Comparing In-House Staff and Consultant Costs for Highway Design and Construction: Follow-Up Investigation

Requested by
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The Caltrans Division of Research and Innovation (DRI) receives and evaluates numerous research problem statements for funding every year. DRI conducts Preliminary Investigations on these problem statements to better scope and prioritize the proposed research in light of existing credible work on the topics nationally and internationally. Online and print sources for Preliminary Investigations include the National Cooperative Highway Research Program (NCHRP) and other Transportation Research Board (TRB) programs, the American Association of State Highway and Transportation Officials (AASHTO), the research and practices of other transportation agencies, and related academic and industry research. The views and conclusions in cited works, while generally peer reviewed or published by authoritative sources, may not be accepted without qualification by all experts in the field.

Executive Summary

Background

In May 2011, the Senate Standing Committee on Budget and Fiscal Review added language to the budget bill that requires Caltrans to commission an independent study of the costs and benefits of hiring consultants to address temporary increases in workload.

To aid in this effort, a Preliminary Investigation dated July 15, 2011, synthesized completed and in-process national- and state-related research that compares the cost of outsourcing highway design and construction activities with the cost of completing those tasks with in-house staff.

This Preliminary Investigation follows up on the next steps identified in the July 15 report as Caltrans continues its evaluation of in-house staff and consultant costs.

Summary of Findings

We contacted representatives from state department of transportation (DOT) research programs and principal investigators to learn more about the following completed research and projects in process.

State Research

Arizona
Cost models described in a 2003 Arizona DOT report compare the direct and indirect costs of transacting business via third parties with costs incurred by Arizona DOT Motor Vehicle Division field offices. Our contact at Arizona DOT is unaware of current use of these models.

Louisiana
The Outsourcing Decision Assistance Model developed in 2002 for Louisiana Department of Transportation and Development (DOTD) includes both qualitative and quantitative elements and evaluates the potential to outsource agency functions and activities.

The model, which is available on CD-ROM upon request, is not currently being used by Louisiana DOTD. The model's developer provides his perspective on why the model has not gained wide acceptance and observes that "numerous studies have been conducted on the subject, and the answer is clear on cost (it is roughly 20 percent more expensive to contract out design services on routine road and bridge designs) but the decision should not be made on cost alone; there are other equally important considerations that need to feature in the decision."

Oregon
A 2007 Oregon DOT report provided a decision tree to aid in making cost-based outsourcing decisions. While our contacts could not confirm that Oregon DOT was using the decision tree, we learned more about a project in process that appears to take precedence over application of the 2007 recommendations.

The project in process was spurred by 2010 legislation that precludes Oregon DOT from outsourcing design and construction project delivery without reasonably based cost estimates. In a project scheduled to conclude in June 2012, researchers are developing a database that provides a range of consultant hours expended for standard tasks related to three types of activities:

- Engineering.
- Technical nonengineering.
- Administrative.

The principal investigator for both the 2007 report and the project in process called our attention to another project in process. Oklahoma State University is developing models and software for estimating preliminary engineering (PE) costs in a study scheduled for completion next summer. Project deliverables will include guidelines for DOT engineers to standardize the PE cost estimating procedure and a computer software program for estimating PE costs that can serve as a national standard for making such estimates.

Texas
A 2009 report prepared for TxDOT found "consistent and large" differences in costs between in-house and consultant projects, and the report's authors recommended further inquiry to assess the accuracy of the in-house charges. Independent follow-up analysis conducted by the author of the 2009 report using more recent data confirms the study's findings: Mixed projects (in-house and consultant charges) cost TxDOT more than in-house projects.

A project in process by Texas State University–San Marcos is re-examining costs associated with in-house and consultant-provided engineering services. Two technical memoranda summarize researchers' efforts to examine all direct and indirect costs associated with in-house preliminary design engineering services and develop a calculation of the in-house per-hour costs associated with engineering project team titles. A final report will be published in November 2011.

Related Research

A 2010 *Transportation Research Record* article describes an Excel-based outsourcing decision support tool and results of its application within an unnamed state DOT. Further work on the tool includes an examination of ways to monetize the loss of implicit knowledge when outsourcing specific functions and subfunctions. The tool will become available to other interested state DOTs in December 2011.

A 2006 conference paper proposed Quality Adjusted Transportation-Related Activities, an index composed of four quality criteria (response time, completion time, life years and public opinion) that compares the performance of the public and private sectors, or two private contractors. No further work has been conducted in connection with this model.

Contacts

During the course of this Preliminary Investigation, we spoke to or corresponded with the following individuals:

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State Research

Below we examine completed research and research in progress undertaken in five states: Arizona, Louisiana, Oklahoma, Oregon and Texas.

Arizona

We contacted Arizona DOT to determine if the models described in the report below are currently in use. At the time of this report, our contact was unaware of any current use of the models and had not yet received confirmation from colleagues to verify that assumption.

Related Resource:

> **Third Party Transaction Cost-Benefit Analysis**, Arizona Department of Transportation, Final Report 539, April 2003.
> http://www.azdot.gov/TPD/ATRC/publications/project_reports/PDF/AZ539.pdf
> This report compares the direct and indirect costs of transacting business via third parties with costs incurred by Arizona DOT Motor Vehicle Division field offices. While the topic of the report deviates from our examination of highway design and construction activities, the report includes a brief description of cost models that may be of interest. Page 21 of the PDF provides an overview of two models: Full Cost Model and the Mini-Model. The Mini-Model uses a standard rate of 16 percent of direct costs to arrive at an indirect cost allocation for internal services and is more limited in scope. The models do not attempt to quantify intangible benefits of outsourcing that may include customer convenience and time savings, productivity gains and quality improvements.

Louisiana

A June 2002 Louisiana Transportation Research Center report describes the development of the Outsourcing Decision Assistance Model (ODAM), which public agencies can use to address outsourcing by considering the relative cost of design services provided by in-house staff versus consultants. Researchers provided training programs for district administrators in the Louisiana DOTD, but DOTD has not actively used the program. At DOTD's suggestion, we contacted ODAM's developer to learn more about possible reasons the program has not been better utilized.

ODAM's developer, Dr. Chester Wilmot, offered the following observations on the potential use of ODAM and outsourcing generally:

- Managers may be less likely to try a new approach given their tendency to rely on experience and judgment.
- Researchers have received inquiries about the program but have no knowledge of its use by other agencies.
- Benefits of the model include:
  - Requiring the user to examine a list of relevant factors and address each one to ensure a comprehensive process.
  - A consistent assessment process among competing activities considered for outsourcing.
  - Incorporating within its records information that otherwise would have to be found each time the process is applied manually (e.g., wage rates of in-house employees and indirect cost rates).
  - Facilitation of the calculation process.

Dr. Wilmot called our attention to a 1998 report cited in Related Resources on page 7 of this Preliminary Investigation, Louisiana Department of Transportation and Development In-House Versus Consultant Design Cost Study, which concludes that the cost of providing road and bridge designs to DOTD is, on average, lower when provided by in-house staff than by consultants. The average cost for in-house designs is estimated at 81 percent of the cost of consultant designs for road projects; bridge projects are estimated at 83 percent of the cost of consultant designs for bridge projects. The extra expense for consultants is typically due to the cost of contract preparation and supervision. After stripping out those two costs, with contract supervision alone almost accounting for the difference, costs are almost the same for consultants and in-house staff.

Noting that the issue of staff versus consultant costs is a matter that requires no further research, Dr. Wilmot observes that "numerous studies have been conducted on the subject and the answer is clear on cost (it is roughly 20 percent more expensive to contract out design services on routine road and bridge designs) but the decision should not be made on cost alone; there are other equally important considerations that need to feature in the decision."

State agencies are encouraged to recognize that in-house staff is required to adhere to one set of standards and procedures, while a consultant has a different set of standards for each client. In-house staff tends to become more specialized and concentrate on more routine designs.

Related Resources:

Designing a Comprehensive Model to Evaluate Outsourcing of Louisiana DOTD Functions and Activities, Louisiana Transportation Research Center, Report No. 358, June 2002.
http://www.ltrc.lsu.edu/pdf/report_358.pdf
Researchers developed the Outsourcing Decision Assistance Model to evaluate the potential to outsource agency functions and activities. To demonstrate the use of ODAM, which evaluates qualitative and cost aspects of contracting out services, researchers applied the model to three activities in the Louisiana DOTD: maintenance of rest areas, highway markers and highway striping. The model's generic design allows for modification by the user to evaluate other types of activities beyond those tested.

To prepare for development of the qualitative aspect of the model, researchers pilot-tested models in use by Arizona and Pennsylvania DOTs. Both models involve assigning weights (or ratings) to a series of noncost attributes (e.g., effect on timeliness of service). The qualitative portion of ODAM uses the subjective judgment of one or more individuals on a set number of perspectives, where each perspective is aimed at a different aspect of the potential for outsourcing.

The cost comparison portion of ODAM is based on a model used by Arizona and New Mexico DOTs. ODAM's cost modeling compares estimated outsourcing costs to two versions of estimated in-house costs: direct in-house costs and full (direct and indirect) in-house costs. The model includes three types of costs: civil service wages, fringe benefits and support services. The model's qualitative and quantitative results offer three possible outcomes: in-house recommended, outsourcing recommended and indeterminate.

Note: A CD-ROM that contains ODAM is available upon request from Jenny Speights at speights@lsu.edu.

User Manual for Outsourcing Decision Assistance Model, Louisiana Transportation Research Center, Report No. FHWA/LA-364, June 2002.
http://www.ltrc.lsu.edu/pdf/final%20report_364.pdf
This manual describes how to install and use the computer program that executes both the qualitative and quantitative portions of ODAM.

Louisiana Department of Transportation and Development In-House Versus Consultant Design Cost Study, Louisiana Transportation Research Center, Report No. LADOTD 309, June 1998.
http://www.ltrc.lsu.edu/pdf/report_309.pdf
From the abstract: Most studies in the past have concluded that consultant design costs are higher than in-house design costs or that there is no significant difference in cost. The Louisiana study found that consultants are approximately twenty percent more expensive than in-house staff in preparing road and bridge designs but that the difference was almost entirely due to the extra cost of contract preparation and in-house supervision required for consultant designs.

Oregon

We contacted Oregon DOT's research manager and the principal investigator to learn more about two projects: a 2007 report that provided recommendations on when to outsource project delivery and an effort in process to develop standard pricing for outsourcing design and construction activities.

