve workforce efficiency and reduce bureaucracy. What specific deliverables would help TxDOT implement the findings / results from this project?				

RMC:	2	OPR: (for RTI use)		Project #: (for RTI use)	
		An evaluation of commercially available communication technologies and an assessment of their efficacy, and the challenges they can help solve under different circumstances, would allow TxDOT to address internal communication issues and, as such, provide a low cost opportunity for operational improvements. Which District, Division, or Office would be responsible for implementing the results from this project? Technology Services.			
Developed By:		0-6637 Research Team			

Research Problem Statement

RMC:	1, 2, and P	OPR: (for RTI use)		Project #: (for RTI use)	
Date:				Research Program Year:	
Project Title:	Management of Design and Planning Processes				
RMC Priority:	What RMC research priority will this project address? Construction and maintenance (RMC 1) Improve construction and design analysis methods and procedures for economy and safety(RMC 2) Policies and practices to enhance organizational performance (RMCP)				
Project Description:	What is the problem? Project planning and design at TxDOT includes development of construction projects from conception to the release of detailed plans for construction bidding. According to the TxDOT Roadway Design Manual, roadway design criteria and technology is a rapidly changing field of study. For example, traditional roadway project development is expanding to include consideration of the impact of project on various stakeholders such as non-facility users and the environment. As noted in the TxDOT Project Development Process Manual, during the development and design phase, the following tasks are performed: Planning and Programming Preliminary design Identifying a project's environmental variables and planning an appropriate level of public involvement. Right of way utilities Plan, Specification, and Estimation, (PS&E) development (i.e., detailed design) Letting Decisions made during the activities mentioned above, especially the PS&E development phase, will directly affect the project schedule and quality. The TxDOT Project Development Process Manual suggests that during this phase of the project, input from the project manager's peers and supervisor should be sought for quality assurance of the project development process. In light of that, TxDOT needs a management methodology at the project level to ensure that all project related issues are addressed. For example, there is a need to tie project level decisions with long-range advanced planning in order to determine long-term/ultimate impacts of projects. As noted in the recent Grant Thornton review of TxDOT's management and organizational structure, the Department is overlooking the critical need to focus on stronger project management methodologies. With respect to the importance of the design and development phase, TxDOT needs to pay specific attention to management practices that				

enhance collaboration between project stages and project participants, as one of the issues frequently noted in assessments of TxDOT, as well as with the 0-6637 Management Science Scoping Study, is the fragmented advanced planning, design, and development activities. For example, the lack of control over determination of a defined scope before going into detailed design (or other sequential phases) has significant financial and project management ramifications.

Another important issue uncovered with the 0-6637 study was the need for improving the current methodology of the Planning and Programming, and Preliminary design phase. As noted in the TxDOT Project Development Process Manual, the following activities are currently performed during the Planning and Programming phase:
1. Needs Identification
2. Project Authorization
3. Compliance with Planning Requirements
4. Study Requirements Determination
5. Construction Funding Identification

Preliminary design phase also includes the following activities:
Design Concept Conference
2. Data Collection/Preliminary Design Preparation
3. Public Meeting(s)
4. Preliminary Schematic
5. Geometric Schematic
6. Value Engineering
7. Geometric Schematic Approval

Factors involved in these activities have a profound effect on subsequent stages of a project, and these factors should be addressed even in the absence of detailed information. In light of that, TxDOT needs to adhere to strong project management methods during advanced planning as well as the design phases.

Who is impacted by the problem?
As a project-driven organization, the entire TxDOT enterprise is impacted by improving management of design and planning processes. More specifically, such improvement will help TxDOT Planners at all levels.

What is the significance / scope of the problem?
The main focus of this study is on design and planning management at the project level. On average, over 800 construction contracts are bid by contractors each year. As reported in the TxDOT Tracker, for the fiscal year 2011, a target of 1,000 construction contracts with total value of $4,541M, is set in state law. Through February 2011, TxDOT had awarded a total of 342 contracts with a total of $1,031M.

