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16. Abstract

Because more and more highway projects are located in congested metro settings, more projects require adjacent utilities be adjusted to make room for new or expanded highway facilities. The adjustment of utilities prior to highway construction is a challenging operation from many perspectives. Because of its complexity, managing utility adjustment is fraught with risk and uncertainty. One major strategic approach that has emerged over the past 15 years is to combine utility adjustment work with the highway contractor's scope of work. Because it allows for better coordination between involved parties, this approach theoretically eliminates or reduces some of the associated complications and risks and is referred to in this research as the Combined Transportation and Utility Construction (CTUC) approach. Given the complications of the issues involved, there is a significant need for a decision support tool to provide guidance to TxDOT and utility decision makers as to when the CTUC approach should be applied. This research aims to document CTUC advantages-disadvantages trade-offs, to better understand those project circumstances with which the benefits of CTUC can be leveraged, and to provide a decision support tool to assist both TxDOT and utility decision makers in identifying significant issues to be addressed for a given utility adjustment. Related topics such as how CTUC affects the actual project performance are also addressed.

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Effectiveness of the Combined Transportation and Utility Construction Strategy

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1. Introduction

1.1 Background Information, Motivation, and Need

Modern highway projects often involve adjusting adjacent utilities in order to make room for new or expanded highway facilities. The conventional approach used by state Departments of Transportation (DOTs) to implement utility adjustments requires that each involved utility owner adjust its facilities prior to highway construction. However, as more and more highway projects are located in congested, interference-prone environments, schedule slippages and increased construction costs will occur if the utilities are not adjusted in a timely manner (GAO, 1999). Recent research has also shown that the most frequently cited causes of highway construction delays are the obstacles state DOTs experience in the utility adjustment process. These obstacles are often created by utility owners who do not see utility adjustment as a priority (Ellis and Thomas, 2003). Moreover, utility owners are reluctant to begin adjustment work unless the detailed design of highway facilities is finalized and confirmed (GAO, 1999). Thus, under the conventional approach, utility adjustment activities usually overlap with the highway construction phase. From the highway contractors' perspective, the utility adjustments undertaken during the highway construction phase not only impede highway construction productivity but sometimes actually suspend some highway construction activities (Blair, 2003). Therefore, using the conventional approach may lengthen a highway construction project's duration.

There are several approaches employed by state DOTs to ameliorate the severe consequences of utility adjustment delays. For example, the use of incentives contingent on timely completion, the use of penalties for schedule overruns, and the use of legal actions against utility owners. Although these approaches might impel utility owners to adjust their facilities in a timely manner, they do little to alter the adversarial nature of the relationship between state DOTs and the utility owners (GAO, 1999). Another strategic approach that has been used sporadically by the Texas Department of Transportation (TxDOT) for over 15 years is to combine utility adjustment work with the highway contractor's scope of work, theoretically eliminating or reducing some of the aforementioned complications and risks. This approach, referred to in this research as the Combined Transportation and Utility Construction (CTUC) approach, puts the bulk construction of major utility-related appurtenances, such as underground duct banks, vaults, manholes, water, sanitary sewer or the placement of telephone poles, under the responsibility of the highway contractor (O'Connor et al., 2004).

In the CTUC approach, because both the utility adjustments and highway construction activities are controlled by the highway contractor, activities requiring the same resources can be scheduled alongside the adjustment to save resources. Another advantage of the CTUC approach is that its overall project organization is simpler than that of the conventional approach because all field-related work is performed and managed by the highway contractor. Nevertheless, the CTUC approach does have its disadvantages and its own set of challenges. For example, utility owners feel less able to control CTUC highway contractors than state DOT personnel, and they lack confidence in the CTUC contractors' competence (Goldman, 2005). Furthermore, if the highway contractor has no experience adjusting a certain type of utility facility, it is difficult for state DOTs to convince the owner of that type of utility to accept the CTUC approach (GAO, 1999). The advantages of the CTUC approach will be dramatically diminished if some of the utility owners affected by a highway project do not participate in the CTUC approach (Goldman, 2005) (O'Connor et al., 2005).

Hence, deciding on whether to use the CTUC approach is challenging. Decision makers from both state DOTs and utility owners need not only to simultaneously consider various decision drivers, but they also need to negotiate with each other to reach agreement on the appropriate approach. In addition, since the CTUC decision has a profound impact on utility service quality as well as on highway project duration, pursuing the CTUC approach without considering both parties' needs might increase the possibility of hiring a highway contractor unable to perform such work. Given the challenges faced by state DOTs and utility owners, and considering the impact of external, unexpected events on construction projects, a clear need emerges for a decision support model that encompasses all the decision factors driving or impeding CTUC implementation. Further, to evaluate the potential benefits and challenges of implementing the CTUC approach, state DOTs and utility owners need a systematic and transparent method for analysis and decision-making on its applicability.

Past studies have investigated the problems brought about by the conventional approach and have established the CTUC approach as the logical solution to them (Marti et al., 2002) (Luther, 1998). However, none of these studies have discussed why utility owners do not want to pursue the CTUC approach, nor are the CTUC decision drivers addressed in any depth in the literature. Instead, most of the studies focus on the problems of the conventional approach and the implementation details of the CTUC approach. To fill in this gap in the research, TxDOT initiated a research project to study the effectiveness of the CTUC approach. This research project was undertaken by a research team at the Center for Transportation Research (CTR) at The University of Texas at Austin. The team comprised Dr. James T. O'Connor, a professor at The University of Texas at Austin, Dr. Carlos H. Caldas, an assistant professor at The University of Texas at Austin, and three graduate research assistants in the Construction Engineering and Project Management (CEPM) program in the Department of Civil, Architectural and Environmental Engineering, Chien-Cheng Chou, Grant Goldman, and Adam Sroka. This research was supervised by the TxDOT Project Monitoring Committee (PMC), a panel of experienced engineers and utility coordinators from multiple TxDOT district offices. Mr. John Campbell, the director of the TxDOT Right-of-Way (ROW) division, served as the Program Coordinator (PC), and Mr. David Kopp, the director of the TxDOT San Antonio district construction office, was the Project Director (PD).

1.2 Research Objectives

Since the ultimate goal of the research project was to study the effectiveness of the CTUC approach, the key components of the research project were to document CTUC advantage-disadvantage trade-offs, to better understand those project circumstances with which the benefits of CTUC can be leveraged, and to better understand how CTUC-related concerns of utilities can be most effectively addressed. To accomplish the goal, this research aimed at designing a decision support model that could represent the opinions of experts from both TxDOT and the utility industry in Texas and assist both parties' decision makers in selecting the best contracting approach for a given utility adjustment. Specific sub-objectives to fulfill the goal included:

- Identify sources of information and collect information;
- Model the CTUC approach;
- Characterize CTUC benefits and challenges;
- Model the CTUC Decision Support Tool (CTUC DST);
- Construct, demonstrate, and refine the CTUC Decision Support Tool; and
- Compile and synthesize the CTUC implementation guide.

1.3 Research Scope and Limitations

The scope of this research was limited to TxDOT utility adjustments in which either the conventional approach or the CTUC approach was applied. Although the CTUC decision support model was designed to be generic and applicable in each TxDOT district, the research team concentrated attention on the relevant issues in the San Antonio, Houston, and Dallas districts. These three districts were appropriate because they serve metropolitan areas and have recurrent highway projects with numerous utility adjustments.

1.4 Structure of Report

This report consists of seven chapters. Following this introduction, Chapter 2 presents the research methodology explaining the steps taken to perform this research. Chapter 3 surveys literature findings regarding utility adjustment delays and the CTUC approach. Chapter 4 presents the characteristic analysis of the CTUC approach. Chapter 5 describes the proposed CTUC decision-making process. Chapter 6 presents the design of the CTUC decision support model and the development of the CTUC Decision Support Tool with brief validation results of the CTUC decision support model. Chapter 7 presents the conclusions, recommendations, and contributions of this research.

2. Research Methodology

This research is divided into eight major steps, as shown in Figure 2.1: (1) Conduct literature review; (2) Characterize CTUC benefits and challenges; (3) Model the CTUC process; (4) Design the CTUC decision support model; (5) Conduct data collection and analysis, (6) Develop the CTUC decision support tool; (7) Demonstrate and validate the CTUC decision support model and tool; (8) Draw conclusions and recommendations. The ensuing sections provide brief descriptions for each of the aforementioned steps.

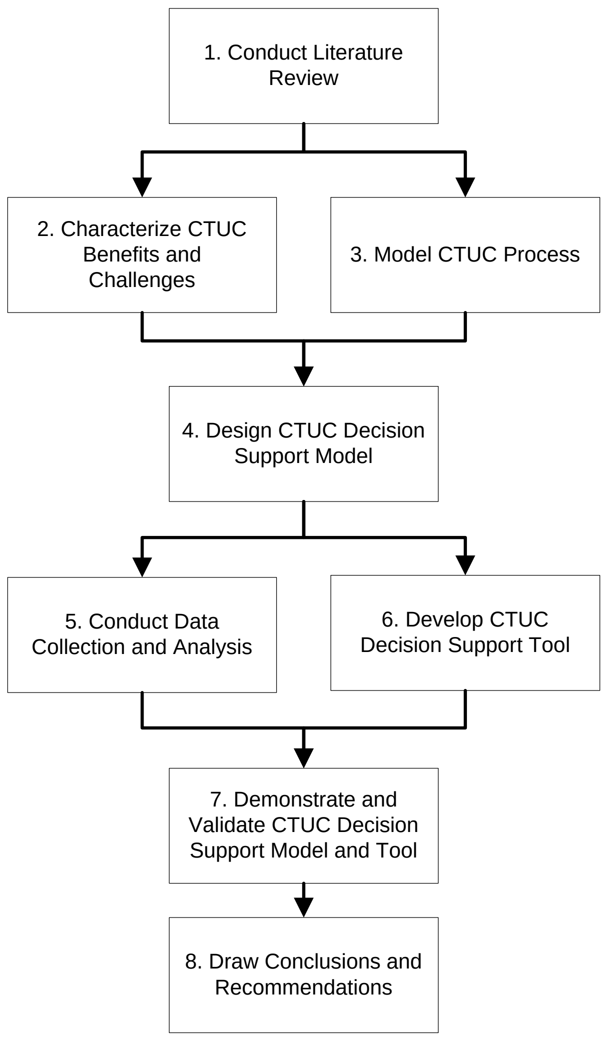

Figure 2.1: Flow chart of the research methodology

2.1 Conduct Literature Review

A comprehensive literature review was undertaken to acquire knowledge and to learn current practices regarding utility adjustments within a highway project. Results of TxDOT's utility-adjustment-related studies (e.g., the TxDOT San Antonio District Coordination Process) were reviewed first, followed by other state DOTs' utility-adjustment-related documents (e.g., regulations, design manuals, and project reports). Case studies on various types of utility adjustments were also collected and reviewed so that appropriate utility owners' opinions and concerns were extracted and classified. Finally, papers pertaining to design consultants' or highway contractors' perspectives on utility adjustments were examined. The results of the literature review also helped the research team develop the questionnaire for preliminary research meetings with TxDOT representatives and utility experts. A summary of the literature review is presented in Chapter 3. The questionnaire for these meetings is listed in Appendix A.