2007 Recommendations

Researchers concluded that when outsourcing of project delivery is necessary, projects with a well-defined scope and an aggressive schedule are highest priority for outsourcing. A decision tree, which appears on page 65 of the 2007 report (page 79 of the PDF), was developed to aid Oregon DOT in making the insource or outsource decision on a project-by-project basis. Neither contact was aware if Oregon DOT is applying the decision tree to current project delivery decisions.

A 2010 law that precludes Oregon DOT from outsourcing design and construction project delivery without reasonably based cost estimates led to the project in process discussed in more detail below. It appears that the project in process is taking precedence over application of the recommendations included in the 2007 report.

Related Resource:

Evaluation of Oregon Department of Transportation Project Delivery, Oregon Department of Transportation, Report No. FHWA-OR-RD-08-03, August 2007.
http://www.oregon.gov/ODOT/TD/TP_RES/docs/Reports/2007/ProjectDelivery.pdf
This report summarizes an analysis of Oregon DOT's methods related to in-house (or insourced) and outsourced project delivery. In evaluating whether to outsource, the report concludes that "when there is an opportunity to choose between outsourcing and insourcing, the decision to outsource or insource should be based on cost." The project's data analysis indicates:

- For preservation projects, both PE and construction engineering (CE) favor insourcing.
- Cost comparisons showed an advantage for insourced-design-bid-build project delivery of CE for modernization projects.
- Statistically significant results indicate a preference to make outsourcing of PE for bridge projects the first choice when outsourcing becomes necessary.
- For bridge and modernization projects, there is no statistically valid difference in PE and CE costs between delivery methods.

Project in Process

In a project expected to conclude in June 2012, researchers are using 185 work orders from local agency projects to compile a database that provides a range of consultant hours expended for 17 standard tasks related to three types of activities:

- Engineering.
- Technical nonengineering.
- Administrative.

Data will also be used from the third Oregon Transportation Investment Act (OTIA III) State Bridge Delivery Program now wrapping up. In 2003, the Oregon Legislature enacted the OTIA III, which provides funding for the repair or replacement of hundreds of aging bridges on major corridors throughout Oregon. (See http://www.oregon.gov/ODOT/HWY/OTIA/bridge_delivery.shtml for more information.)

The consultant hours populating the database are derived from cost breakdowns provided by consultants during the project negotiation process. Researchers determined that obtaining this data from actual invoices would be cost-prohibitive.

The database can be used by Oregon DOT when negotiating with consulting firms to compare proposed costs with those Oregon DOT might expect based on similar work conducted for the agency. Jon Lazarus, Oregon DOT Research Coordinator, notes that the initial project takes a first cut at gathering the data, and implementation of the database will require a follow-up project funded through another DOT department; the information technology, bridge and procurement departments are suggested as possibilities. Assistance from internal information technology experts will be required to populate the database with information from other Oregon DOT applications and ensure that the tool reflects current data and trends.

Dr. David Rogge, the principal investigator for this project, notes that a similar TxDOT project attempting to develop a predictive tool to determine engineering costs encountered difficulties in collecting data. (See page 10 of this Preliminary Investigation for more discussion of TxDOT projects.) An Oklahoma State University study scheduled for completion this summer (see the citation in Related Resources below) is developing models and software for estimating PE costs in a project expected to produce a program that can serve as a national standard for making such estimates.

Related Resources:

"Determining Outsourcing Feasibility and Standard Pricing Methodologies," Oregon State University, expected completion date: June 2012.
http://rip.trb.org/browse/dproject.asp?n=28393
Sponsored by Oregon DOT, this research is in response to mandates of Oregon House Bill 2867, effective January 2010, which preclude Oregon DOT from outsourcing design and construction project delivery without reasonably based cost estimates and a comparative analysis of Oregon DOT's internal cost estimates and consultant cost estimates. Researchers will propose guidelines and a methodology for cost estimating and comparative cost analyses and test them with a pilot program.

Research Project Work Plan for Delivering Better Value for Money: Determining Outsourcing Feasibility and Standard Pricing Methods, Oregon Department of Transportation, SPR738, March 2011.
See Appendix A.
The work plan provides background on the topic of outsourcing and a list of deliverables for the project.

"Procedures and Models for Estimating Preliminary Engineering Costs of Highway Projects," Oklahoma State University, expected completion date: summer 2012.
http://trid.trb.org/view/2010/P/1095747
In a project co-sponsored by the USDOT Research and Innovative Technology Administration, researchers are investigating current PE cost estimating practices to identify significant factors and mechanisms that affect PE costs using 10 years of highway project data from Oklahoma DOT. Results of the project will provide Oklahoma DOT with a streamlined procedure for estimating PE costs and facilitate consistent practices and a structured format of PE cost estimating.

Project deliverables include:

- Prediction models of PE costs with neural networks.
- A computer software program for estimating PE costs.
- Guidelines for DOT engineers to standardize the PE cost estimating procedure.

The software program will be flexible enough to apply to different state conditions. The research team sees the potential for the software to become a national standard.

Texas

In a 2009 report prepared for TxDOT, researchers found "consistent and large" differences in costs between in-house and consultant projects. These differences prompted speculation as to the reasons, and the report's authors recommended further inquiry to assess the accuracy of the in-house charges.

We contacted the 2009 report's author, Dr. Khali Persad and learned that TxDOT contracted with Texas State University–San Marcos to re-examine the issue. With regard to the accuracy of the in-house charges reflected in the 2009 report, Dr. Persad conducted an independent examination of TxDOT's data for fiscal years 2008 through 2010 and found that 30 percent to 40 percent of in-house staff's available time is not reflected in let projects. Some follow-up interviews indicated that the time goes to "planning projects" (projects that are the precursors of actual lettable projects) or to projects that are shelved for various reasons. The new data confirms Dr. Persad's findings reflected in the 2009 TxDOT report using data from fiscal years 2006 and 2007: Mixed projects (in-house and consultant charges) cost TxDOT more than in-house projects.

The follow-up study conducted by Texas State University is examining the total cost of performing engineering activities in-house as compared to contracting with the private sector for those services. A joint working group composed of the Consultant Engineer Council and TxDOT representatives is coordinating the study. See Related Resources below for citations and a discussion of the results of the project's first two tasks. The final report will be published in November 2011.

Related Resources:

Special Studies for TxDOT Administration in FY 2009, Texas Department of Transportation, Report No. FHWA/TX-10/0-6581-CT-1, December 2009.
http://www.utexas.edu/research/ctr/pdf_reports/0_6581_CT_1.pdf
One of the special studies appearing in this report is an analysis of PE and CE costs. (Study results begin on page 21 of the PDF.) Researchers conducted a statistical analysis of PE and CE costs for TxDOT construction projects let in fiscal years 2006 and 2007. Projects were classified as fully in-house (no consultant charges) or mixed (in-house and consultant charges). There were no 100 percent consultant projects at the project level, though specific functions can be recorded as 100 percent in-house PE or 100 percent consultant PE.

Findings from a direct comparison of in-house and consultant PE costs follow:

- Consultant PE is about 5.4 times as costly as in-house PE when controlling for project size (cost), with caveats detailed in the report.
- PE for the median mixed project is 12.47 times as expensive as the median in-house project.
- PE cost increases with increasing project size, and for two projects of identical construction cost, the PE cost of a mixed project is 7.55 times the cost of the in-house project.
- For the same project size and the same PE function, in-house cost is less than consultant cost by a factor that ranges from 1.82 for signing up to 15.14 for feasibility studies.

A similar direct comparison of in-house and consultant CE costs was not included in the study.

Technical Memorandum 0-6730-PA-Task 1, Examining Engineering Costs for Development of Highway Projects, Texas State University–San Marcos, March 2011.
See Appendix B.
Since September 1, 1997, Texas state law provides that 35 percent of appropriated funds are to be expended to private sector providers for engineering-related services. This technical memorandum begins with a discussion of four studies sponsored by TxDOT over the past 25 years in an attempt to determine the engineering costs for TxDOT's highway projects.

- A May 1987 study examined the use of external consultants for complex projects requiring particular expertise or specialized equipment, or when TxDOT did not have the capacity to perform the project in a timely manner. Researchers concluded that the cost for in-house staff was lower than the cost of consultants.

- An August 1997 report describes results of a project to evaluate the methodologies for ensuring compliance with achieving outsourced work and identified costs that should be used to determine whether the costs of in-house and consultant services were equivalent. The study concluded that PE cost data had limited usefulness given the inclusion of indirect costs that were not appropriate for comparing the cost of in-house and consultant services.

- A February 1999 comparative study of in-house and consultant PE and design work concluded that outsourced design was more expensive than in-house design for eight out of 13 types of processes.

- In 2009, researchers examined the incremental benefits of using consultants rather than in-house staff for engineering activities in highway, bridge and maintenance operations. Results indicate that the data collected by TxDOT is not easily comparable to consultants' data given differing cost classifications, which prevented researchers from drawing any conclusions.

Researchers note that these study results indicate the "answer to the question of engineering costs remains clouded." Factors contributing to this uncertainty include a lack of readily available data, the fact that many projects use both in-house and consultant staff, and a lack of definition as to which costs should be included in a comprehensive analysis.

The purpose of the current study is to examine all direct and indirect costs associated with maintaining an engineering employee who does preliminary design engineering at TxDOT. Researchers are employing two approaches:

Approach 1: Mimic the consultants' approach by using direct labor costs and hours charged to specific projects. Direct labor costs are combined with indirect costs of benefits, office space costs, division and district general and administration allocation, resident engineer overhead and other PE costs.

Approach 2: Use detailed costs from three district offices to determine the cost per hour of PE. This method considers direct labor costs to include both salary and benefits. The cost per productive hour is combined with costs associated with training, human resources, benefits, technology and office space.

Researchers note that the calculations above may be used to make decisions on whether to retain design engineering in-house or contract it out. It is not an avoidable cost per hour.

Technical Memorandum 0-6730-PA-Task 2, Examining Engineering Costs for Development of Highway Projects, Texas State University–San Marcos, June 2011.
See Appendix C.
The task documented in this memorandum focuses on the calculation of the in-house per hour costs associated with engineering project team titles. These project teams are responsible for a range of activities that includes engineering, land surveys, environmental review, transportation feasibility, financial management, real estate appraisal and materials laboratory services. A table on page 5 of the PDF summarizes the per-hour costs and range of per-hour costs across three district offices. Tables 1 and 2, which begin on page 6 of the PDF, provide consultant and in-house grade descriptions to aid in the conversion of external consultant titles to in-house project roles.