What are the technical objectives of this project?
The main objective of this project is to improve the current project management methodology for the design and development phase to address the issues mentioned above. Current research within and outside of the transportation industry has documented

	the importance of adequate and proper project management techniques and methods. This project proposes a comprehensive evaluation and assessment of TxDOT's project management process with a focus on how management science applications could enhance the efficiency and effectiveness of the organization.
	What benefits would this project deliver, and how would the results be used within TxDOT? Addressing the issues mentioned above will result in better collaboration between design activities, which will in turn result in improvement of the design decision making.
	What specific deliverables would help TxDOT implement the findings / results from this project? The TxDOT Project Development Process Manual may be updated with the findings.
	Which District, Division, or Office would be responsible for implementing the results from this project? Design Division
Developed By:	0-6637 Research Team

Research Problem Statement

RMC:	2 and P	OPR: (for RTI use)		Project #: (for RTI use)	
Date:				Research Program Year:	
Project Title:	Prioritizing Project for Financial Allocation				
RMC Priority:	What RMC research priority will this project address? Procedures to enhance the planning and environment processes (RMC 2) Policies and practices to enhance organizational performance (RMCP)				
Project Description:	**What is the problem?** The construction and transportation industries have suffered excessively from the recent economic recession. As a result, significant emphasis has been placed on policies and procedures to identify and prioritize which projects to undertake when financial resources are constrained. Additionally, as noted in the TxDOT Strategic Plan, TxDOT needs a mechanism to "facilitate the development and exchange of comprehensive multimodal funding strategies with transportation program and project partners." Limited funding highlights the importance of project prioritization and selection for an owner organization such as TxDOT. In prioritizing projects, owner organizations have to consider different kinds of benefits that candidate projects would provide to the wide range of stakeholders. The issue of considering various stakeholders is of greater importance to agencies such as TxDOT. For example, as noted in assessments of TxDOT, as well as with the 0-6637 Management Science Scoping Study is that TxDOT should ensure that financial resources are allocated in areas that have documented needs as opposed to ad-hoc criteria. Another issue that TxDOT faces is that in order to prioritize projects, vast amounts of information filter through different departments and need to be processed at different levels of the organization. In light of that, TxDOT needs to improve its portfolio management system on an enterprise level to optimize its projects based on criteria, addressing long-range and short-term considerations. In allocation of funds, TxDOT also needs to take into account different types of projects (e.g., construction vs. maintenance), as well as organizational improvement actions conducted within the organization. For example, investing on improving administrative and support processes, such as internal communication and IT tools, may influence overall efficiency of the organization. **Who is impacted by the problem?** The entire organization is impacted by improving current project prioritization and selection practices. Additionally, citizens of Texas would benefit from improvement in efficiency of funding strategies.				

RMC:	2 and P	OPR: (for RTI use)		Project #: (for RTI use)	
		What is the significance / scope of the problem? The grand total of the TxDOT budget for 2010-2011 is $16.94B. 2.77% of this amount is devoted to the administration and support functions (i.e., $0.47B). On the other hand, the budget requested for 2012-2013 is reported to be $15.63B, $0.47B of which is to be allocated to the administration and support functions. This emphasizes the importance of project prioritization and efficient use of available funds to support organizational improvement projects within TxDOT. What are the technical objectives of this project? The main objective of this project is to develop a decision-making tool to be used for project prioritization. What benefits would this project deliver, and how would the results be used within TxDOT? The decision-making tool will help TxDOT improve its overall financial efficiency and meet the needs of different project stakeholders.			
		What specific deliverables would help TxDOT implement the findings / results from this project? A project prioritization decision-making tool and a manual describing how to use the tool will be developed. Which District, Division, or Office would be responsible for implementing the results from this project? Finance Division			
Developed By:		0-6637 Research Team			

Research Problem Statement

RMC:	P	OPR: (for RTI use)		Project #: (for RTI use)	0-6637
Date:		10/28/2011		Research Program Year:	2012

Project Title:	Implementing an Optimization–based Pavement Management System

RMC Priority:	What RMC research priority will this project address? Construction and maintenance (RMC 1) Policies and practices to enhance organizational performance (RMCP)