2.2 Characterize CTUC Benefits and Challenges

After the questionnaire for preliminary research meetings had been developed, a search for knowledgeable sources from both TxDOT and the utility industry in Texas began. Experts from TxDOT San Antonio, Houston, and Dallas districts were invited to participate in this research because their districts are in metropolitan areas and had more recent CTUC utility adjustments than other districts. Experts from the utility industry were then identified with TxDOT's assistance. Three meetings with the TxDOT experts and four meetings with the utility experts were conducted to gather experts' opinions and comments on specific aspects of the CTUC approach. A total of forty-eight experts attended these meetings, and the associated findings were reported in the document produced for TxDOT 0-4997-P1, including CTUC implementation successes, best practices, limitations, implementation challenges, circumstances for leveraging benefits, lessons-learned, utilities' barriers (both real and perceived) to CTUC participation, and ideas on how to facilitate the CTUC approach. The findings are also summarized below in Sections 4.1-2, and Appendix B lists complete CTUC benefits and challenges.

In addition, it became apparent that there was a need to know how actual project performance criteria, such as schedule and cost, are affected by use of the CTUC approach. The research team recognized that this information could strengthen project stakeholders' confidence in using the CTUC approach at the appropriate time. Hence, a survey form focusing on how recent applications of CTUC have affected project performance was designed (see Appendix C). Several assessment surveys by TxDOT on completed CTUC projects were conducted with these questionnaires, and twenty TxDOT engineers or managers representing twenty-nine actual projects provided input. The results are summarized in Section 4.3.

2.3 Model the CTUC Process

Determining the right time to pursue the CTUC approach is as important as deciding whether to use the CTUC approach. Because TxDOT has no CTUC-specific process model, the process model governing the use of the CTUC approach was first developed based on the TxDOT San Antonio District Coordination Process, the TxDOT ROW Utility Manual, and the work product of TxDOT Research Project 0-4617. The differences between CTUC-specific activities and those of the conventional approach were highlighted, and the availability of required CTUC decision information was analyzed. Finally, the CTUC decision-making process model was proposed. The results of this step were reported in the document produced for TxDOT 0-4997-P1 and are summarized in Chapter 5.

2.4 Design the CTUC Decision Support Model

Based on the results of the preliminary research meetings and literature review, characteristic analysis of CTUC decision-making was performed in order to isolate the requirements of the CTUC decision support model and tool. Unlike traditional score-based decision support systems, CTUC is a negotiation decision that needs active involvement of both parties; for a decision that requires so much negotiation of details, decision makers cannot rely on simple numeric values for the conventional and CTUC approaches. Hence, the software architectures of major decision support systems were reviewed so that the one that can assist decision makers in identifying significant issues in a more efficient and effective way could be selected and developed further. Basic functions associated with this architecture and with the corresponding CTUC decision support model were then designed. This decision support model should be able to represent all relevant issues regarding CTUC decision making, as well as provide the knowledge base to store the opinions of both parties' experts. Finally, the CTUC decision drivers assessment form was developed and served as a data gathering tool for collecting experts' opinions. The results of this step are summarized in Sections 6.1-4.

2.5 Conduct Data Collection and Analysis

The data collection and analysis step was performed once the development of the CTUC decision drivers assessment form was complete. A brief description of each activity in this step is shown in Figure 2.2. The primary purpose of these activities was to determine the impact level and resolvability data of each CTUC decision driver from both TxDOT experts' and utility experts' perspectives. In Activities 5.2-3, a PMC meeting was scheduled to review the CTUC decision drivers assessment form and to identify experts familiar with both approaches. In Activities 5.4-5, six CTUC decision drivers assessment workshops were conduced with twenty-eight experts from TxDOT and twenty-four experts from the utility industry. Activity 5.6 was performed to clarify an expert's response when he or she selected two contradictory answers to one question. Finally, the analysis results and findings of the assessment workshops are summarized in Sections 6.5-6.6.

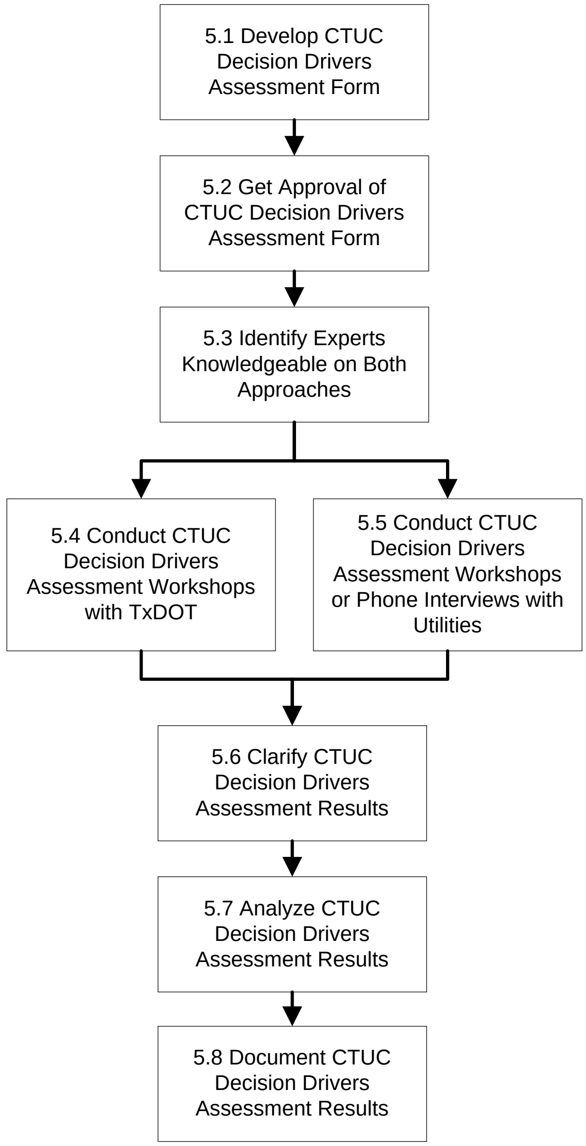

Figure 2.2: Flow chart of the data collection and analysis step

2.6 Develop the CTUC Decision Support Tool

After the decision support model was complete, the data collection and analysis step and the development of the CTUC Decision Support Tool were performed concurrently. Developed using Microsoft® Visual Basic for Application (VBA) and Microsoft® Excel, the CTUC Decision Support Tool is aimed at creating an interactive decision support environment allowing both TxDOT decision makers and utility representatives to easily enter data on their utility adjustments. The CTUC Decision Support Tool can then isolate significant issues pertaining to the given utility adjustment and can display the corresponding opinions from both TxDOT and utility experts on these issues in order to facilitate communication and coordination between both parties. The functional requirements of the CTUC Decision Support Tool were based on the analysis of the characteristics of CTUC decision making and the software architecture specified above. The complete user guide for the CTUC Decision Support Tool was drafted in the document produced for TxDOT 0-4997-P2 and is summarized in Section 6.7.

2.7 Demonstrate and Validate the CTUC Decision Support Model and Tool

The soundness of the CTUC decision support model and the reasonableness of each CTUC decision driver were expected to be verified by experienced, actual project stakeholders. Hence, numerous utility adjustments on highway projects between 0 percent and 60 percent PS&E at that time were identified first. A total of 12 CTUC Tool demonstration meetings were conducted with 20 TxDOT assessors and 11 utility assessors. A total of 22 sets of actual utility adjustments data were provided by TxDOT assessors, and ten of them were from projects that were between 0 percent and 30 percent PS&E at that time. A total of ten sets of actual utility adjustments data were provided by the utility industry. During each demonstration meeting, utility-adjustment-specific data were entered into the CTUC Decision Support Tool, and the graphical and text reports generated by the CTUC Decision Support Tool were reviewed by each meeting attendee. Feedback and comments on the CTUC Decision Support Tool were collected and are summarized in Section 6.8. Based on the average of the validation results, most meeting attendees agreed that the CTUC Decision Support Tool could improve the quality of CTUC decision making.

2.8 Draw Conclusions and Recommendations

Chapter 7 summarizes the conclusions of this research and recommendations on the CTUC approach and on future development of the CTUC Decision Support Tool.

3. Literature Review

This chapter provides background information on utility adjustments and discusses issues that might influence the CTUC decision. Project stakeholders of a typical highway project with utility adjustments are described first. Then, the financial, legal, and schedule aspects of utility adjustments are addressed. The causes and impacts of utility adjustment delays are also explored. Finally, other state DOTs' approaches to reduce utility adjustment delays are presented.

3.1 Responsibilities of Utility Adjustment Project Stakeholders

A typical highway project may involve several utility adjustments. The project configuration and the responsibilities of major project stakeholders play a key role in CTUC decision making and are described in the following paragraphs.

3.1.1 State DOT

The state DOT is the owner of a highway project and is responsible for all the needed highway rights-of-way (R/W). The state DOT manages its highway designers and contractors and performs inspection of highway facilities in accordance with the contracts. The agency also coordinates all the utility adjustment activities involved in the project. Currently, several state DOTs, including TxDOT, are investigating the area of outsourcing utility coordination (Stockburger, 2004). For TxDOT, if the CTUC approach is applied, TxDOT is responsible for managing the utility adjustment work and performing inspection of alignments of utility facilities (TxDOT, 2005).

3.1.2 Highway Designer

Highway designers are responsible for the design of highway projects. State DOTs may use their design staff to design the highway or they may retain private design consultants to perform the work. In some cases, the highway design consultants may also be responsible for designing all of the utility adjustments involved. This approach, called *joint design*, can provide better design coordination and thereby reduce engineering and coordination costs (Goldman, 2005). Further, as reported by both utility companies and TxDOT, the CTUC approach is preferred for optimal design coordination when joint design is applied (Goldman, 2005).