Related Research

The publications below highlight tools that evaluate the implications of outsourcing and assess the performance of the public and private sectors.

"Outsourcing Decision Making in Public Organizations: Proposed Methodology and Initial Analytic Results from a Department of Transportation," Robert J. Eger III, Subhashish Samaddar, *Transportation Research Record*, Vol. 2199, 2010: 37-47.
Citation at http://dx.doi.org/10.3141/2199-05
This article presents an outsourcing decision support tool (ODST) that evaluates the multidimensional implications of outsourcing. In a two-year project, researchers developed and tested the ODST with a state DOT. The process began with identifying competencies and core competencies, and then moved to a survey of DOT managers to conduct a pro-con-risk assessment of potential outsourcing functions. In examining the agency's competencies, researchers concluded "the great majority of DOT functions and subfunctions could be outsourced if oversight of the outsourced function or subfunction is well defined and supported."

Researchers gathered information about subfunctions that allowed for clustering of similar activities and identified potential priorities in outsourcing from the perspectives of two managerial teams. A knowledge audit conducted with the use of a questionnaire identified four types of knowledge assets associated within each subfunction:

- Implicit.
- Explicit.
- Organizational and managerial.
- Contextual relationship.

A cost analysis considered direct and indirect costs, including estimates of experience and education for the subfunctions and training cost investments.

The ODST automates analysis of data entered into a spreadsheet using built-in Excel macros. For most DOTs, entry of raw data can be automated through uploads from internal databases. The user can elect the type of output—Excel or Access—to see the savings and cost implications of outsourcing on:

- Direct labor and asset costs.
- Human resources.
- Knowledge assets (implicit and explicit).

Further development will enhance the tool's ability to forecast future spending patterns.

Current Status

We contacted Dr. Robert Eger to learn more about the project's current status. Dr. Eger remains under contract until December 2011with the state DOT participating in development and testing of the ODST. After contract expiration, the state DOT participating in the project can be named and the ODST will be available to other DOTs wishing to use it.

The state DOT now using the ODST identified challenges with monetizing implicit knowledge.
Dr. Eger's evaluation of that aspect of the ODST is the topic of an article submitted for publication that presents a new measuring tool which identifies the costs associated with losing implicit knowledge before outsourcing occurs.

"Extending CEA: Facilitating the Debate Over Public Outsourcing," Amanda Wilsker, Robert J. Eger III, *A Performing Public Sector: The Second TransAtlantic Dialogue*, June 2006.
http://soc.kuleuven.be/io/performance/paper/WS5/WS5_%20Eger%20and%20Wilsker.pdf
Instead of converting everything into monetary terms, as is the case in cost-benefit analyses, cost-effective analysis (CEA) relies on the inclusion of a quality measure to provide a mechanism to estimate the tradeoff between cost and quality. This conference paper described Quality Adjusted Transportation-Related Activities, an index composed of four quality criteria (response time, completion time, life years and public opinion) that compares the performance of the public and private sectors, or two private contractors. The model focuses on DOT maintenance activities but can be extended for use with other activities. The authors note that an ongoing challenge in conducting a proper CEA is accurately measuring costs, and that DOTs have not adequately addressed estimating overhead and oversight costs despite the adoption of newer database systems.

Dr. Eger reports that no further work has been conducted on this model.

APPENDIX A

Research Project Work Plan

for

Delivering Better Value for Money: Determining Outsourcing Feasibility and Standard Pricing Methods

SPR 738

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Research Project Work Plan
for
Delivering Better Value for Money: Determining Outsourcing Feasibility and Standard Pricing Methods

1.0 Identification

1.1 Organizations Sponsoring Research

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2.0 Problem Statement

Outsourcing is a proven project delivery method integral to ODOT's abilities to carry out its mission to provide a safe, efficient transportation system that supports economic opportunity and livable communities for Oregonians. According to mandates of Oregon House Bill 2867, effective January 2010, without reasonably based cost estimates and comparative cost analyses between ODOT's internal cost estimates and consultant cost estimates, ODOT is precluded from outsourcing design and construction project delivery. ODOT needs to develop a methodology for cost estimating and comparative cost analyses between ODOT internal cost estimates and consultant cost estimates that is accurate and transparent, in order that outsourcing may continue as an essential element in ODOT's delivery of projects. Without outsourcing, ODOT cannot sustain the level of project delivery expected by the legislature and the public.

3.0 Objectives of the Study

The research goal is to obtain and synthesize the information necessary to assure that ODOT methodology for comparison of internal cost estimates and consultant cost estimates meets the mandate of Oregon House Bill 2867, and serves as a valuable tool for effectively managing outsourcing. To this end, the research objectives are as follows:

- Document current ODOT procedures for estimating costs, determining internal overhead, determining consultant profit rates, conducting comparative analyses, and integrating delay costs and utilization rates into cost estimates.
- Determine the cost estimating procedures of other DOT's and summarize normally accepted procedures for allocating internal overhead of public agencies to projects.
- Provide guidelines for ODOT procedures that will assure all stakeholders that the mandate of Oregon House Bill 2867 is being, or will be, met.

3.1 Benefits

The research and resulting methodology will enable compliance with Oregon House Bill (HB) 2867, effective January 2010, and will demonstrate ODOT's proactive responsiveness to US DOT Office of Inspector General (OIB) audit recommendations of February 2009, and to various Oregon Secretary of State audits and Federal Highway Administration (FHWA) reviews and requirements, and will continue to enhance ODOT's partnership with the A&E industry. The research will allow ODOT to do a better job of managing consultant services. The research will be of benefit to several departments within the agency that use outsourcing methods. Other transportation agencies who are dealing with similar issues will also benefit from this effort. If the research is not performed, there is a higher likelihood that ODOT could be determined noncompliant with Oregon House Bill 2867, possibly leading to elimination of outsourcing of project delivery. If this were to happen, it is highly unlikely that ODOT would be able to deliver projects at the levels needed to provide adequate transportation infrastructure. This research into comparative analysis and cost estimating methodology will provide ODOT with a more robust cost estimating tool and background data. ODOT will be positioned to more effectively provide oversight for outsourced project delivery.

4.0 Background and Significance of Work

The past 30 years have seen a dramatic increase in the use of outsourcing of engineering services by transportation agencies (Rogge et.al. 2007; Warne, 2003). This trend means that accurately comparing costs of insourced and outsourced engineering services is becoming more important and that the need is more widespread. Before embarking on the current research, a preliminary literature review was conducted. A search for literature relevant to the problem statement and research objectives included a search of the Transportation Research Information Services (TRIS) database, as well as other sources.

Ellis (2000) reported on a study comparing costs of insourced and outsourced construction engineering and inspection for the Florida DOT. Schneider (1998) reported on a study comparing costs of insourced and outsourced construction engineering and inspection for the Louisiana DOTD. Schneider's methodology is based on methodologies reported from studies of transportation agencies in Texas, California, Wisconsin, and Missouri from the 1970's, 1980's, and 1990's. If more recent methodology cannot be identified, Schneider's methodology at least provides a reference point for the current research.

Publications by, Schneider (1998), Ellis (2000), and Rogge (2007) indicate that a major challenge faced in comparing outsourced costs to insourced costs is the proper allocation of transportation agency overhead to determine a true cost for performing the contracted services insourced to be compared to costs of outsourced services. Accepted methodologies for determining public agency overhead and applying to contract work do exist. For example, following the direction of OMB Circular A-21 (OMB 2004), research universities periodically are reviewed by a designated federal government agency to determine allowable overhead rates that will be accepted for contracted research. The previously cited study by Schneider (1998) also deals with the topic of allocating agency overhead to insourced design by the Louisiana DOTD. If better or more recent methodologies cannot be found, these procedures provide a reference point for the current research.

5.0 Implementation

Research findings will be summarized in the final report. It is expected that the Project Delivery Leadership Team, Contract Leadership Team, Region Technical Centers, Project Leaders and Local Agency Liaisons will become aware of the findings through the project's Technical Advisory Committee. Through the actions of these groups and individuals, and the obvious need to comply with Oregon House Bill 2867 and with the US DOT Office of Inspector General audit recommendations, research findings will be implemented.

6.0 Research Tasks

The following matrix summarizes the research tasks:

Task 1	Responsible Party(ies)	Cost
Task #1: Document current ODOT practice. Review and analyze current ODOT practices for estimating consultant contract amounts and for allocating agency overhead for insourced activities through review of documents and meetings and interviews with ODOT personnel and consultants. *Time Frame: 4 months* *Deliverables:* • *Presentation to TAC* • *Comprehensive written summary to be included in the final report* *TAC Decision/Action: Assess progress, review findings and provide feedback to PI.*	PI	$20,000

Task 2	Responsible Party(ies)	Cost
Task #2: Literature review. Review and analyze published research and procedures used by other state DOTs and Canada. Examine guidance from accounting organizations and the ACEC for consultant cost estimates, and from the federal government OMB for allocating overhead costs for state and local government agencies. *Time Frame: 4 months* *Deliverables:* • *Presentation to TAC* • *Comprehensive written summary to be included in the final report* *TAC Decision/Action: Assess progress, review findings and provide feedback to PI.*	PI	$20,000

Task 3	Responsible Party(ies)	Cost
Task #3: Agency surveys. Conduct surveys of DOTs to develop a summary of current practices relating to estimating costs of consultant services and agency overhead allocation. *Time Frame: 2 months* *Deliverables:* • *Presentation to TAC* • *Comprehensive written summary to be included in the final report* *TAC Decision/Action: Assess progress, review findings and provide feedback to PI.*	PI	$5,000

Task 4	Responsible Party(ies)	Cost
Task #4: Interviews. Identify experts identified in Tasks 1-3. *Time Frame: 2 months* *Deliverables:* • *Presentation to TAC* • *Comprehensive written summary to be included in the final report* *TAC Decision/Action: Assess progress, review findings and provide feedback to PI.*	PI	$2,000

Task 5	Responsible Party(ies)	Cost
Task #5: Analysis, Experimentation and Tool Development. Review analysis and synthesis of data collected. Propose guidelines and methodology, test with pilot program selecting projects based on ODOT Procurement Office input, and document results. Develop tool for use from data sources and TAC guidance. Software prototype to be developed. *Time Frame: 5 months* *Deliverables:* • *Presentation to TAC* • *Comprehensive written summary to be included in the final report* • *Prototype tool* *TAC Decision/Action: Assess progress, review findings and provide feedback to PI.*	PI	$63,000

Task 6	Responsible Party(ies)	Cost
Task #6: Final report. Assemble the information obtained in tasks 1-5 into a comprehensive report including guidelines and methodology for ODOT for estimating costs of consultant services contract and comparable costs if contract work were to be performed by ODOT personnel. *Time Frame: 4 months* *Deliverables:* • *Final report. Report will be produced in the standard ODOT Research Group report format.* • *Presentation to TAC* *TAC Decision/Action: Review draft of final report and provide feedback; approve final version of final report.*	PI	$30,000

7.0 Time Schedule

The tentative timeline to perform the activities in this research project is shown below. This timeline was developed assuming January 1, 2011, as the start date for the project. Cells with asterisks indicate approximate time frames when the PI intends to meet with ODOT to present and discuss preliminary findings.