Project Description:	What is the problem? Allocating scarce funds to maintain Texas roads and highways is one of TxDOT's most pressing problems, especially in the current environment of shrinking budgets. It is widely recognized that optimization-based Pavement Management Systems (PMS) are far superior to current approaches used by TxDOT in performing this task. In 1982, Arizona won an award for the year's best Management Science application by implementing such a system. In reference (2) below, they reported verified savings of $14 million in 1980-81, and forecasted annual savings of $25 million in future years. Reference (3) reports on experience with improvements in this system through 1996, and on the significant additional benefits obtained. Reference (1), published in 2011, describes use of an Optimization-based PMS by the New Brunswick (Canada) Department of Transportation (NBDot). This work was a finalist for the 2010 best management science application award. The paper reports that "NBDoT anticipates $72 million (discounted) in annual savings". Our research team conducted interviews with TxDOT employees in the summer of 2011, and learned that TxDOT was exploring the best way to develop or acquire such a system. In our opinion, this project has great potential for improving road network quality at minimum cost, and is probably the highest priority project among those considered in this report. **References** 1. Feunekes, U., Palmer, S., Taking the Politics out of Paving: Transportation Asset Management Excellence Through OR. *Interfaces*, Vol. 41, No 1, 2011, pp. 51-65. 2. Golabi, K., Kulkarni, R.B., Way, G.B. A Statewide Pavement Management System. *Interfaces*, Vol.12, No. 6, 1982, pp. 5-21. 3. Wang, K., Zaniewski, J., 23/30 Hindsight: The New Pavement Optimization in the Arizona State Highway Network, *Interfaces*, Vol. 26, May 1996, pp.77-89.

RMC:	P	OPR: (for RTI use)		Project #: (for RTI use)	0-6637
		Who is impacted by the problem? As a project-driven organization, the entire TxDOT enterprise is impacted by improving management of the maintenance process. More specifically, such improvement will help all TxDOT units involved in maintaining pavements, and will provide peripheral benefits to those involved in planning new road capacity. What is the significance / scope of the problem? The scope is statewide and affects every mile of Texas' road network. What are the technical objectives of this project? Develop a decision-support tool to better allocate maintenance funds across the entire road network, using a multi-year planning horizon. What benefits would this project deliver, and how would the results be used within TxDOT? The results would be used by those directly involved in deciding which maintenance projects to do, and would lead to decisions which make the best use of the available maintenance budget.			
		What specific deliverables would help TxDOT implement the findings / results from this project? An optimization-based Pavement management system, and enhancements to TxDOT's data bases which support maintenance decisions Which District, Division, or Office would be responsible for implementing the results from this project? TxDOT Maintenance Division			
Developed By:		0-6637 Research Team For TxDOT employees only – Would you be willing to serve as the Project Director or as a Project Advisor, or can you suggest someone else knowledgeable about the problem / issue?			
Submission:		Email completed Problem Statements, as MS Word files, to **rtimain@txdot.gov**			

		Form ProbStat (Rev. 2/2009) (RTI)
	Research Problem Statement	

RMC:	P	OPR: (for RTI use)		Project #: (for RTI use)	0-6637
Date:	10/28/2011			Research Program Year:	2012

Project Title:	**Predictive Right of Way Acquisition**

RMC Priority:	What RMC research priority will this project address? • Construction and maintenance (RMC 1) • Advanced planning and environmental streamlining (RMC 2) • Policies and practices to enhance organizational performance (RMCP)

Project Description:	**What is the problem?**

What is the problem?

http://www.countyprogress.com/index.php?page=legacy&article=83&tableDB=articles_4-departments

The most expensive part of many transportation projects, especially roadway expansions, is acquiring the Right-of-Way (ROW). TxDOT's current annual right of way budget is approximately $500 million. TxDOT has deployed a host of tools and techniques to decrease these costs including advanced acquisition and an on-line system to document and track the right-of-way acquisition process. A model for predicting the total right-of-way acquisition duration, from right-of-way Release to Possession, using inherent factors has also been developed with TxDOT project 0-5478. Other state DoTs have encountered problems with advanced acquisition practices, such as excess land acquisition, lack of guidelines on preservation tools, and the increased need for communication between cities, counties, and the state DOT. When and how TxDOT acquires ROWs to expand roadways is an issue with important financial and non-financial ramifications. Whereas advanced acquisition may be a strategic tool in certain cases, there is a need for a more detailed analysis that would look at the overall right of way process including those that could predict which parcels are most likely to go condemnation – the most expensive and time consuming option of right-of-way acquisition.

Who is impacted by the problem?

Right-of-way acquisition is a significant cost item for highway construction, and can have a significant impact on project cost and schedule. As a result, the entire TxDOT enterprise is impacted by an inefficient right-of-way acquisition process.

What is the significance / scope of the problem?

TxDOT's current annual right of way budget is approximately $500 million. Application and oversight of the current TxDOT right-of-way acquisition process varies from District to District, project to project. Increasing efficiency in developing a more accurate ROW cost estimate can significantly affect the cost and schedule of TxDOT projects.