3.1.3 Highway Contractor

A highway contractor is responsible for construction of the highway facilities specified in the project contract. Depending on the scope of the contract, the highway contractor may hire several subcontractors to perform different types of tasks. In the CTUC approach, the highway contractor may have a subcontractor perform a utility adjustment. In such cases, utility owners have no right to direct the highway contractor or any of its subcontractors.

3.1.4 Special Contractor

There are two reasons to use special contractors. One is that some special highway construction tasks may be beyond the general highway contractor's competence. The other is that some special tasks need to be finished before the highway contract can be awarded. For example, a special contractor may be excellent at handling hazardous materials (HAZMAT), while general highway contractors are not (Goldman, 2005). In addition, Subsurface Utility Engineering (SUE) contractors are needed prior to highway construction to provide detailed underground utility position information for potential bidders. In the CTUC approach, special contractors are managed by the state DOT or the general highway contractor and may be shared with utility owners to perform utility-specific work with lower costs, whereas in the conventional approach, utility owners demanding special contractors may not be able to obtain any financial assistance from the state DOT.

3.1.5 Utility Owner

The term "utility" has a rigorous definition in the domain of R/W acquisition and is adopted in this report as follows:

> A privately, publicly, or cooperatively owned line, facility or system for producing, transmitting, or distributing communications, cable television, power, electricity, light, heat, gas, oil, crude products, water, steam, waste, storm water not connected with highway drainage, or any other similar commodity, including any fire or police signal system or street lighting system, which directly or indirectly serves the public.
>
> (FHWA-1 2002).

This definition can be used to determine whether a state DOT considers a particular facility to be a utility under its own state laws (FHWA, 2003). If the facility is producing, transmitting, or distributing any of the commodities outlined in the Federal Highway Administration (FHWA) definition for use by or for the direct benefit of the public, then the state DOT treats a facility as a utility (FHWA, 2003).

A utility owner owns the utility facilities to be adjusted in the highway project. The utility owner is definitely responsible for the utility adjustments, but the design or construction work can be performed either by its crew or by another company. After the completion of the utility adjustments, the comprehensive examination work must be done by inspection staff of the utility owner.

Currently, the TxDOT Utility Database identifies the seventeen utility adjustment work types that TxDOT has been confronted with on recent highway projects (TxDOT, 2004):

1. Water
2. Wastewater
3. Wastewater Pump Station
4. Water Well
5. Overhead Communication
6. Underground Communication
7. Microwave Tower
8. Overhead Distribution Power Line
9. Underground Distribution Power Line

10. Transmission Pole
11. Underground Transmission Power Line
12. Transmission Tower
13. High Pressure Gas Line
14. Low Pressure Gas Line
15. Liquid Petroleum Line
16. Irrigation Pipeline
17. Irrigation Canal

All of the above utility adjustment work types were considered in this research. In addition, the utility industry is divided into public and private sectors. Water and wastewater are usually operated by a local city administration or a governmental authority. Because it is in fact a governmental entity, TxDOT has special provisions to process this type of utility adjustment. For example, on non-reimbursable projects, State Utility Procedure (SUP) removes the responsibility for handling utility adjustment work from any affected Local Public Agency (LPA) and allows the LPA to escrow funds until the project is completed (TxDOT, 2005). An LPA may elect to do all ROW activities or select those activities that it can accomplish/perform while converting or assigning those ROW activities it cannot perform to TxDOT.

A utility owner in the private sector is a regular company that owns utility facilities. Such a company may have several different types of utility facilities. For example, most power companies have transmission and distribution divisions with facilities that require unique sets of skills to adjust. Energy companies also commonly own power and natural gas utilities. Examples of this kind of company are CPS Energy in the San Antonio district and CenterPoint Energy in the Houston district.

3.1.6 A Group of Utility Owners That Share the Same Set of Facilities

Some of the utility owners affected by a highway project may share the same set of physical underground or overhead facilities. In such a case, the group of utility owners involved can be regarded as a single utility owner as long as these utility owners choose to continue sharing the facilities. Because of physical constraints, adjusting the complete set of utility facilities usually accompanies a special construction sequence. Thus, if any of these utility owners chooses to opt out of the share, it may have to rebuild its own facility. For example, utility vaults, trenches at different depths, multi-duct conduits, or utility corridors are underground physical facilities that may be shared by different utility owners. Power poles are another type of overhead facility that may be shared by a power company (pole owner), a CATV company, and a telephone company (Lindly, 2005).

3.1.7 Utility Adjustment Designer

A utility adjustment designer is responsible for the design of a utility adjustment. A utility owner may use its design staff to design the utility adjustment or retain a design consultant to complete the work.

As noted above, joint design is a special approach presently applied in some TxDOT projects in order to support the CTUC approach. However, both TxDOT and utility owners indicated that joint design is not always possible for all utilities requiring adjustments (Goldman, 2005).

3.1.8 Utility Adjustment Contractor

A utility contractor is responsible for adjusting utility facilities. A utility owner may have its construction crew perform the adjustment work or retain a utility adjustment contractor to do the job. Basically, in the conventional approach, neither the state DOT nor its highway contractors have the right to direct utility adjustment contractors. In Texas, if the utility adjustment contractor cannot comply with the adjustment schedule, the highway contractor will conduct a construction coordination meeting so that TxDOT can negotiate with the utility owner. The purpose of this meeting is to allow the utility adjustment contractor to take appropriate alternative action (TxDOT, 2005).

3.2 Financial Aspects of Utility Adjustments

The state DOT can contribute to the costs of utility adjustments, provided that the utility owner has the right to occupy the land. This right is called Compensable Property Interest, or Prior Right. In addition, Chapter 203, Section 203.092 of the Transportation Code by law makes needed utility adjustments associated with a project on the Interstate System compensable regardless of possession (or lack thereof) of a property interest, i.e. prior right. If the costs of a utility adjustment are paid by the state DOT, this type of utility adjustment is referred to as a "Reimbursable Project." Conversely, if the utility owner assumes the financial responsibility, this type of utility adjustment is referred to as a "Non-Reimbursable Project."

Currently in Texas, if the utility owner claims its compensable property interest, TxDOT pays all costs associated with purchasing a new utility easement as well as the costs for adjusting the existing utility facilities. For interstate highway systems, state law (TC 203.092) makes these adjustments eligible regardless of possession of a property interest. It should be noted that 23 CFR Part 645 mandates prior approval from the state DOT and the FHWA for any phase of utility adjustment work. New real property interests acquired by the utility owner after the adjustment are not eligible for cost participation (TxDOT, 2005).

Many utility adjustments on TxDOT highway projects are at least partially reimbursable. A utility adjustment is reimbursed based on the eligibility of a utility facility. Eligibility is determined by the utility's *eligibility ratio*. The eligibility ratio calculation for a utility is typically included with that utility's assembly package; it is based on the utility's real property interest within the proposed highway ROW divided by the total highway ROW occupied by the utility facility (Hedemann, 2005). In general, TxDOT pays for the following cost items (TxDOT, 2005):

- "In-Kind" facilities, i.e., if a utility has a 4-in. galvanized steel pipeline, it will get paid for a 4-in. galvanized steel pipeline, not an 8-in. pipeline;
- Forced Betterments: if utility regulations have changed, the utility has to build an upgraded system to replace what they remove. For example, if there is an existing, uncased 8-in. pipeline that has been grandfathered in, a new line must be built with a concrete casing;
- Engineering costs to the utility, in-house or out-sourced;
- Construction costs, in-house or out-sourced;

- Replacement ROW for easement taking; and
- Purchase of facilities the utility is abandoning. However, it should be noted that if utility facilities are being abandoned and functionally replaced or relocated, then purchase by the State of the abandoned facilities is not allowed.

3.3 Legal Aspects of Utility Adjustments

Utility adjustments are governed by a set of legal requirements that can be grouped into a three-tiered hierarchy, as shown in Figure 3.1: (1) Polices and guidelines; (2) state DOT-specific codes and regulations; and (3) Federal codes and regulations. Policies and guidance aim to assist TxDOT in reinforcing established laws and requirements, and TxDOT codes and regulations for utility adjustments are generally more restrictive than the Federal ones (TxDOT, 2005). Some of the legal requirements specify the safety codes to be followed when related utility adjustment work is performed. For example, electric transmission adjustments need to get approval from the Electric Reliability Council of Texas (ERCOT) before the work is begun. The other legal requirements regulate the rights and obligations that utility owners have when their utility facilities are adjusted for a highway project. For example, in the Local Government Code, Natural Resources Code, Water Code, and Utilities Code, public utilities have been granted the right to occupy state R/Ws, while private utility lines can cross but should not be permitted longitudinally on state R/Ws. Some legal requirements even state the ideal situation of a utility adjustment. For example, if all utility adjustment work can be finished prior to highway construction, a utility-interference-free environment can benefit all involved parties, per the scope and intent of the FHWA utility clearance requirement in 23 CFR 635.309 (Ney, 2001) (GAO, 1999).

There are four cases regarding the location of utility facilities and the reimbursability of a utility adjustment. The decision to use the CTUC approach and reimbursability are addressed in the following paragraphs.

The first case is that when the utility owner has prior rights and the new utility location is in the proposed highway R/Ws. Per 43 TAC 21.36, it is TxDOT's preference that these utility R/Ws will be acquired, less oil and gas, as part of the highway R/Ws. The utility owner can retain the easements (TxDOT, 2005). TxDOT pays for the associated adjustment costs.

The second case is that the utility owner has prior rights; however, it is unsafe to incorporate the types of utility facilities such as oil, gas, and sulphur into the proposed highway R/Ws. In such situations, TxDOT will participate in the eligible costs associated with the replacement R/Ws and adjustments (TxDOT, 2005). The replacement R/Ws must be purchased by the utility owner after the highway R/Ws are released, which may shortens the time for the utility adjustment when the conventional approach is taken.

The last two cases are the situations in which the utility owner does not have any prior right. In these cases, the utility owner can either put their facilities in the new highway R/Ws or purchase another easements for the new utility location. The utility owner pays for the associated adjustment costs.