	FY 2011		FY 2012			
Project Tasks	**Qtr 1** Jan - Mar	**Qtr 2** Apr - Jun	**Qtr 1** July - Sep	**Qtr 2** Oct - Dec	**Qtr 3** Jan - Mar	**Qtr 4** Apr - Jun
Task 1: Document ODOT Practice Deliverable:		*				
Task 2: Literature Review Deliverable:		*				
Task 3: Agency Surveys Deliverable:			*			
Task 4: Interviews Deliverable:			*			
Task 5: Analysis and Experimentation Deliverable:					*	
Task 6: Final Report Deliverable:						*

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TEXAS STATE UNIVERSITY
SAN MARCOS
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TECHNICAL MEMORANDUM 0-6730-PA-Task 1

EXAMINING ENGINEERING COSTS FOR DEVELOPMENT OF HIGHWAY PROJECTS

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March 2011

Project 0-6730-PA-Task 1
Technical Memorandum #1
Examining Engineering Costs for Development of Highway Projects

1.1 Background

The Texas Department of Transportation's (TxDOT) focus is to act in the best interest of the citizens of Texas in every endeavor. TxDOT's administration is actively engaged in determining the appropriate engineering staff levels to conduct the business of the department in the most efficient manner possible while implementing various laws and regulations. TxDOT's administration realizes the valuable role both in-house staff and consultant staff serve in conducting the business of the state. Numerous studies, including one conducted by the Comptroller of Public Accounts in response to Rider 57 last session, have examined the question of engineering costs for TxDOT projects developed internally by staff and developed externally by consultants. Despite these numerous studies, the answer to the question of engineering costs remains clouded. Several issues contribute to this uncertainty; these include a lack of readily available data, the fact that many projects are developed partially internally and partially externally and a lack of definition as to which costs should be included for a complete analyses.

This study utilizes a joint working group comprised of the Consultant Engineering Council and TxDOT representatives with Texas State University-San Marcos Department of Accounting. The joint working team determined common definitions of costs so that a TxDOT preliminary engineering hour cost could be comparable to a consultant's cost. The Research Project Team consists of Rosie Morris, Matthew Sansone, David Casteel, Steve Stagner, Kef Mason, Bob Cuellar, Teresa Lemons, Ken Barnett, Camille Thomason, Glen Knipstein, Susie Abright, Paul Summerbell, Raymond Martinez, Robert Stuard, Duane Sullivan, and Sandra Kaderka.

Since September 1, 1997, state law provides that 35 percent of appropriated funds are to be expended to private sector providers for engineering-related services. Specifically section 223.041 of the Texas Transportation Code states that :

> Sec. 223.041. ENGINEERING AND DESIGN CONTRACTS. (a) The department shall use private sector engineering-related services to assist in accomplishing its activities in providing transportation projects. For the purpose of this section, engineering-related services means engineering, land surveying, environmental, transportation feasibility and financial, architectural, real estate appraisal, and materials laboratory services. These engineering-related services are for highway improvements, right-of-way acquisition, and aviation improvements.
>
> (b) The department, in setting a minimum level of expenditures in these engineering-related activities that will be paid to the private sector providers, shall provide that the expenditure level for a state fiscal year in all strategies paid to private sector providers for all department engineering-related services for transportation projects is not less than 35 percent of the total funds appropriated in Strategy A.1.1. Plan/Design/Manage and Strategy A.1.2. of the General Appropriations Act for that state fiscal biennium. The department shall attempt to make expenditures for engineering-related services with private sector providers under this

subsection with historically underutilized businesses, as defined by Section 2161.001, Government Code, in an amount consistent with the applicable provisions of the Government Code, any applicable state disparity study, and in accordance with the good-faith-effort procedures outlined in the rules adopted by the comptroller.
(http://www.statutes.legis.state.tx.us/Docs/TN/htm/TN.223.htm#223.041)

In procuring professional engineering services, Sections 2254.003 and 2254.004 of the Texas Government Code require a state agency to first select the most highly qualified provider of those services on the basis of demonstrated competence and qualifications, and then attempt to negotiate with that provider a contract at a fair and reasonable price.

This memo will detail previous studies, current study project approach, results and limitations of the study. The results of this task are presented in Tables 1 and 2. Tables 3 and 4 summarize prior studies, and Table 5 presents a glossary of cost accounting terms.

1.2 Previous Studies

Over the past 25 years, TxDOT has sponsored studies to determine the engineering costs to Texas taxpayers. These four studies, with findings and limitations are summarized below. Additionally, two out-of-state studies are summarized for application to TxDOT. These studies are summarized in Table 3.

Texas A&M Texas Transportation Institute

Texas A & M Texas Transportation Institute analyzed the cost, quality, and policy of using consulting services in a report released in May, 1987. The study examined the use of external consultants for complex projects requiring particular expertise or specialized equipment, or when TxDOT did not have the capacity to perform the project in a timely manner. The study analyzed projects in pairs, comparing in-house projects with out-sourced projects. The study included training, operating supplies, safety, supervision, indirect labor, overtime premiums, fringe benefits and travel as components of overhead costs. The limitations of the study include quality assessments, personnel and size of the projects. Project characteristics were not consistent across all projects and likely not generalizable. The study concluded that cost of using state engineers was lower than the cost of external consultants.

Office of the State Auditor

The Office of the State Auditor reported on the engineering costs at TxDOT in August, 1997. At the time, statute did not require cost to be the determining factor in contracting engineering services. The department often outsourced the work based on workload, staff availability, expertise, and time constraints. Under the law, the department was required to achieve a balance in the use of TxDOT employees and private contractors, if the cost for preliminary, construction, and design engineering services were equivalent. The objectives of the study were to evaluate the methodologies for ensuring compliance with achieving outsourced work and to identify costs which should be used in determining whether the cost of in-house and consultant services were equivalent. Overheads costs included utilities, phone and communications, distributed service center costs and indirect administration costs such as accounting, human resources, executive office and direct administration. The limitations of the study include incorrect allocation of costs between the segments of a project and inaccurate calculations of indirect cost rates. The study recommended that the department improve its cost allocation process to provide decision-makers inside and outside the department with more relevant, reliable information about the costs of its products and services. The conclusion of the study was that the methodology of determining preliminary engineering cost data may be acceptable for some purposes, but was not appropriate for cost-based decisions which require a more equitable distribution of indirect costs. The department's response to this study was that the procedures in use were consistent with standard procedures in outsourcing analyses.

PricewaterhouseCoopers

TxDOT requested that PricewaterhouseCoopers (PwC) conduct a comparative study of in-house and contract preliminary engineering and design work in February, 1999. Cost comparisons were made from the perspective of the Texas taxpayer. Costs were analyzed and associated with processes, not broken down into direct and indirect costs for 13 different design categories. The study employed a reallocation of certain overhead costs based on cause and effect relationships, which may change over time. It concluded that out-sourced costs are higher than in-house costs for a majority of the design categories. If out-sourced or in-house costs were greater was indeterminate in the remaining design categories.

Reznick Group

The 2009 Texas Legislature directed the Comptroller of Public Accounts to examine engineering staffing patterns at TxDOT in highway, bridge, and maintenance operations. Reznick Group conducted the study with an objective to determine the incremental benefits of using outside consultants rather than TxDOT personnel. Indirect costs were defined as equipment operations, maintenance, depreciation costs, fringe benefits, and salary costs for management and support personnel. The data collected by TxDOT is not easily comparable to consultants' data because of differing cost classifications. This incomparability prevented any conclusions to be drawn.

Out of State Studies

A study by New York University (NYU) examined the New York State Department of Transportation. This study compared the cost of public-sector design work performed in-house versus out-sourcing. Both functional and administrative overhead was analyzed. There was considerable variability in the estimates used to determine the in-house design of an average employee. The study concluded that the cost of an in-house design engineer exceeds that of a private design engineer.

The University of California, Berkeley studied the State of California, examining the pay and benefits of public sector workers compared to those in the private sector, and investigated whether California public employees are overpaid at the expense of California taxpayers. Note that this study was of all public employees, not just transportation or design engineers. Regression adjusted analysis was used to compare the compensation package of public versus private sector employees. Overhead was not separately addressed in the study. The study made many assumptions on the human capital and fundamental personal characteristics of full-time public and private sector employees. Most California public employees are unionized which allows for those with a high school education or less to earn considerably more than their private sector counterparts, while college educated public sector employees earn considerably less than their private sector counterparts. The conclusion of the study was that public employees in California are neither overpaid nor overcompensated. Wages received by California public employees are about 7% lower, on average, than wages received by comparable private sector employees; however, public employees receive more generous benefits.

A summary of the out of state studies can be found in table 4.

1.3 Current Study: Project Approach

This study examines all of the direct and indirect costs associated with maintaining an engineering employee who does preliminary design engineering at TxDOT. These costs include salary, retirement contributions, insurance, computers, software, equipment, office space, training, support (human resources, finance, supervision, public relations, etc.), leaves (vacation, sick, military, etc.) and other costs.

The research team of private consultants, TxDOT representatives, and Texas State representatives met to agree on definitions and treatment of indirect costs. The team focused on calculating a preliminary engineering cost (PE) per hour from two different approaches. Approach one (1) would mimic the approach of consultants by using total costs from the previous fiscal year and allocating indirect costs to direct labor costs. Approach two (2) would use detailed costs from three district offices to capture the relevant costs and determine the cost per hour of preliminary engineering. Because of the diversity among districts across the state, three districts were selected for extensive examination, one representing a large metropolitan area (Dallas), one a mid-sized metropolitan area (Beaumont), and the last a rural area (Odessa). TxDOT currently accounts for costs and makes allocations to maximize Federal Highway dollars. This method considers direct labor costs to include both direct labor salary costs and benefits. Below are the variables and assumptions for the study.