	What are the technical objectives of this project? This project proposes a comprehensive analysis of current right-of-way acquisition procedures and practices and an assessment to optimize the detection of which parcels are most likely to go to condemnation. This project will also analysis the process of estimating ROW costs in order to increase the accuracy of the estimates. An enhanced understanding of factors affecting right-of-way acquisition time and cost would be highly useful for the project team in improving its planning and acquisition. **What benefits would this project deliver, and how would the results be used within TxDOT?** Addressing the issues mentioned above will result in increasing efficiency in the right-of-way acquisition process and reduce overall delays and costs of TxDOT projects.
	What specific deliverables would help TxDOT implement the findings / results from this project? Methodology and procedures to predict and lower right-of-way costs. **Which District, Division, or Office would be responsible for implementing the results from this project?** Right of Way Division
Developed By:	0-6637 Research Team For TxDOT employees only – Would you be willing to serve as the Project Director or as a Project Advisor, or can you suggest someone else knowledgeable about the problem / issue?
Submission:	Email completed Problem Statements, as MS Word files, to **rtimain@txdot.gov**

![Texas Department of Transportation logo]	**Research Problem Statement**	**Form ProbStat (Rev. 2/2009) (RTI)**

RMC:	P	OPR: (for RTI use)		Project #: (for RTI use)	0-6637
Date:	10/28/2011			Research Program Year:	2012

Project Title:	**Determination of Eligible Utility Accommodation Reimbursements**

RMC Priority:	What RMC research priority will this project address? • Construction and maintenance (RMC 1) • Advanced planning and environmental streamlining (RMC 2) • Policies and practices to enhance organizational performance (RMCP)

Project Description:	**What is the problem?** Utility accommodation is an integral factor in road construction and design. TxDOT's utility cooperative manual explains that in order to provide for efficient accommodation of utilities and minimize delays, it is necessary to coordinate the process from program inception to completion. As noted in the manual efficient accommodation of utilities is accomplished by: - Defining authorities regarding utility adjustments across the functional areas of District planning, design, right of way and construction. - Developing a Utility Memorandum of understanding for utility companies to improve relations and reduce possible misunderstanding between TxDOT and utilities. - Providing for District approval of utility contracts - Improving utility accounting procedures. The major procedures used to accomplish the adjustment of utility facilities on TxDOT projects are identified and includes the identification of non-reimbursable accommodations. While the overall process for determining eligible utility accommodations and reimbursements, there is not any precise method to analyze and quantify potential savings these procedures provide. For example, according to TxDOT rules, local utility procedures can be used in place of TxDOT procedures. Few eligible utility accommodation reimbursements have been assessed, and little has been done to determine the most efficient and effective process. An independent study should be conducted to analyze procedure, optimization, and to develop a best practice for utility accommodation.

	Who is impacted by the problem? Utility accommodation is a significant cost item for highway construction, and can have a significant impact on project cost and schedule, as well as the long-term viability of the associated utilities. As a result, the entire TxDOT enterprise is impacted by an inefficient utility accommodation process. **What is the significance / scope of the problem?** The main focus of this study is on utility accommodation and right of way acquisition for TxDOT projects. TxDOT's Right of Way Division is responsible for statewide oversight of right of way acquisition, and each of TxDOT's 25 Districts have a Right of Way Section responsible for right of way activities in its specific area. TxDOT's current annual right of way budget is approximately $500 million. Application and oversight of the current TxDOT utility accommodation process varies from District to District, project to project, and utility to utility. An optimization of the process for reimbursement of eligible utility accommodations is needed. **What are the technical objectives of this project?** This project proposes a comprehensive assessment of current utility adjustment and accommodation processes with a focus on improving efficiency. **What benefits would this project deliver, and how would the results be used within TxDOT?** Addressing the issues mentioned above will result in increasing efficiency in the utility accommodation process and reduce overall delays and costs of TxDOT projects.
	What specific deliverables would help TxDOT implement the findings / results from this project? The TxDOT Project Development Process Manual may be updated with the findings. **Which District, Division, or Office would be responsible for implementing the results from this project?** Right of Way Division
Developed By:	0-6637 Research Team For TxDOT employees only – Would you be willing to serve as the Project Director or as a Project Advisor, or can you suggest someone else knowledgeable about the problem / issue?
Submission:	Email completed Problem Statements, as MS Word files, to **rtimain@txdot.gov**