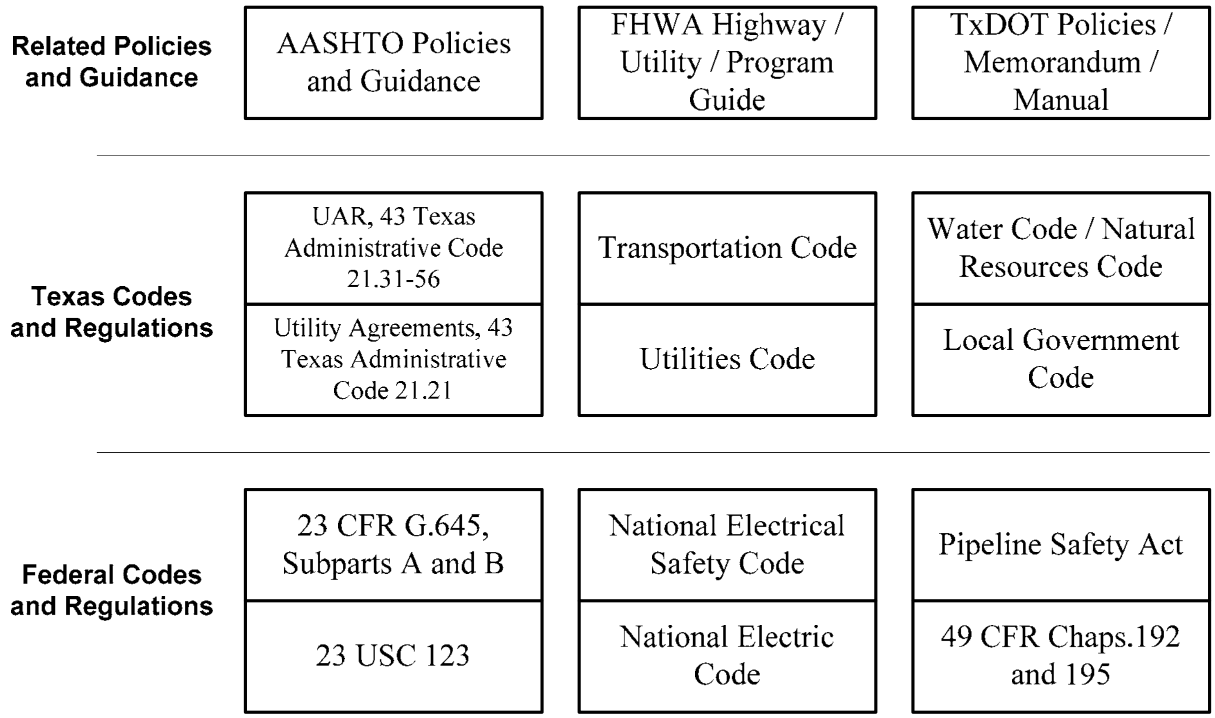

Figure 3.1: Hierarchy of regulations governing utility adjustments

In sum, acquiring additional replacement R/Ws poses a schedule constraint on conventional utility adjustments because the conventional approach conducts ROW acquisition in tandem with the highway construction. A recent TxDOT research project has also shown that utility adjustments can only begin when the R/Ws needed have been acquired and drainage designs are complete (Chang, 2005). Hence, the timeframe between the completion of ROW acquisition and the beginning of the highway construction is not enough for conventional utility adjustments. In addition, previous studies found reimbursable adjustments to take significantly longer than non-reimbursable adjustments because a reimbursable project has more legal requirements than a non-reimbursable project (Hedemann, 2005). Satisfying these requirements usually takes considerable time, and thus, the utility adjustment activities often delay the highway construction phase under the conventional approach.

3.4 Utility Adjustment Procedure Types

In this section, TxDOT-specific utility adjustment procedure types are presented in order to discuss their impacts on CTUC decision making. This presentation is drawn from TxDOT's process model for performing utility adjustments, known as the TxDOT-Utility Cooperative Management Process. This process model is provided as guidelines to TxDOT and utility personnel for managing utilities that occupy TxDOT R/Ws. The model also outlines how to develop agreements, how to determine the utility's eligibility ratio, and how to secure funding. There are four different types of procedures that can be followed based on what type of adjustment project a particular utility owner falls under (TxDOT, 2005).

3.4.1 Federal Utility Procedure

The federal utility adjustment and Federal Utility Procedure (FUP) are mainly intended for use on interstate highway projects. Under this procedure, utility adjustments are eligible for reimbursement at any location, regardless of prior property rights held. It can be used in conjunction with the CTUC approach. Complete descriptions of this procedure are available in the TxDOT ROW Utility Manual (TxDOT, 2005).

3.4.2 State Utility Procedure

The State Utility Procedure (SUP) may be applied with or without federal aid in a state utility adjustment. This procedure relieves any affected LPA of the responsibility of handling utility adjustment work. In addition, this procedure requires that an LPA put funds in an escrow account until the project is completed. TxDOT considers this procedure advantageous because it requires that R/Ws and utility adjustment activities remain the responsibility of TxDOT. The SUP can be used in conjunction with the CTUC approach as well. The procedure is slightly more complicated than the federal procedure and involves either ten or twelve steps, depending on whether federal aid is present. Complete descriptions of this process are available in the TxDOT ROW Utility Manual (TxDOT, 2005).

3.4.3 Local Utility Procedure

Under the Local Utility Procedure (LUP), LPAs retain responsibility for acquiring R/Ws and adjusting utility facilities on local utility adjustments. If there is to be state or federal compensation or if TxDOT will assume responsibility for the maintenance of the highway, the LPA must ensure that the work complies with TxDOT regulations. Therefore, it does not fit within the context of the CTUC approach. This procedure is the most complex of any of the major procedures, both in the number of documents and the number of processes involved. Complete descriptions of this process are available in the TxDOT ROW Utility Manual (TxDOT, 2005).

3.4.4 Non-Reimbursable Procedure

Utility owners that are required to adjust facilities but have no compensable property interests are handled by this procedure. Because of the lack of cost participation by TxDOT, there are not as many guidelines for TxDOT personnel to follow and there is less documentation required. It needs the “Joint Use Agreement, Non-Reimbursable” version of the agreement if the utility owner wants to occupy TxDOT R/Ws. In addition, this procedure can be used in conjunction with the CTUC approach. Further information is available in the TxDOT ROW Utility Manual (TxDOT, 2005).

3.5 Schedule Aspects of Utility Adjustments

3.5.1 Highway Project Phase

The development of a highway project is complex and time-consuming, and if the highway project includes utility adjustments, tremendous extra work will be required by both the state DOT and the utility owners. Figure 3.2 shows major phases of a typical highway project and illustrates how such an undertaking can take 9-19 years to plan, get approved, and construct

(GAO, 2002). The activities of each phase are listed in the following paragraphs, along with a discussion of related utility adjustment activities (GAO, 2002).

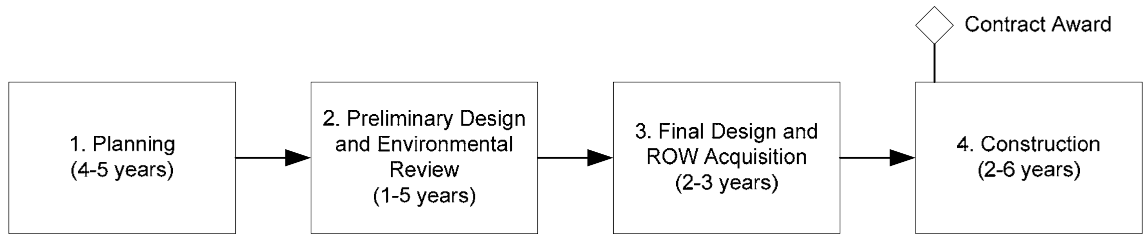

Figure 3.2: Phases of a typical highway project (GAO, 2002)

Phase 1: Planning

- Assess transportation purposes and needs.
- Solicit public comments.
- Gain approval for the project to be included in the state's 20-year plan, with the expectation that funds will be available.
- Gain approval for the project to be included in the state's short-term plan, covering at least 3 years, with the expectation that funds will be available.
- Secure funding.

Phase 2: Preliminary Design and Environmental Review.

- Consider alignment issues and required lanes.
- Identify alternatives, including not building the project, to minimize potential harm to the environment and historic sites.
- Select the preferred alternative.
- Identify project cost, level of service, and construction locations.
- Prepare a preliminary design of the highway.
- Solicit comments on the project and its potential effects from the public and from local governments.
- Gain concurrence from federal agencies from which environmental and historic preservation concurrence is required.

Phase 3: Final Design and ROW Acquisition

- Finalize design plans.
- Appraise and acquire property.
- Relocate utilities and affected citizens before construction if necessary.
- Finalize project cost estimates.

Phase 4: Construction

- Advertise the project.
- Evaluate bids.
- Award contracts.
- Begin construction.
- Resolve unexpected problems.
- Accept delivery.

The actual utility adjustment activities occur during Phase 3 when the conventional approach is taken, while they occur in Phase 4 when the CTUC approach is used. As noted in Section 3.4, the TxDOT-Utility Cooperative Management Process defines the major steps, interfaces, and interaction between TxDOT and the utility owner required for utility adjustments. The simplified process diagram is shown in Figure 3.3 (TxDOT, 2005) (Quiroga, 2005). Although these activities are designed to assist TxDOT personnel in coordinating and managing utility adjustments, the essential steps and interfaces can be applied by other state DOTs as well.