1.4 Variables and Assumptions

Direct Labor Costs

The base salaries per person for each title are treated as direct labor costs and a base salary cost per productive hour was calculated. A productive hour is time spent on engineering tasks and not on training or personal time off (PTO). The analysis assumed a utilization rate of 75% for each productive hour or the time spent on engineering projects (not phone calls, emails, etc., unrelated to engineering projects). The treatment of this variable is the same whether using approach 1 or 2.

Indirect Costs

Fringe Benefits

Fringe benefits are calculated as a payroll additive of 0.7161 multiplied by base pay for 2010, the baseline year of the study. The payroll additive is updated each year and includes state longevity, leaves (vacation, sick, military, etc.), retirement matching, benefit replacement, state paid portion of FICA, worker's compensation, compensatory time, health insurance premiums, unemployment insurance, retirement dues, longevity, and overtime pay. The treatment of this variable is the same whether using approach 1 or 2.

Division and District G&A

Division and District general and administrative costs, such as accounting, human resources, and research, are collected and allocated based on direct labor costs for approach 1. For approach 2, the allocation is based on direct labor costs.

Detail of District Indirect Costs

In addition to salaries and payroll additives, the cost of a PE to the state of Texas includes various other indirect cost components: office space, computer and technology support, human resource, and training. For approach 1 these costs were combined to calculate general and administrative overhead per direct labor costs. For approach 2, these costs were combined to calculate general and administrative overhead per each position and job title for each district office.

Human Resources

Human resource costs include the sum of HR salaries, office space, technology and computers. For approach 1, these costs are captured within the division and district general and administrative overhead; for approach 2, these costs are allocated on a fixed per employee basis within each district office.

Office Space

Annual cost of office space includes an average office size and cost per square foot which was specific for each district. Actual building costs reported by TxDOT are based on historic cost, date of purchase, expected life, etc. because TxDOT owns the offices it occupies. To standardize this cost, the cost of office space per district was based on average annual rental costs in that district. In this way, there is a cost/benefit relationship that exists between the occupancy of office space and the cost of that office space. Office space used for engineering activities associated with the completion of individual projects is considered an overhead cost for that project. For approach 1, the district annual rentals were averaged and allocated at a rate of $1.58 per direct labor hour, which is a state average rental rate allocated on direct labor hours. For approach 2, the rental rates for the district office were calculated for the estimated PE office space.

Technology

For approach 2, annual technology costs include cost of a computer, software, and technology support. Technology support included the salaries of the techs, the portion of the human resources costs associated with them plus the techs' office space costs. This assumes a four year life for the computers and one computer per PE.

Training

For approach 2, training costs per job title data was provided by TxDOT. These costs were strictly the cost of providing the training. The number of hours of training for each job title and the related cost per hour was determined. The hours spent in training for PEs as well as their PTO was subtracted from the yearly hours worked (2080) to determine productive hours for each job title in the district office.

1.5 Results

Approach 1 uses direct labor costs and hours charged to specific projects. The direct labor costs are combined with the indirect costs of benefits, office space costs, division and district general and administrative allocation, resident engineer overhead, and other preliminary engineering costs. Under approach 1, the average cost per hour per PE for TxDOT is $114.44. The total indirect and overhead costs to direct labor costs ratio is 285.76%. A table of approach 1 is found in table 1.

Approach 2 combines the cost per productive hour plus training costs, human resource costs, benefit costs, technology costs and cost of office space (the cost to the state of Texas to employ a Professional Engineer in each of the three districts examined). Under approach 2, the average cost of employing a PE in the Odessa district is $117.18, in the Beaumont district, $123.98, and in the Dallas district, $107.86. The overhead costs to direct labor costs for the Odessa district is 303.73%; for the Beaumont district 291.03%, and in the Dallas district is 299.61%. A table of approach 2 is found in table 2.

Comparison of Approach 1 and Approach 2

		PE cost per hour	Overhead Rate
Approach 1	$	114.44	285.76%
Approach 2			
Dallas	$	107.86	299.61%
Beaumont	$	123.98	291.03%
Odessa	$	117.18	303.73%

Limitations

The study calculates the per hour cost of a preliminary engineering design hour under two different approaches. This calculation may be used to make decisions on whether to out-source or utilize in-house design engineering. It is not an avoidable cost per hour. That is, TxDOT could not out-source all preliminary engineering design work and not incur in-house engineering design costs (most notably TxDOT would still have to oversee the outsourced work). Strategic considerations regarding out-sourcing versus in-house costs include the quality of work, expertise needed, TxDOT workload, relationships with contractors, and project completion timeline.

Table 1
Texas State University-San Marcos
Approach 1
TEXAS DEPARTMENT OF TRANSPORTATION
Analysis of Preliminary and Construction Engineering Expenditures
FY 2010

COST CATEGORY	PE	CE	Total PE and CE
Direct Labor Hours	1,636,817	2,529,627	$ 4,166,444
Direct Labor (base rate)	$ 48,557,916	$ 59,234,721	$ 107,792,637
Indirect Costs			
Benefits	$ 25,836,843	$ 31,517,790	$ 57,354,633
Other	$ 11,082,615	$ 345,988	$ 11,428,603
Space	$ 2,586,171	$ 3,996,811	$ 6,582,982
Division & District G&A	$ 80,072,003	$ 97,678,055	$ 177,750,058
Res Eng Overhead	$ 19,183,293	$ 30,084,276	$ 49,267,569
Total Overhead	$ 138,760,925	$ 163,622,920	$ 302,383,845
Total Engineering Costs	$ 187,318,841	$ 222,857,640	$ 410,176,481
per Hour	$ 114.44	$ 88.10	$ 98.45
Overhead Rate	285.76%	276.23%	280.52%
Reimburseable Costs			
Rental Equipment	$ 844,744	$ 9,152,697	$ 9,997,441
Materials and Supplies	$ 18,660	$ 553,185	$ 571,845
Travel	$ 39,454	$ 71,037	$ 110,491
In House Survey	$ 450,767	$ 15,886	$ 466,653
	$ 1,353,625	$ 9,792,805	$ 11,146,430
Additional TxDOT Costs			
In House Lab & Core Tests	$ 339,600	$ 19,084,441	$ 19,424,041
In House Photgram Services	$ 481,972	$ -	$ 481,972
Advertisement	$ 978,686	$ 12,047	$ 990,733
Inter Agency Prof Fees	$ 409,729	$ -	$ 409,729
	$ 2,209,987	$ 19,096,488	$ 21,306,475

Table 2
Texas State University-San Marcos
Approach 2 - District Offices

Job Title	Average Total Cost Per Productive Hour			Average Base Hourly Base Pay			Average Fringe Benefits Paid			Average General and Administrative		
	Dallas	Beaumont	Odessa	Dallas	Beaumont	Odessa	Dallas	Beaumont	Odessa	Dallas	Beaumont	Odessa
Adv Project Devlpmt Dir I Total			$ 93.71			$ 40.55			$ 29.04			$ 24.11
Adv Project Devlpmt Dir II Total	$ 110.44			$ 48.14			$ 34.47			$ 27.83		
Area Engineer I Total		$ 121.62			$ 41.94			$ 30.04			$ 49.64	
Area Engineer II Total			$ 100.27			$ 42.87			$ 30.70			$ 26.70
Area Engineer III Total	$ 106.49	$ 106.29		$ 48.02	$ 46.01		$ 34.39	$ 32.95		$ 24.08	$ 27.33	
Area Engineer IV Total	$ 106.05			$ 48.50			$ 34.73			$ 22.81		
Assistant Area Engineer I Total	$ 97.88		$ 78.41	$ 36.38		$ 32.37	$ 26.05		$ 23.18	$ 35.45		$ 22.87
Assistant Area Engineer II Total	$ 86.57			$ 37.47			$ 26.83			$ 22.27		
Assistant Area Engineer III Total	$ 101.48			$ 41.99			$ 30.07			$ 29.42		
Deputy District Engineer Total	$ 128.26			$ 62.64			$ 44.85			$ 20.77		
Dir of Trans Plan & Devlpmt I Total		$ 114.90	$ 121.74		$ 51.31	$ 47.00		$ 36.74	$ 33.66		$ 26.85	$ 41.07
Dir of Trans Plan & Devlpmt II Total	$ 114.20			$ 56.20			$ 40.25			$ 17.75		
Dir of Transportation Ops I Total		$ 110.57			$ 49.60			$ 35.52			$ 25.44	
Director of Construction I Total		$ 113.07			$ 49.61			$ 35.52			$ 27.94	
Director of Construction II Total	$ 135.52			$ 55.11			$ 39.46			$ 40.95		
Director of Maintenance I Total		$ 110.03			$ 51.31			$ 36.74			$ 21.98	
Director of Maintenance II Total	$ 136.33			$ 53.21			$ 38.10			$ 45.02		
Director of Operations I Total			$ 110.08			$ 47.26			$ 33.85			$ 28.96
Director of Operations II Total	$ 113.86			$ 53.95			$ 38.63			$ 21.28		
District Engineer Total	$ 152.39	$ 126.26	$ 133.46	$ 77.24	$ 63.07	$ 63.07	$ 55.31	$ 45.17	$ 45.17	$ 19.83	$ 18.02	$ 25.22
Transportation Engineer I Total	$ 69.20			$ 27.95			$ 20.01			$ 21.24		
Transportation Engineer II Total	$ 76.98	$ 70.57	$ 83.36	$ 27.27	$ 25.69	$ 27.54	$ 19.53	$ 18.40	$ 19.72	$ 30.17	$ 26.48	$ 36.10
Transportation Engineer III Total	$ 75.41	$ 152.56	$ 74.18	$ 29.41	$ 34.61	$ 29.21	$ 21.06	$ 24.78	$ 20.92	$ 24.94	$ 93.16	$ 24.04
Transportation Engineer IV Total	$ 79.82	$ 83.46		$ 32.37	$ 36.78		$ 23.18	$ 26.34		$ 24.27	$ 20.33	
Transportation Engineer V Total	$ 88.42	$ 83.01		$ 35.77	$ 36.01		$ 25.62	$ 25.79		$ 27.04	$ 21.21	
Transportation Engineer VI Total	$ 94.77	$ 96.42	$ 94.75	$ 38.77	$ 41.98	$ 42.56	$ 27.76	$ 30.06	$ 30.48	$ 28.25	$ 24.38	$ 21.72
Transportation Engr Supvr I Total	$ 83.63		$ 80.03	$ 38.40		$ 32.86	$ 27.50		$ 23.53	$ 17.73		$ 23.64
Transportation Engr Supvr II Total	$ 93.80	$ 90.08	$ 107.98	$ 34.57	$ 36.45	$ 35.81	$ 24.76	$ 26.10	$ 25.65	$ 34.47	$ 27.52	$ 46.52
Transportation Engr Supvr III Total	$ 104.30	$ 101.30	$ 90.55	$ 43.63	$ 42.56	$ 42.22	$ 31.24	$ 30.48	$ 30.23	$ 29.42	$ 28.27	$ 18.09
Transportation Engr Supvr V Total	$ 103.79			$ 44.91			$ 32.16			$ 26.72		
Transportation Engr Supvr VI Total	$ 110.27			$ 47.66			$ 34.13			$ 28.48		
Weighted Average Cost per hour of PE	102.24	117.52	111.07	$ 36.00	$ 42.60	$ 38.58						
Weighted Average Cost with G&A	107.86	123.98	117.18									
	299.61%	291.03%	303.73%									