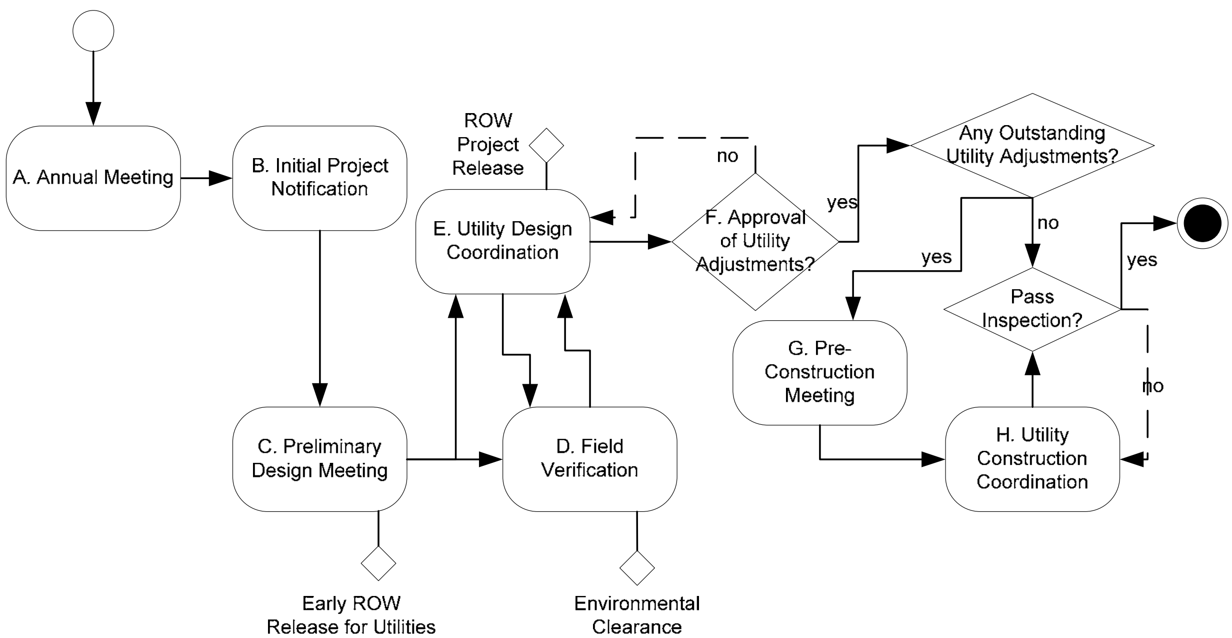

Figure 3.3: Simplified model of TxDOT-Utility Cooperative Management Process (Quiroga, 2005)

3.5.2 Utility Design Coordination Meeting

In Figure 3.3, the two activities, Activity C: Preliminary Design Meeting and Activity E: Utility Design Coordination, can be considered a combined design coordinating meeting. At this meeting, TxDOT, highway designers, the utility owner, and utility adjustment designers develop the utility adjustment specifications that will satisfy both TxDOT and the utility owner. In fact, addressing all potential problems of utility adjustments often requires that several utility design coordination meetings be scheduled. Important tasks of such meetings are described below (TxDOT, 2005):

- Review the drawing accuracy of existing utility locations. In some cases, TxDOT or the utility owners may have to perform field verification several times in order to obtain accurate drawings.
- Review right-of-way issues, especially for utilities that need additional R/Ws. Because adjusting reimbursable utility facilities will require a ROW account to be charged, the early or formal ROW account number must be released during this activity.
- Get approval of required environmental clearance regarding this utility adjustment.
- Obtain required permits, e.g., a utility adjustment usually needs to get a city permit.
- Determine reimbursement eligibility criteria.
- Cooperatively discuss TxDOT and utility design concepts and criteria.
- Cooperatively discuss design schedules and construction schedules for all entities, including the highway contract letting schedule.
- Perform utility adjustment design or possible highway design modifications to minimize utility conflicts.
- Review the compliance of utility-adjustment-related regulations.
- Clarify utility inspection requirements.
- Draft the utility adjustment agreement.
- Review current construction site conditions.

If the project is reimbursable, the following issues may need to be addressed:

- Get approval of relating federal, state, or local authorities.
- Estimate the utility adjustment costs.
- Discuss the bid process and contracting options of the utility adjustment.

If the project is non-reimbursable, the following issues may need to be addressed:

- Evaluate the financial status of the utility owner.
- Provide the utility adjustment loan, if needed.

Theoretically, utility adjustment design should be completed early in the highway design phase. If the conventional approach is applied, the early completion of utility adjustment design would lead to the completion of actual utility adjustment work before highway construction begins (GAO, 1999). However, per the FHWA utility clearance requirement in 23 CFR 635.309, it is not mandated that all utilities be adjusted prior to highway construction (Ney, 2001). Hence, in the worst case, utility adjustment design might still have lots of modifications at the end of the highway design phase. Interweaving utility adjustment design with highway construction is a logistical nightmare. The following issues are identified in TxDOT ROW Utility Manual (TxDOT, 2005):

- Perform the utility adjustment design, but once complete, transfer responsibility from the TxDOT design team to the construction team.
- Discuss and accommodate the current status of ROW acquisition and utility adjustments in reference to clearance dates defined in the highway contract.

Using the conventional approach leaves a project open to the kinds of problems mentioned above. The CTUC approach aims to shift the burden of actual utility adjustment work to the highway contractor, thus it stands as a reasonable solution because the highway contractor is supposed to handle all activities during the highway construction phase.

3.5.3 Utility Construction Coordination Meeting

A utility design coordination meeting is a necessary part of the process for both the conventional and the CTUC approaches. However, under the conventional approach, two activities shown in Figure 3.3, Activity G: Pre-Construction Meeting and Activity H: Utility Construction Coordination, are needed only when utility adjustment activities cannot be finished prior to highway construction.

Under the CTUC approach, both the utility design coordination meeting and the utility construction coordination meeting are needed but will be conducted in a different, simpler format.

Activities G and H can also be considered as a combined coordinating meeting attended by TxDOT, the highway contractor, utility owners, and utility adjustment contractors in order to build the highway and perform utility adjustment work cooperatively. In order to address all potential problems of utility adjustments, several utility construction coordination meetings are often necessary. Important tasks of this meeting are described as follows (TxDOT, 2005):

- If the construction site is not cleared or graded, some state DOTs use a separate contractor to perform such advance roadway work, while others may let utility contractors perform the work and compensate them later (AASHTO, 2004) (Goldman, 2005).
- Review current utility adjustment status in reference to clearance dates identified in the highway contract.
- Integrate remaining utility adjustments into the highway project sequence of work.
- Conduct pre-construction meetings, which provide an opportunity for TxDOT and utility owners to communicate any final changes in project schedules, jointly review and approve final sets of plans, and identify key points of contact for the project. The meeting also provides an opportunity for the highway contractor and utility owners to agree upon work schedules that will minimize possible conflicts during highway construction.
- Utility contractors will perform utility adjustment work and document utility installations.

- TxDOT will perform alignment inspections for the utility adjustment work, while utility owners will inspect all aspects of the utility adjustment.
- Utility contractors will prepare payment documents which will be reviewed by the utility owner or TxDOT.

Clearly, a huge amount of Communication, Coordination, and Cooperation (CCC) is required between the highway contractor, the state DOT, utility owners, and utility contractors (LTS, 2002) (Cisneros, 1996) (Ellis, 1996). The real potential for utility adjustment delays might force the highway contractor to put in significant contingencies, which may further increase the overall highway bid price (GAO, 1999) (Ellis, 2003) (Blair, 2003) (LTS, 2002).

3.6 Causes of Utility Adjustment Delays

Much research has gone into finding the causes of utility adjustment delays. In this section, assorted reasons for utility adjustment delays are discussed in the context of state DOTs' perspective, followed by utility owners' perspective.

Table 3.1 lists the reasons most frequently indicated for such delays and lists them according to the number of state DOTs that consider them to be a moderate or major reason for delays (GAO, 1999). These reasons can be categorized into five types and are explained in the following paragraphs.

Table 3.1: The reasons for utility adjustment delays (GAO, 1999)

#	Reason	# of state DOTs
1	Utility lacked resources.	34
2	Short timeframe for state DOTs to plan and design a project.	33
3	Utilities gave low priority to adjustments.	28
4	Increased workload on utility adjustment crews because highway/bridge construction had increased.	28
5	Delays in starting utility adjustment work: some utilities would not start until the construction contract was advertised or let.	28
6	Phasing of construction and utility adjustment work was out of sequence.	26
7	Inaccurate locating and marking of existing utility facilities.	23
8	Delays in obtaining R/Ws for utilities.	23
9	Shortages of labor and equipment for utility contractors.	19
10	Project design changes required changes to utility adjustment designs.	19
11	Utilities were slow in responding to highway contractors' requests to locate and mark underground utilities.	16
12	Inadequate coordination or sequencing among utilities using common poles/ducts.	13

3.6.2 Lack of Resources for Utilities

This type includes three of the reasons for utility adjustment delays: (1) utility lacked resources, (4) increased workload on utility adjustment crews, and (9) shortages of labor and equipment for utility contractors.

Utility owners may not have enough resources for the utility adjustment work requested from state DOTs. For example, some small utility companies have just created their businesses, so they do not have the financial strength or other resources to accomplish the work. In Texas, TxDOT can assist utility owners in four ways: (1) provide loans through the State Infrastructure Bank (SIB); (2) alleviate the burden of constructing utility infrastructure facilities by means of the CTUC approach; (3) provide assistance in utility adjustment design; and (4) declare the "Pauper Utility" status as detailed in Transportation Code 203.0921.

Although some utility owners may have adequate resources, the demand of utility adjustment work will still be too high for them to meet with their ordinary adjusting capacity. With recent increases in the federal funding of highway and bridge projects, state DOTs are planning and designing an increasing number of projects (GAO, 1999). In one preliminary research meeting, a utility company official reported that two simultaneous projects in one area may have so much adjustment work that the capacity of all qualified contractors in the vicinity may not be sufficient for the workload in terms of labor or equipment. Other interviews indicated that it may takes up to six months to hire a qualified utility design consultant during such a demanding period (Goldman, 2005).

Therefore, while utilities' lack of resources may be resolved by TxDOT's assistance, the requirements of each utility adjustment may make the work prohibitive. To avoid this outcome, the workload and resources should be considered in the highway planning phase. This consideration should be made in coordination with other projects so that the supply and demand of labor and equipment can maintain a balance.

3.6.3 Short Timeframe to the Highway Plan and Design Phases

This type includes three of the reasons for utility adjustment delays: (2) short timeframe for state DOT to plan and design a project, (5) delays in starting utility adjustment work, and (8) delays in obtaining R/Ws for utilities.

A short timeframe to plan and design a highway project compresses the schedule of the conventional approach. In other words, the reason utility owners often cannot adjust their facilities on schedule is that there are substantial tasks that need to be done before the utility adjustment work begins. The adjustment work itself also takes considerable time. The state DOT and its highway contractors would most prefer that all utility adjustments be done before highway construction begins, but the actual time allocated for the highway design phase is not sufficient to accommodate all the utility adjustment needs.

As noted before, ROW acquisition is the most time-consuming task in the highway design phase. If utility facilities are located on state DOT R/Ws, and if existing R/Ws are not sufficient to contain a planned utility adjustment, additional R/Ws need to be acquired. If the utility owner does not have any prior right, they are responsible for acquiring the additional R/Ws. If the utility owner does have prior rights, the state DOT is responsible for acquiring the utility R/Ws. Because the utility owner cannot adjust their facilities unless they have R/Ws for the new location, delays in obtaining utility R/Ws, in turn, may result in delays of the utility adjustment (GAO, 1999). Utility adjustment planning should be coordinated with the ROW process for efficiency and for ensuring that the required R/Ws are available in time for utility adjustment work to proceed (Ney, 2001) (Chang, 2005).

Another physical issue that needs to be resolved before utility adjustment work begins is that a utility adjustment is often the first work to occur on a newly-acquired ROW. These new tracts often require substantial advance roadway work before they are ready for adjustment work (Goldman, 2005). Advance roadway work may consist of, but is not confined to, the following activities: clearing and grubbing, slope staking, monumentation, demolition of buildings, and advance grading (Goldman, 2005). From the utility owners' perspective, it is unreasonable to let the utility contractor perform such advance roadway work. Their argument is that the cost burden of this clearing should not be borne by the first utility on site but should be shared with the other utility owners, with TxDOT, or both (Goldman, 2005). In addition, from a schedule constraint perspective, advance roadway work should be included in another contract and should be done before utility adjustment work begins (GAO, 1999). However, this approach does not solve the core problem of utility adjustment delays, i.e., the often short timeframes of the highway planning and design phases. All of the tasks, including utility ROW acquisition, advance roadway work, and the actual utility adjustment work, need ample time to be completed. Nevertheless, the highway planning and design phases are not usually timeframes planned to accommodate all utility-related work.

3.6.4 Utility's Priority Issues

This type includes two of the reasons for utility adjustment delays: (3) utilities gave low priority to adjustments, and (11) utilities were slow in responding to contractors' requests to locate and mark underground utilities.

Highway contractors seldom consider work schedules provided by utility owners at pre-construction conferences to be specific or reliable (GAO, 1999). Moreover, utility owners are often unresponsive to highway contractors' requests for needed actions because: (1) highway contractors often make changes to construction work schedules, (2) utility owners usually have limited resources to respond to highway contractors' requests, and (3) utility owners' first obligation is in servicing their existing and new customers (GAO, 1999). Even on a 100 percent reimbursable project, utility owners do not profit from the adjustment work and generally do not recover all of their indirect costs (GAO, 1999).

3.6.5 Multi-Party Coordination

This type includes two of the reasons for utility adjustment delays: (6) phasing of construction and utility adjustment work out of sequence and (12) inadequate coordination or sequencing among utilities using common poles/ducts.

The relationship between the highway contractor and the utility owners who have to adjust their facilities in the highway construction phase is complex. Both need intensive coordination efforts, and if any of the parties do not comply with the proposed schedule, delays will occur.

3.6.6 Design Changes

In general, even under the best of circumstances, designing a highway project often takes a long time and frequently involves delays, cancellations, changes in alignment, and other factors that can alter the involvement of utility owners. These conditions encourage state DOTs to wait until later in the design process to involve the utilities (GAO, 1999). Similarly, utility owners prefer to wait until they are certain that the project's design is firm before they begin their adjustment work (Ellis, 2003) (Zembillas and Beyer, 2004). This shared mentality further jeopardizes the entire highway schedule.

3.7 Impacts of Utility Adjustment Delays

Just as there is no quantifiable information on the actual extent of utility adjustment delays, there are no figures on how these delays affect project schedules or other aspects of the highway construction process (GAO, 1999). Based on the current literature reviewed, five impact types were identified and are discussed as follows:

3.7.1 General Impact on the Public

State DOTs would like highway contractors to complete highway projects in a timely and cost efficient manner. Delays in the completion of highway construction projects result in greater inconvenience to the public, as well as higher costs to state DOTs (TRB, 2001). When projects are delayed or stopped for an extended period of time, traffic congestion may be increased due to construction staging (Blair, 2003). Business owners located adjacent to construction zone areas may be affected by the traffic congestion and/or restricted to access to their establishments (Blair, 2003).

3.7.2 Impact on the Highway Project Schedule

Delays in adjusting utilities can cause highway construction work to be rescheduled or delayed (GAO, 1999). Utility adjustment work has been found to be one of the primary sources of delays and added cost to highway construction projects (Abraham, 2004). Some researchers claim that the most frequently cited reason for delays in highway construction is utility adjustments delays (Ellis and Thomas, 2003); others claim that issues related to existing utilities have the highest average impact on project schedule, cost, and quality (Hancher, Thozhal, and Goodrum, 2003). While state DOTs can compensate highway contractors for delays caused by adjusting utilities by extending highway project completion schedules, utility owners are responsible for these contingencies (GAO, 1999).

3.7.3 Impact on the Highway Project Costs

Although some state DOTs can compensate highway contractors for such delays, highway contractors may not have the time to prepare the paperwork for the compensation (TRB, 2004). Anticipation of the costs associated with utility adjustment delays by highway contractors may cause them to add to their bid prices. These padded bids do not bring any added benefit to the project and are considered avoidable in nature by state DOTs (TRB, 2004).

State DOTs may pay for additional project inspection costs due to delays in resolving utility problems (Blair, 2003). In addition, state DOTs can compensate highway contractors for delays caused by adjusting utilities by paying highway contractors' claims for increased costs (GAO, 1999). It is estimated that as much as $120 million per year of highway contract claims result from utility adjustments (TRB, 1984). Construction problems caused by utility conflicts result when utility locations are unknown or when utility removal is late. Both interfere with contractors' schedules and cause delays and thus may result in claims being filed (TRB, 1984).

3.7.4 Impact on Other Aspects of the Highway Project

In addition to the claims and litigation that can be occasioned by delays in adjusting utilities, such delays also harm the public image of the state DOTs (GAO, 1999). While damage to public relations may not cost money, the public perception that highways are not being constructed correctly affects the ability of state DOTs and contractors to obtain funding for future public works projects (Blair, 2003).

3.7.5 Impact on the Highway Contractor Selection Process

The amount of utility adjustment contingencies that a highway contract can include in a bid should be low enough that a highway contractor still has a reasonable chance of getting the contract (Blair, 2003). If there is no mechanism within the contract specifications for recovery of additional unforeseen costs associated with utility conflicts or delays, the highway contractor may be forced to pursue legal alternates for cost recovery. This creates the scenario of putting highway contractors in adversarial positions to state DOTs (Blair, 2003). In addition, highway contract bidders may be able to exercise every effort to clearly define the current conditions of utility adjustments when the contract is awarded and signed. However, state DOTs would like to select the contractor who can successfully finish the project on schedule and with the allocated funding. The potential for unforeseen utility adjustment conditions arising on a highway project may lead the state DOT to select the contractor who is most skilled at defining these conditions, but who may not excel in completing the project (Blair, 2003).

3.8 Similar Utility Adjustment Strategies in State DOTs

Research shows that the CTUC approach has increasingly been pursued by many state DOTs in recent years. A survey conducted in the 2001 AASHTO / FHWA Right of Way and Utilities Conference reported that two thirds of the state DOTs have applied the CTUC approach in at least one of their highway projects (North, 2001). Under the CTUC approach, the highway contractor can perform most of the adjustment work for water and wastewater utilities (GAO, 1999). Because some state DOTs can force utility owners to allow highway contractors to adjust their facilities, utility owners rarely willingly agree to this arrangement (North, 2001). One research report even named this approach as Joint Project Agreement (JPA) or Utility Work by Highway Contractor agreement (UWHC) (Zembillas and Beyer, 2004). Utility representatives find JPA to be a time-saving agreement between the utility owner and the contracting agency, which allows the highway contractor to adjust conflicting utility facilities at the best possible stage in the project timeline (Zembillas and Beyer, 2004). Although the utility owner still needs to put the new line into service before the old one can be removed, JPA or UWHC offers protection to the utility owner against highway contractor delay claims (Zembillas and Beyer, 2004).

Use of the CTUC approach does not imply that the highway contractor can perform all utility adjustment work involved in the highway project, nor does it mean that the utility owners perform nothing but inspection. Both state DOTs and utility practitioners acknowledge that more coordination efforts may be needed if CTUC is chosen over the conventional approach (Goldman, 2005). Therefore, the decision to use the CTUC approach is very complex and requires much deliberation.

Past studies indicate that if a state DOT incorporates utility adjustment work into a highway contract, it will normally acquire and pay for any needed permits. This financial responsibility provides a major benefit to utility owners (Austin, 2001). Because the CTUC approach separates work items in accordance with each party's responsibilities, the CTUC approach is perceived as capable of solving the central problem of the conventional approach, i.e., the utility owner has to finish the utility adjustment design and work in a very short timeframe (Austin, 2001). In the following paragraphs, several state DOTs' CTUC approaches are explored.

3.8.1 California Department of Transportation

The California Department of Transportation (Caltrans) has extensive experience in using the highway contractor to perform utility adjustments to control utility adjustment delays. In their online Right of Way Manual, Caltrans outlines their agreements for several different contracting approaches. These utility agreements account for four different contracting techniques: (1) work performed by owner per owner's plans; (2) work performed by state contractor per state's plans; (3) work performed by state contractor per owner's plans, and (4) work performed by both owner and state's contractor per owner's plans (Caltrans, 2005).

Contractual language is similar for all four agreement types, but the versions that include utility work in the highway contract include notes that indicate the need for special provisions under certain circumstances (Caltrans, 2005). For instance, if the utility owner wishes to retain ownership of an old facility removed by a state contractor, a clause must be added to the special provisions section of the agreement. Further, liability and reimbursement issues are addressed in a similar manner, with either additional forms or language required (Caltrans, 2005).

3.8.2 Michigan Department of Transportation

Chapter 9 of the Michigan Department of Transportation (MDOT)'s Roadway Design Manual contains information on the state's utility adjustment procedures. The Interim Update Volume 3, dated on October 14, 2003, outlines Michigan's procedure for including utility adjustment work in MDOT's contracts with roadway contractors. The stated purpose of this type of contract is to control utility adjustment delays (MDOT, 2003). Michigan sometimes requires up-front payment for CTUC adjustment work. It should be noted that this procedure collects payment from the utility owner prior to the contractor's performance of the utility work. Because of past procedural problems and process improvement efforts, MDOT and utility representatives have mutually agreed to this arrangement (MDOT, 2003).