Table 2 A
Texas State University-San Marcos
Approach 2 - District Offices
Assumptions

		Dallas	Beaumont	Odessa
1) Human Resource Expense is fixed and constant for every individual				
2) The Cost Per Computer, Software, and all Peripheral equipment is				
Cost per Computer on a Yearly Basis		$ 425.00	$ 425.00	$ 425.00
3) The Average Office Size is (in Square Feet)		120	120	120
The Cost Per Square Foot of Office Space is	Per Year	$ 15.11	$ 12.36	$ 11.64
District and Division general and administrative per direct labor costs		5.50%	5.50%	5.50%
Employees at TxDot are efficient and produce billiable hours at a an efficiency rate equal to while at the office		75%	75%	75%

Table 3
Summary of Past TxDOT Studies

	Texas A& M *Texas Transportation Institute*	*Office of the State Auditor*	*PWC*	*Reznick Group*
Date Study Completed	May 1987	August 1997	February 1999	January 2010
Study Sponsor	Texas State Department of Highways and Public Transportation	The State of Texas	Texas Department of Transportation (TxDOT)	Texas Comptroller of Public Accounts
Study Purpose and Reason	Analyze the cost, quality, and policy of using consulting services. Response to increased work load "peak loads" or to obtain experts or specialized equipment.	Report on the engineering costs at TxDOT. State law at the time provided that cost was the determinate factor in decisions to contract for engineering services; the Department decided to outsource the work based on factors such as workload, staff availability, expertise, and time constraints.	Comparative study of in-house and contract preliminary engineering and design work. Determinates to outsource: Costs, available resources, quality of work, timelines.	Analyze the benefits of using transportation consultants. 2009 Texas Legislature directed the Comptroller of Public Accounts to examine engineering staffing patterns at TxDOT. When demand exceeds TxDOT's in-house resources or engineering capabilities, TxDOT considered outsourcing the opportunity to the consulting community.
Ways in which Study was Analyzed	Projects were analyzed in pairs of in-house projects compared to external consultants.	Analyzed the state statute requiring balance in the use of Department employees and private contractors for preliminary and construction engineering and design engineering services when costs were equivalent.	Cost comparisons were made from the perspective of the Texas taxpayer. Costs were analyzed and associated with processes.	Incremental benefit of using transportation consultants to perform highway construction and maintenance engineering services compared to using TxDOT personnel
Overhead/Indirect Components	Training, operating supplies, safety, supervision, indirect labor, overtime premiums, fringe benefits, and travel	Overhead Costs: Utilities, phone and communications, and distributed service center costs. Indirect Admin Costs: accounting, human resources, executive office, and district administration	Costs were assigned to specific processes, not broken down into components. There was a reallocation of certain overhead costs based on cause and effect relationships, which may change over time.	Indirect costs: equipment operations, maintenance, depreciation costs, fringe benefits, and salary costs for management and support personnel. Indirect costs, which are not identifiable to a specific project, are collected in the accounting system as indirect costs and allocated to projects based upon total direct costs incurred for a particular project.
Study Limitations	Quality Assessment of organization structure, personnel and size of the projects, use of consulting engineers, quality of work appraisal completed by both SDHPT personnel and consultants, and project characteristics.	Incorrect allocation of costs between the segments of a project, improper inclusion of projects paid for by third parties, and inaccurate calculations of indirect cost rates	Different project databases (5 year process map and 10 year statistical analysis), different thresholds to define what constitutes an in-house project (10% direct costs outsourced versus 25%) and cost adjustments to data in the statistical analysis so study was comparable	TxDOT would need to have historical cost data from projects that were performed solely by TxDOT and from projects performed solely by consultant engineers of similar scope and nature to produce a meaningful analysis and comparison. (It should be noted that the Office of the State Auditor's report stated that there are no pure (100 percent) consulting engineering jobs.)
Conclusions	Cost of using state engineers was lower than the use of consultants.	PE cost data had limited usefulness, contained inaccuracies, and included allocations of indirect costs that were not appropriate for comparing the cost of in-house and consultant services.	Out-source design was more expensive than in-house design for 8 out of 13 types of processes.	Reznick could not accurately determine the true cost impact of a "one percent increase in production by consultants offset by a reduction to production by Department of Transportation personnel."

Table 4
Summary of Out-of-State Studies

	New York University	*University of California, Berkeley*
Date Study Completed	October 2008	October 2010
Study Sponsor	New York State Department of Transportation	State of California
Study Purpose and Reason	Compare cost of public-sector design work performed in-house versus outsourcing. To accomplish their programs and in-house training goals, many agencies set design work-load targets of 25% in-house and 75% outsourced.	To determine how the pay and benefits of public sector workers compare to those in the private sector and investigate whether California public employees are overpaid at the expense of California taxpayers.
Ways in which Study was Analyzed	Analyze and compare the cost of having public-sector design work performed in-house with outsourcing that same work to private engineering consulting companies.	Regression adjusted analysis was used to compare the compensation package of public versus private sector employees. For the study, self-employed, part-time, agricultural and domestic workers were excluded from the study. The study includes all other state and local employees, including educational employees.
Overhead/Indirect Components	Overhead: Functional and Administrative	Overhead not separately addressed in the study.
Study Limitations	There was considerable variability in the estimates used to determine the in-house design cost of an average employee.	The study made many assumptions on the human capital and fundamental personal characteristics of full-time public and private sector employees. Most California public employees are unionized and allows for those with a high school education or less to earn considerably more than their private sector counterparts. On the other hand, college educated private sector employees earn considerably more than similarly educated public sector workers.
Conclusions	In-house design engineer's actual expected cost to the taxpayer exceeds that of a private design engineer by about 14%, based on conservative assumptions.	Public employees in California are neither overpaid nor overcompensated. Wages received by California public employees are about 7% lower, on average, than wages received by comparable private sector workers; however, public employees do receive more generous benefits.

Table 5

Glossary of Cost Accounting Terms

Definitions obtained from the Houghton Mifflin Brief Accounting Dictionary (Copyright 2000)

- Cost Allocation—The process of assigning a specific cost to a specific objective. Also called cost assignment.

- Cost Center—Any part of an organization or area of activity, such as a specific division or department, for which there is a reason to record, calculate, and allocate cots. Another term for expense center.

- Direct Cost—A cost that can be easily and economically traced to a specific product that was completed during an accounting period.

- Direct Expense—An operating (or overhead) expense that can be assigned to a specific department and is under the control of the department head. *The usual way to identify a direct expense is: If the department did not exist, the expense would not exist.*

- Direct Labor Costs—The labor cost is for specific work that can be easily and economically traced to an end product.

- Direct Material—A material that will become part of a finished product and can be easily and economically traced to specific product units.

- Indirect Cost—Any cost that cannot be conveniently and economically traced to a specific department; a manufacturing cost that is not easily traced to a specific product and must be assigned using an allocation method. For example, a property tax is an indirect expense because it is incurred by the entire company, not a single department. Another term for indirect expense.

- Indirect Expense—Another term for indirect cost.

- Indirect Labor Costs—Labor costs for production-related activities than cannot be connected with or conveniently and economically traced to a specific end product.

- Indirect Materials—Minor materials and other production supplies that cannot be conveniently and economically traced to specific products.

- Overhead—The operating expenses of a business, such as rent, insurance premiums, taxes, and electricity

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TECHNICAL MEMORANDUM 0-6730-PA-Task 2

EXAMINING ENGINEERING COSTS FOR DEVELOPMENT OF HIGHWAY PROJECTS

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Project 0-6730-PA-Task 2
Technical Memorandum #2
Examining Engineering Costs for Development of Highway Projects

1.1 Introduction

This memo provides an update on task 2 for Examining Engineering Costs for Development of Highway Projects. Task 2 requires the study team to determine the annual cost to the taxpayer for an engineering project team.

1.2 Engineering Project Teams

Engineering project teams are used in both in-house and out-sourced engineering and design services for transportation projects. Transportation projects include engineering, land surveys, environmental, transportation feasibility, financial, architectural, real estate appraisal, and materials laboratory services for highway improvements, right-of-way acquisition, and aviation improvements. A project team may be as few as two individuals or may be comprised of many individuals with the same and/or different titles working on complex transportation projects. The relevant roles included in a typical TxDOT project team include design team leader (professional engineer, PE), design team member(s) (PE), engineering assistant (graduate engineer that is not registered as a PE), lead design technician or specialist (non-engineer), mid-grade design technician (non-engineer), entry level design technician (non-engineer), principle in charge, and administrative support.

The project team roles have been used by TxDOT district offices for a few years. Each employee of TxDOT also has a staffing classification, such as Design Technician I-VI, Transportations Specialist I – V, Engineering Assistant I – V, Transportation Engineer I – VI, Area Engineer, District Engineer, etc. The staffing classifications are comparable to external engineering firms classifications of employees. Tables 1 and 2 at the end of this memo aid in the conversion of external consultant titles or grades to project roles. Table 1 details the different professional grade descriptions. This table was developed from the Texas Council of Engineering Companies (TCEC) annual salary survey. Table 2 details the different engineering grade descriptions with associated equivalent Federal General Schedule grade (GS ranking as used by the Federal Highway Administration). This table was developed from the National Society of Professional Engineers (NSPE) annual salary survey. These tables, used for annual salary surveys, summarize the accepted definitions within the engineering industry, based on progressive increase in experience and professional responsibility.

The engineering project PE team roles equivalent to TCEC and NSPE grade descriptions for this task are: design team leader is equivalent to professional or engineer VI or VII (and very rarely professional or engineer VIII or IX); design team member(s) is equivalent to professional or engineer III, IV, V, or VI; and engineering assistant is equivalent to professional or engineer I, II or III. (The correlation of project titles to grades is in the table below.) The results will be detailed by both project team roles and engineering or professional grade below.

PROJECT ROLES CORRELATED TO GRADE		
TxDOT Project Roles	**TCEC Professional Grades**	**NSPE Engineering Grades**
Design Team Leader	Professional VI or VII	Engineer VI or VII
Design Team Member	Professional III, IV, V, or VI	Engineer III,IV, V, or VI
Engineering Assistant	Professional I, II, or III	Engineer I, II, or III

1.3 Current Study: Task 2 Approach

This task examines the salaries of those with different job titles fulfilling the various roles on engineering project teams. The overhead and utilization rates, determined in task 1, are applied to per hour costs for each role. TxDOT provided the research team with monthly salary information and approximate design team roles by job classification for all 25 district offices. Comparing this with the details provided for the three district offices of Dallas, Beaumont, and Odessa, not all job titles could easily be assigned to a project role. This may be due to TxDOT's encouragement of engineering and maintenance staff to share high workload demands within and across districts with less workload demands.

Per Hour Costs

The per hour costs across all TxDOT offices was compared to the range of four per hour costs; those of the Dallas, Beaumont, and Odessa offices, and the average per hour costs of those three offices. The TxDOT averages fall within that range except for the Lead Design Technician role. This could be due to longevity of the personnel in that role across TxDOT or due to the competition for that role in the three offices compared to the other locations. Using the utilization rate of 75 percent and overhead rate of 285.76 percent from task 1, the design team per hour costs to the taxpayer was calculated by the research team. Results are presented on the next page.

Annual Costs

Task 2 requires that the annual cost to the taxpayer be calculated for an engineering project team. However, since each design team role rarely works on one design task for an entire year and each individual team member may utilize a different amount of leave and receive differing amounts of training, it is difficult to accurately determine the number of annual hours. The overhead of 285.76 percent from task 1 includes an amount for leave and training. If the standard annual yearly hours of 2,080 (52 weeks at 40 hours a week) was used, leave taking would then be included twice in the annual costs. The research team determined per hour costs to be more meaningful and are comparable with the approach of external engineering firms. Thus, the annual costs of each team member was not calculated nor presented.

1.4 Assumptions

The relationships of indirect costs to direct labor costs as determined in task 1 are assumed to be applicable to the design team costs examined in this task. The roles of principle in charge and administrative support are assumed to be part of general and administrative costs included in the overhead rates of task 1 and not delineated for this task.

1.5 Results

The table on the next page summarizes the per hour costs and range of per hour costs across the offices of Dallas, Beaumont, and Odessa of each design team role using the above assumptions.

Costs of Engineering Project Team Roles

Project Team Role	Average of all TxDOT Offices Per Hour Costs	Range Across 3 Offices and Average of 3 Offices Per Hour Costs
Design Team Leader (PE) *(Professional or Engineer VI, VII)*	$ 137.69	$128.49 - $155.34
Design Team Member (PE) *(Professional or Engineer III, IV, V, VI)*	$ 112.08	$107.92 - $116.03
Engineering Assistant (Grad. Engr. Non-PE) *(Professional or Engineer I,II, III)*	$ 92.67	$ 84.63 - $ 97.07
Lead Design Technician or Specialist (Non Engr.)	$ 99.44	$ 83.02 - $ 98.61
Mid-grade Design Technician (Non Engr.)	$ 81.74	$ 79.80 - $ 89.15
Entry Level Design Technician (Non Engr.)	$ 63.89	$ 60.12 - $ 71. 35

1.6 Limitations

This task calculates the in-house per hour costs of engineering project team titles. The range of the per hour costs of the Dallas, Beaumont, Odessa offices, and the average of those offices are presented for comparison. The annual costs of project teams are not calculated. Additionally, the hour requirements for each job title vary by project and may require less time from the leadership roles versus the technician roles. The above calculations may be used to make decisions on whether to out-source or utilize in-house design engineering; however, it should not be considered as avoidable cost per hour. That is, TxDOT could not out-source all preliminary engineering design work without incurring in-house engineering design costs (most notably TxDOT would still have to oversee the out-sourced project work). Strategic considerations regarding out-sourced versus in-house costs include the quality of work, expertise needed, TxDOT workload, relationships with contractors, and project completion timeline.

TABLE 1
PROFESSIONAL GRADE DESCRIPTIONS

GRADE	Professional I/II	Professional III	Professional IV	Professional V
General Characteristics	This is the entry level for professional work.	Independently evaluates, selects, and applies standard techniques, procedures, and criteria, using judgment in making minor adaptations and modifications.	Plans and conducts work requiring judgment in the independent evaluation, selection, and substantial adaptation and modification of standard techniques, procedures, and criteria.	Requires the use of advanced techniques and the modification and extension of theories, precepts, and practices of her/his field and disciplines.
Direction Received	Receives close supervision on new aspects of assignments.	Receives instructions on specific assignment objectives, complex features, and possible solutions.	Independently performs most assignments with instructions as to the general results expected.	Supervision and guidance relate largely to overall objectives, critical issues, new concepts, and policy matters.
Typical Duties & Responsibilities	Using prescribed methods, performs specific and limited portions of a broader assignment of an experienced professional.	Performs work which involves conventional types of plans, investigations, surveys, structures, or equipment with relatively few complex features.	Plans, schedules, conducts or coordinates detailed phases of the professional work in a part of a major project or in a total project of moderate scope.	One or more of the following: (1) In a supervisory capacity, plans, develops, coordinates, and directs a large and important project or a number of small projects with many complex features. (2) As individual researcher or worker, carries out complex or novel assignments requiring the development of new or improved techniques and procedures. (3) As staff specialist, usually performs as a staff advisor and consultant as to a technical specialty, a type of facility or equipment, or a program function.
Responsibility for Direction of Others	May be assisted by a few aides or technicians.	May supervise or coordinate the work of others who assist in specific assignments.	May supervise or coordinate the work of other professionals who assist in specific assignments.	Supervises, coordinates, and reviews the work of a small staff of professionals.
Typical Position Titles	Staff or Junior Engineer/Scientist	Engineer/Scientist	Engineer/Scientist	Senior Engineer/Scientist
Education	Bachelor's Degree			
Registration Status	Certified Engineer/Scientist in Training		Registered Professional Engineer/Scientist	
Typical Professional Attainments	Member of Professional and Technical Societies		Member of Professional Society; Member of Technical Society.	Member of Professional Society; Member of Technical Society; Publishes professional papers.

Source: Texas Council of Engineering Companies (TCEC) annual salary survey.

GRADE	Professional VI	Professional VII	Professional VIII	Professional IX
General Characteristics	Plans and develops projects concerned with unique or controversial problems which have an important effect on major organization programs.	Makes decisions and recommendations that are recognized as authoritative and have an important impact on extensive professional activities.	Make decisions and recommendations that are recognized as authoritative and have a far-reaching impact on extensive professional and related activities of the company.	A professional at this level is either: (1) in charge of programs so extensive and complex as to require staff and resources of sizable magnitude; or (2) is an individual researcher or consultant who is a national and/or international authority and leader.
Direction Received	Supervision received is essentially administrative.	Supervision received is essentially administrative.	Receives general administrative direction.	
Typical Duties & Responsibilities	One or more of the following: (1) In a supervisory capacity (a) plans, develops, coordinates, and directs a number of large and important projects or a project of major scope and importance, or (b) is responsible for the entire program of her/his profession of an organization when the program is of limited complexity and scope. (2) As individual researcher or worker conceives, plans, and conducts research in problem areas of considerable scope and complexity. (3) As a staff specialist serves as the technical specialist.	One or both of the following: (1) In a supervisory capacity is responsible for an important segment of the professional program of an organization. Generally requires several subordinate organizational segments or teams. Recommends facilities, personnel, and funds required to carry out programs. (2) As individual researcher and consultant is a recognized leader and authority in her/his organization in a broad area of specialization or in a narrow but intensely specialized field. Selects research problems to further the organization's objectives.	One or both of the following: (1) In a supervisory capacity is responsible for an important segment or a very extensive and highly diversified program. (2) As individual researcher and consultant, formulates and guides the attack on problems of exceptional difficulty and marked importance to the organization or industry.	
Responsibility for Direction of Others	Plans, organizes, and supervises the work of a staff of professionals and technicians.	Directs several subordinate supervisors or team leaders, some of whom are in positions comparable to Professional VI.	Supervise several subordinate supervisors or team leaders.	
Typical Position Titles	Senior or Principal Engineer/Scientist	Principal Engineer/Scientist, Department Manager, Director or Assistant Director of Research, Consultant, Professor, Distinguished Professor or Department Head	Chief Engineer, Bureau Engineer/Scientist, Director of Research, Department Head or Dean, County Engineer, Senior Advisor, Senior Consultant	Director of Engineering, General Manager, Vice President, President, Partner, Dean, Director of Public Works
Education	Bachelor's Degree			
Registration Status	Registered Professional Engineer/Scientist			
Typical Professional Attainments	Member of Professional Society; Member of Technical Society; Publishes professional papers			