The MDOT design manual lists common work items included in the highway contract. These are: storm sewer drop inlets, adjustment of utility manholes, existing facility removal, and utility bridge attachments (MDOT, 2003). The MDOT roadway contractor generally performs little complex utility adjustment. Further, adjustments assigned to the roadway contractor costing less than $1,000 are performed at no charge to the utility owner. Adjustments that cost between $1,000 and $50,000 are invoiced following the completion of work, and those costing greater than $50,000 must be paid in advance, as noted above (MDOT, 2003).

The MDOT design manual lists the steps to be taken by the MDOT Project Manager (PM) and Utility Coordinator (UC) when the combined approach is considered. The following are the collaborative steps taken by the PM and UC once CTUC has been chosen (MDOT, 2003):

- A meeting between the UC and the PM is convened to discuss all utility coordination issues. Utility coordination issues regarding the proposed construction schedule, type of work required, and the plan completion date shall be discussed to determine whether any work on behalf of the utility owner should be included in the MDOT contract.

- When work on behalf of the utility owner will be included in the MDOT contract, the PM shall perform design to include the agreed upon utility work. Once the utility work has been added into the plans, the PM shall contact the UC so they can review the plans with the utility owner for their acceptance.
- If utility modifications are not to be included in the MDOT contract, or if the utility owner does not approve the estimated cost, the UC shall notify the utility owner to perform any necessary adjustment work prior to construction. If adjustment is not possible prior to construction and the utility owner chooses to do the work himself, then a coordination clause is developed for the project.

3.8.3 New York State Department of Transportation

New York State has a manual called "The Design Quality Assurance Bureau – Highway Design Manual." Chapter 13 of this design manual is dedicated to utility issues associated with highway design and construction (NYSDOT, 2003). Mitigating utility adjustment delays is one of the manual's primary objectives. For example, several sections are dedicated to emphasizing the vital importance of communication between the numerous entities involved in projects requiring utility adjustments. Furthermore, the New York manual makes very clear the need for accurate Subsurface Utility Engineering (SUE) as early in project development as possible (NYSDOT, 2003). In fact, the manual reports that conservative estimates based on the department's experience, as well as the experiences of other states, indicate that for every $1 spent on SUE, overall project savings can average between $5 and $10. Based on these findings, NYSDOT recommends the extensive use of SUE on any project which may experience utility conflict (NYSDOT, 2003).

NYSDOT's familiarity with and support of the CTUC approach has led them to devise a process for adjusting utility facilities using the CTUC approach. According to Chapter 13 of their design manual, it is often beneficial to the overall project schedule to have as much of the utility facility work included in the highway contract as possible (NYSDOT, 2003). Consequently, NYSDOT's experience with the combined approach has allowed them to develop methods to encourage utility owners to agree to the combined approach. In their process, an appropriate and acceptable method of encouraging utility owners to include their adjustment work in highway contracts is to use "Fixed Price Lump Sum Items." The design manual also documents the types of agreements required for each approach, along with reimbursement options, procedures, inspection, etc. (NYSDOT, 2003).

3.8.4 Rhode Island Department of Transportation

The Rhode Island Department of Transportation (RIDOT) has defined a Work Breakdown Structure (WBS) with numerous tasks and corresponding documents to assist its personnel and consultants in handling highway project development. The WPS also provides guidelines for managing and controlling the entire highway project schedule. Because utility adjustment delays have been recognized as the root cause for delays in highway construction, a RIDOT contractor may be able to perform utility adjustment work to expedite highway construction, provided that (RIDOT, 2004):

- Consultants prepare and submit an estimate for all utility work to be performed by the contractor.
- The contractor performs utility work during the construction of the project, which could not be reasonably or logistically done by the utility company. Typical work items performed by the contractor would include hydrant adjustment, adjusting gas and water gates, arranging temporary water services, etc.

RIDOT has tried other approaches to reduce utility adjustment delays. For example, in 1998, they considered legislation that would have required utility owners to adjust their facilities within 30 days of receiving notice. If utility facilities were not adjusted within the allowed timeframe, RIDOT would have been permitted to contract for the adjustment with a contractor, and the utility owner would have to have paid for the cost of the contract (GAO, 1999). RIDOT argued that since utility owners had agreed on the proposed adjustment completion dates, any adjustment delay costs or contractor claims that were the result of adjustment delays should be charged to the utility companies (GAO, 1999). However, utility owners successfully argued that having them pay for the adjustments would increase the cost to their utilities' customers, and the proposed legislation was not enacted (GAO, 1999).

3.8.5 Texas Department of Transportation

TxDOT has tried several approaches for reducing utility adjustment delays. While expediting utility adjustment is identified as a method that positively affects project delivery, it is also clear that improvements to utility adjustment may not be as feasible as improvements to other project processes (Hedemann, 2005). The CTUC approach, on the other hand, implied a fundamental change of project configuration. TxDOT's goal in applying the CTUC approach is to implement an adjustment plan that is compatible with TxDOT's established contract award scheduling and construction sequencing (TxDOT, 2005). Basically, both the conventional and CTUC approaches revolve around the TxDOT-Utility Cooperative Management Process, a process framework that can accommodate either approach.

TxDOT has had experience with the CTUC approach in several districts, most notably in the San Antonio, Houston, and Dallas districts. To a limited extent, the CTUC approach has been applied in the San Antonio district since the late 1980s. In 1994, the San Antonio district commissioned a Value Analysis study that resulted in a streamlined Utility Coordination Procedure (EMS, 1994). In 1997, the San Antonio district conducted a Value Engineering workshop in which coordinated utility solutions and the CTUC approach were identified as key opportunities for further enhancement of project stakeholder value (EMS, 1997). A key product of the workshop was a Memorandum of Understanding (MOU) between the TxDOT San Antonio district and the City of San Antonio to promote greater consideration and implementation of innovative utility-related approaches. Similar MOUs have since been developed with other San Antonio-area utilities. In these MOUs, the level of complexity is defined so as to determine the degree of coordination efforts needed between TxDOT and utility owners. Level I implies that the CTUC approach should be applied and delineates the project characteristics as follows: extensive adjustments for one or more utilities; complexity or numerous conflicts with various design elements; short development schedule requiring close coordination and no float time; requirement of new or additional ROW; and upgrade of utility facility (EMS, 1997).

3.8.6 FHWA and AASHTO Recommendations for the CTUC Approach

In 2002, the FHWA initiated a policy of encouraging the study of nontraditional innovative contracting practices around the world. The policy was aimed at identifying the practices that have the most potential to enhance the quality of highways and minimize the negative impacts of inefficient highway construction to road users (FHWA-2, 2002). The same year, the FHWA completed a best practices study, focusing on European strategies for improving working relationships between highway staff and utility officials (FHWA-2, 2002). The study's goal was to help improve cooperation, coordination, and communication between highway builders and utility companies in the United States.

The American Association of State and Highway Transportation Officials (AASHTO) charged its Highway Subcommittee on ROW and Utilities with preparing recommended guidelines and best practices for ROW and utility processes. More specifically, their assignment was to develop and advocate guidelines and best practices to ensure timeliness of procurement, clearance of R/Ws, and adjustment of utilities (AASHTO, 2004). The subcommittee used its own expertise, along with research conducted by the International ROW and Utilities European Scan Team. Further, personnel from the utility and ROW consultant industry added comments and recommendations to the report (AASHTO, 2004). The ROW and Utilities Guidelines and Best Practices document is divided into the following eight major areas: (1) project development, (2) appraisal and appraisal review, (3) acquisition, (4) adjustment, (5) property management, (6) utilities, (7) management practices, and (8) training. Each area is based on one to ten more specific guidelines that serve as user goals. These guidelines are each supported by specific best practices designed to help the user attain the associated goal. Although the areas, guidelines, and best practices relate in some way to utility adjustment, only those directly related to the CTUC approach are listed below (AASHTO, 2004):

Area: Utilities:

Guideline 4: Use or consider establishing utility corridors for utilities crossing major highways or located longitudinally along highway R/Ws.

Have highway contractors relocate utility and municipal facilities, when possible.

- Although it is generally acceptable for the utility owner to relocate its facilities with its own forces, other construction methods are available, including but not limited to having the work performed on the owner's behalf by the highway contractor. In consultation with the utility, select the appropriate method based on cost effectiveness considerations, including whether the work can be done at a reasonable cost and at a time convenient to and in proper coordination with the associated highway construction.
- Incorporating the utility adjustment work into the highway contract has the following potential advantages:
  - Greater utilization of contractor's equipment and manpower.
  - Less duplication of effort on items such as traffic control.
  - Lower bid prices on consolidation items such as excavation.
- In determining if the highway contractor should relocate utilities, consider:

- Whether the utility work must be performed prior to or concurrent with highway work.
- Whether the highway contractor can be reasonably expected to perform the utility work; or if the work can be readily subcontracted. In some cases a pre-approved list of contractors acceptable to the utility company is an option.
- Whether the utility work substantially alters the planned scope of the highway project.
- Whether utility owner and/or labor union policies allow others to perform the work, and if so, under what conditions, e.g., the use of pre-approved subcontractors, use of proprietary materials.
- Potential efficiencies to be gained by consolidating the utility and highway work.
- Whether the necessary funding can be put in place.

- In determining whether having the highway contractor perform the utility adjustment results in improved ability to control the work, state DOTs should coordinate sequential or concurrent operations and investigate whether a corresponding reduced risk of delay or disruption occurs.
- If state DOT and utility agree to incorporate the work into the highway construction contract, make appropriate written arrangements for work performance, standards, payment, inspection, liability, etc. If the utility is responsible for adjustment costs, make provision for the utility to fund the work in advance. In the event that bid prices for the utility work are excessively high, make contingency plans for the work to be withdrawn from the contract and performed by other suitable means, or for the responsible party to make up the shortfall. As needed, incorporate utility-furnished or approved plans and specifications into the highway project bid package. Make adequate provisions for the owner to inspect and accept the work.
- Consider utility installations by highway contractors to enhance the highway contractor's control of their production schedule and to reduce subsequent delays or disruptions. In Norway and the United Kingdom, highway contractors sometimes place conduit for the utility companies. This also occurs on some projects in the U.S. State DOTs, in conjunction with utility companies, should consider allowing highway contractors, or their subcontractors, to install such items as conduit for later use by utilities, storm and sanitary sewers, water lines, and possibly power, communications, and high-pressure pipelines. This will provide an improved ability for the highway contractor to control the work and to coordinate sequential or concurrent operations, thus reducing the risk of delays or disruptions.