TABLE 2
ENGINEERING GRADE DESCRIPTIONS

	1001 Engineer I/II	1003 Engineer III	1004 Engineer IV	1005 Engineer V
Equivalent Federal General Schedule Grade*	GS-5, 7	GS-9	GS-11	GS-12
General Characteristics	This is the entry and second level for professional work. Performs assignments designed to develop professional engineering work knowledge and abilities, requiring application of standard techniques, procedures, and criteria in caring out a sequence of related engineering tasks. Limited exercise of judgment is required on details of work and in making preliminary selections and adaptations of engineering alternatives.	Independently evaluates, selects, and applies standard engineering techniques, procedures, and criteria, using judgment in making minor adaptations and modifications. Assignments have clear and specified objectives and require the investigation of a limited number of variables. Performance at this level requires developmental experience in a professional position or equivalent graduate level education.	As a fully competent engineer in all conventional aspects of the subject matter of the functional area of the assignments, plans and conducts work requiring judgment in the independent evaluation, selection, and substantial adaptation and modification of standard techniques, procedures, and criteria. Devises new approaches to problems encountered. Requires sufficient professional experience to assure competence as a fully trained worker. Completion of all requirements for a doctoral degree may be substituted for experience.	Applies intensive and diversified knowledge of engineering principles and practices in broad areas of assignments and related fields. Makes decisions independently on engineering problems and methods, and represents the organization in conferences to resolve important questions and to plan and coordinate work. Requires the use of advanced techniques and the modification and extension of theories, precepts and practices of his/her field and related sciences and disciplines. The knowledge and expertise required for this level of work usually result from progressive experience.
Direction Received	Supervisor screens assignments for unusual or difficult problems and selects techniques and procedures to be applied on non-routine work. Receives close supervision on new aspects of assignments.	Receives instruction on specific assignment objectives, complex features, and possible solutions. Assistance is furnished on unusual problems and work is reviewed for application of sound professional judgment.	Independently performs most assignments with instructions as to the general results expected. Receives technical guidance on unusual or complex problems and supervisory approval on proposed plans for projects.	Supervision and guidance related largely to overall objectives, critical issues, new concepts, and policy matters. Consults with supervisor concerning unusual problems and developments.
Typical Duties & Responsibilities	Using prescribed methods, performs specific and limited portions of a broader assignment of an experienced engineer. Applies standard practices and techniques in specific situations, adjusts and correlates data, recognizes discrepancies in results, and follows operations through a series of related detailed steps or processes.	Performs work which involves conventional types of plans, investigations, surveys, structures, or equipment with relatively few complex features for which there are precedents. Assignments usually include one or more of the following: Equipment design and development, test of materials, preparation of specifications, process study, research investigations, report preparation, and other activities of limited scope requiring knowledge of principles and techniques commonly employed in the specific narrow area of assignments.	Plans, schedules, conducts, or coordinates detailed phases of the engineering work in a part of a major project or in a total project of moderate scope. Performs work which involves conventional engineering practice but may include a variety of complex features such as conflicting design requirements, unsuitability of conventional materials, and difficult coordination requirements. Work requires a broad knowledge of precedents in the specialty area and a good knowledge of related specialties.	One or more of the following: (1) In a supervisory capacity, plans, develops, coordinates, and directs a large and important engineering project or a number of small projects with many complex features. A substantial portion of the work supervised is comparable to that described for Engineer IV. (2) As individual research or worker, carries out complex or novel assignments requiring the development of mew or improved techniques and procedures. Work is expected to result in the development of new or refined equipment, materials, processes, products, and/or scientific methods. (3) As staff specialist, develops and evaluates plans and criteria for a variety of projects and activities to be carried out by others. Assesses the feasibility and soundness of proposed engineering evaluation tests, products, or equipment when necessary data are insufficient or confirmation by testing is advisable. Usually performs as a staff advisor and consultant as to a technical specialty, a type of facility or equipment, or a program function.
Responsibility for Director of Others	May be assisted by a few aids or technicians.	May supervise or coordinate the work of technicians and others who assist in specific assignments.	May supervise or coordinate the work of engineers, other professionals, technicians, and others who assist in specific assignments.	Supervises, coordinates, and reviews the work of a small staff of engineers, other professionals, and technicians. Estimates personnel needs, and schedules and assigns work to meet completion date. Or, as individual researcher or staff specialist, may be assisted on projects by other engineers, other professionals, or technicians.
Typical Position Titles	Junior Engineer, Associate, Detail Engineer, Engineer-in-Training, Assistant Research Engineer, Construction Inspector.	Engineer or Assistant Engineer, (Project, Plant, Office, Design, Process, Research) Inspector, Engineering Instructor.	Engineer or Assistant Engineer, (Resident, Project, Plant, Office, Design, Process, Research) Chief Inspector, Assistant Professor.	Senior or Principal Engineer, (Resident, Project, Office, Design, Process, Research) Assistant Division Engineer, Associate Professor, Project Leader.

* Shown for comparison of job characteristics and responsibility levels only, not to indicate desirable salary levels.

Equivalent Federal General Schedule Grade*	GS-13	GS-14	GS-15	Senior Executive Service GA-16, 17, 18
General Characteristics	Has full technical responsibility for interpreting, organizing, executing, and coordinating assignments. Plans and develops engineering projects concerned with unique or controversial problems which have an important effect on major organization programs. This involves exploration of subject area, definition of scope and selection of problems for investigation and development of novel concepts and approaches. Maintains liaison with individuals and units within or outside his/her organization, with responsibility for acting independently on technical matters pertaining to his/her field. Work at this level usually requires extensive progressive experience.	Makes decisions and recommendations that are recognized as authoritative and have an important impact on extensive engineering activities. Initiates and maintains extensive contacts with key engineers and officials of other organizations and companies, requiring skill in persuasion and negotiation of critical issues. At this level, individuals will have demonstrated creativity, foresight, and mature engineering judgment in anticipating and solving unprecedented engineering problems, determining program objectives and requirements, organizing programs and projects, and developing standards and guides for diverse engineering activities.	Makes decisions and recommendations that are recognized as authoritative and have a far reaching impact on extensive engineering and related activities of the organization. Negotiates critical and controversial issues with top level engineers and officers of other organizations. Individuals at this level demonstrate a high degree of creativity, foresight, and mature judgment in planning, organizing, and guiding extensive engineering programs and activities of outstanding novelty and importance.	An engineer in this level is either (1) in charge of programs so extensive and complex as to require staff and resources of sizeable magnitude (e.g., research and development, a department of government responsible for extensive engineering programs, or the major component of an organization responsible for the engineering required to meet the objectives of the organization); or (2) is an individual researcher or consultant who is recognized as a national and/or international authority and leader in an area of engineering or scientific interest and investigation.
Direction Received	Supervision received is essentially administrative, with assignments given in terms of broad general objectives and limits.	Supervision received is essentially administrative, with assignments given in terms of broad general objectives and limits.	Receives general administrative direction.	
Typical Duties & Responsibilities	One or more of the following: (1) In a supervisory capacity, (a) plans, develops, coordinates, and directs a number of large and important projects or a project of major scope and importance, or (b) is responsible for the entire engineering program of an organization when the program is of limited complexity and scope. The extent of his/her responsibilities generally require a few (3 to 5) subordinate supervisors or team leaders with at least one in a position comparable to Engineer V. (2) As individual researcher or worker, conceives, plans, and conducts research in problem areas of considerable scope and complexity. The problems must be approached through a series of complete and conceptually related studies, are difficult to define, require unconventional or novel approaches, and require sophisticated research techniques. Available guides and precedents contain critical gaps, are only partially related to the problem or may be largely lacking due to the novel character of the project. At this level, the individual researcher generally will have contributed inventions, new designs, or techniques which are of material significance in the solution of important problems. (3) As a staff specialist, serves as the specialist for the organization (division or company) in the application of advanced theories, concepts, principles, and processes for an assigned area of responsibility (i.e., subject matter, function, type of facility or equipment, or product). Keeps abreast of new scientific methods and developments affecting his/her organization for the purpose of recommending changes in emphasis of programs or new programs warranted by such developments.	One or both of the following: (1) In a supervisory capacity, is responsible for (a) an important segment of the engineering program of an organization with extensive and diversified engineering requirements, or (b) the entire engineering program of an organization when it is more limited in scope. The overall engineering program contains critical problems requiring major technological advances and opening the way for extensive related development. The extent of his/her responsibilities generally requires several subordinate organizational segments or teams. Recommends facilities, personnel, and funds required to carry out programs which are directly related with and directed toward fulfillment of overall organization objectives. (2) As individual researcher or consultant, is a recognized leader and authority in his/her organization in a broad area of specialization or in a narrow but intensely specialized field. Selects research problems to further the organization's objectives. Conceives and plans investigations of broad areas of considerable novelty and importance for which engineering reprecedents are lacking in areas critical to the overall engineering program. Is consulted extensively by associates and others with a high degree of reliance placed on his/her scientific interpretations and advice. Typically, will have contributed inventions, new designs, or techniques which are regarded as major advances in the field.	One or both of the following: (1) In a supervisory capacity, is responsible for (a) an important segment of a very extensive and highly diversified engineering program, or (b) the entire engineering program when the program is of moderate scope. The programs are of such complexity that they are of critical importance to overall objectives, include problems of extraordinary difficulty that often have resisted solution, and consist of several segments requiring subordinate supervisors. Is responsible for deciding the kind and extent of engineering and related programs needed for accomplishing the objectives of the organization for choosing the scientific approaches, for planning ad organizing facilities and programs, and for interpreting results. (2) As individual researcher or consultant, formulates and guides the attack on problems of exceptional difficulty and marked importance to the organization or industry. Problems are characterized by their lack of scientific precedents and source material, or lack of success of prior research and analysis so that their solution would represent an advance of great significance and importance. Performs advisory and consulting work for the organization as a recognized authority for broad program areas or in an intensely specialized are of considerable novelty and importance.	
Responsibility for Director of Others	Plans, organizes, and supervises the work of a staff of engineers, other professionals, and technicians. Evaluates progress of the staff and results obtained, and recommends major changes to achieve overall objectives. Or, as individual research or staff specialist, may be assisted on individual projects by other engineers, other professionals, or technicians.	Directs several subordinate supervisors or team leaders, some of whom are in positions comparable to Engineer VI or, as individual researcher, staff specialist, or consultant, may be assisted on individual projects by other engineers, other professionals, or technicians.	Directs several subordinate supervisors or team leaders, some of whom are in positions comparable to Engineer VII. As an individual researcher, staff specialist, or consultant, may be assisted on individual projects by other engineers, other professionals, or technicians.	
Typical Position Titles	Senior or Principal Engineer, Division or District Engineer, Production Engineer, Assistant Division, District or Chief Engineer, Consultant, Professor, City or County Engineer.	Principle Engineer, Division or District Engineer, Department Manager, Director or Assistant Director of Research, Consultant, Professor, Distinguished Professor or Department Head, Assistant Chief or Chief Engineer, City or County Engineer.	Chief Engineer, Bureau Engineer, Director of Research, Department Head or Dean, County Engineer, City Engineer, Director of Public Works, Senior Fellow, Senior Staff, Senior Advisor, Senior Consultant, Engineering Manager.	Director of Engineering, General Manager, Vice President, President, Partner, Dean, Director of Public Works, Executive Director