(AASHTO, 2004)

3.9 Other Approaches to Ameliorate Utility Adjustment Delays

In addition to the CTUC approach, state DOTs have devised several approaches to ameliorate utility adjustment delays. Described below are some examples of state DOTs that have developed their own approaches to coping with utility adjustment delays.

3.9.1 Early Planning and Coordination

Almost all state DOTs have used this type of approach (GAO, 1999). It aims to provide much earlier notice of upcoming projects, invite utility owners to meetings early in the design phase of a project, hold monthly, quarterly, or other periodic planning and coordination meetings, provide R/Ws and utility adjustment funding before the highway construction work is funded, and improve coordination efforts and working relationships (GAO, 1999).

The TxDOT-Utility Cooperative Management Process is an example of this approach. This process offers a means of discovering and then incorporating utility owners' concerns into the planning, design, acquisition, and construction phases of a highway project development. Early coordination provides for more efficient highway design, economical utility adjustment, and reduced highway construction costs (TxDOT, 2005). Thus, this cooperative mindset should be adopted by every project stakeholder when utility adjustments are involved.

3.9.2 Use of Incentives or Penalties

This type of approach will either encourage utility owners to adjust their facilities in a timely manner in order to earn incentives or burden them with extra penalties through permits, agreements, and regulations, if there are delays. A survey conducted by the Government Accountability Office (GAO) showed that although three state DOTs provided monetary incentives to encourage utility owners to complete utility adjustments on federal-aid highway and bridge projects, none of these incentives were contingent on the timely completion of the adjustment work (GAO, 1999). Those state DOTs who pursued this approach either charged the utilities for the costs that the state DOT incurred or for contractor claims that were paid as a result of utility adjustment delays. These penalties were not directly tied to missed utility adjustment dates but were assessed on a case-by-case basis (GAO, 1999).

Although there is no statutory regulation or utility policy in Texas dictating that incentives will be given to utility owners when their facilities are adjusted in a timely manner, use of monetary incentives to persuade utility owners into buying the CTUC approach has been considered by TxDOT. In addition, utility owners recognize that utility adjustment delays may require them to bear the delay costs (Goldman, 2005).

3.9.3 Use of Legal Actions

This type of approach cannot prevent delays and is seldom used to discipline utility owners for untimely utility adjustments. While the use of courts to compel utility owners to adjust in a timely manner has been considered, it is difficult for state DOTs to prove that utility owners are at fault. State DOTs would need to demonstrate that: (1) it or the construction contractor had notified the utility owner in a timely manner of the work to be done; and (2) the utility had not been kept from doing its adjustment work (GAO, 1999). However, because state DOTs usually work closely with utility owners to resolve problems and conflicts, litigation is thought to jeopardize the positive working relationship that exists between state DOTs and the utilities (GAO, 1999).

3.9.4 Use of Partnering or Outsourcing Utility Coordination Services

Special contracting methods, including design-build, advance roadway work, the CTUC approach, partnering, and outsourcing utility coordination services, have been used extensively by state DOTs. In this subsection, two of these methods are presented.

Partnering, which is advocated by at least one national contractor association, seeks to remove the adversarial relationships that sometimes exist between DOTs, contractors, and utility owners, and replace them with business relationships that are based on common goals and a desire to productively work together (GAO, 1999). According to the contractor association, partnering does not change or release any contractual requirements but helps all parties recognize that a basic tenet of contract law is to act in good faith (GAO, 1999). Partnering does help improve communications and reduce delays; however, it does not resolve all delay problems (GAO, 1999).

Outsourcing utility coordination services is another approach currently used by TxDOT. Stockburger pointed out that TxDOT has been confronted by higher construction letting volumes and accelerated construction letting schedules in recent years (Stockburger, 2004). Moreover, there are fewer people in the district and area offices to perform the required utility coordination tasks, and thus it has been noted that adjusted utility facilities that are installed in the wrong location contribute most to highway constructor delays. Therefore, TxDOT has commenced to purchase utility coordination services in order to eliminate highway contractor delays due to unclear utilities and to eliminate secondary utility adjustments. All such efforts are aimed at ensuring that utility facilities are installed correctly and in accordance with the rules the first time (Stockburger, 2004). A typical utility coordination service contract includes a specific set of coordination duties for contract consultants. These duties are (Stockburger, 2004):

- Meeting Coordination;
- Horizontal and Vertical Alignment Design and Review;
- Agreement and Permit Preparation and Review;
- Agreement Billing Processing; and
- Utility Construction Inspection.

3.9.5 Use of Design-Build

If the design-build process is used on a project, ROW and utilities must be involved in the design-build planning and contract development to ensure compliance with FHWA requirements, 23 C.F.R., Parts, 627, 635, 636, 637, and 710. FHWA and AASHTO have examined the feasibility of incorporating ROW functions, as well as utilities, into the design-build process (Kraker, 2001) (Quinn, 1997). They encourage state DOT ROW and utilities personnel to study advantages of design-build; they emphasize its ability to shorten the project development process by eliminating many of the procedural procurement processes (AASHTO, 2004).

3.9.6 Use of Advance Roadway Work

This approach aims to initiate separate contracts for advance roadway work on selected projects prior to utility adjustments. On such selected projects, the letting of advance roadway work as separate contracts in advance of the grading may enable utilities to be adjusted prior to the letting of the highway contract. This will help reduce delays to the contractor waiting for utilities to be adjusted (AASHTO, 2004). However, this approach is not recommended by some state DOTs. Such a phased approach can generally extend the length of each job, and utility owners are reluctant to relocate utility facilities too soon because of the possibility of subsequent project redesigns (GAO, 1999).

4. Characterization of CTUC Benefits and Challenges

This chapter contains three sections: characterization of CTUC benefits and challenges; suggested process changes related to CTUC benefits and challenges; and assessment of CTUC benefits and challenges.

4.1 Characterization of CTUC Benefits and Challenges

Analyzing CTUC benefits and challenges helped the research team develop a Decision Support Tool for TxDOT to use for selecting the best contracting approach. The research team conducted a series of preliminary research meetings with both TxDOT personnel and utility representatives. The questionnaire for these meetings is listed in Appendix A. Once a somewhat exhaustive investigation of the benefits and challenges had been conducted, the research team modified the benefits and challenges data into a set of preliminary CTUC decision drivers that reflected whether a given criteria lent itself more or less to the CTUC approach. A summary of the preliminary CTUC decision drivers and their influence on the CTUC decision are listed in Appendix B. A parameter marked "Pro-CTUC" is one that leverages a benefit for the CTUC approach over the conventional approach. Conversely, a parameter marked "Anti-CTUC" is one for which the conventional approach provides benefit over the CTUC approach. Further, the parameters marked both 'Pro-' and 'Anti-CTUC' are ones that cannot always be classified as a benefit or challenge, but must be considered on a project-specific basis to determine what effect they will have on the adjustment in question. This parameter classification resulted from observation of project complexities, conflicting expert opinions, policy discrepancy by district, differing utility policy by area, etc. The "Explanation" column contains descriptions of the benefit or challenge presented by each approach when the given decision driver is considered. The final column entitled "Suggest Process Change" indicates whether or not the research team has found evidence to suggest that a modification to the current adjustment procedure would provide substantial benefit to the overall project process. The suggested modification to the adjustment procedure could be a change in TxDOT policy, utility policy, Texas State Law, etc. The main benefits and challenges of the CTUC approach identified in the preliminary research meetings are summarized as follows:

CTUC Benefits

- If the conventional approach is applied, utility adjustment should precede contract letting. The CTUC approach allows the utility adjustment to occur following contract letting. If projects are complex, using CTUC may prevent the utility adjustment from delaying the entire project because utilities will be adjusted under the contractor's schedule.
- The CTUC process can alleviate demand for the utility owners to supply adjustment crews because the work is performed by the TxDOT contractor.
- With the conventional contracting approach, construction contractors will bid with contingencies built in for delays due to unadjusted utilities. The CTUC approach requires no utility delay contingency because the contractor will control the adjustment.

- Less litigation can be expected due to the positive relationships developed with utility owners resulting from the CTUC approach. Although CTUC does not eliminate all litigation, the majority are removed.
- If the CTUC approach is pursued, the opportunity exists for the contractor to optimize the work sequence without concern for adjustment delay. In addition, simplified or better coordinated construction including site preparation, traffic control, and combined work activities lead to higher productivity. Further, when utility adjustment involves required lane/road closures, TxDOT is more experienced in traffic management than most utility owners. When multiple utilities perform their own adjustments, road closures will occur on several occasions. The CTUC approach allows one road closure for all involved utilities.

<u>CTUC Challenges</u>

- A gas utility pursued the CTUC approach over 50 percent of their adjustments with TxDOT. They now applied the CTUC approach in very few adjustments because of a reported 30 percent higher cost versus the conventional approach.
- Utility owners usually want to see direct cost savings before using CTUC.
- When non-reimbursable CTUC adjustments occur, the utility owner must make funding available for the entire adjustment up front in an escrow account.
- The lowest bidder for the entire highway construction project may save TxDOT money at the expense of the utilities.
- When the adjustment contract is conventional and non-reimbursable, the utility owners may choose adjustment subcontractors without justifying selection (e.g. low bid or best value). When the CTUC approach is used, TxDOT must ensure that their highway contractor receives the legal minimum number of bids, and that they justify their subcontractor selection. Complication may arise if, for example, one utility names the sub that they would like to perform the adjustment, but a lower bid is available that does not involve this utility specified sub.
- The TxDOT contractor provides no warranty period while some utility owners require their contractors to provide 1-2 years.
- Too many safety issues associated with the CTUC contractor's capability exist.
- The CTUC approach may introduce complication due to disjointed specs between TxDOT and utility owners resulting in misunderstanding. If the CTUC approach is to be used, TxDOT will need to update their specs more frequently in order to accommodate rapidly changing adjustment specifications.
- When the CTUC approach is used, it is likely that one or more utilities will elect to proceed without CTUC. Any delay caused by non-CTUC utilities will diminish the advantages of the CTUC approach for those utilities who are "on board," and have money placed in escrow accounts.
- When gas lines need to be adjusted inside of TxDOT ROW, the CTUC contract includes only the portions of the lines which require adjustment within ROW limits.

If the adjustment requires further work outside of the ROW, the gas utility must execute a separate contract.

As stated, Appendix B summarizes data collected from various meetings with utility owners and TxDOT personnel from the three districts most experienced in the CTUC approach. The preliminary CTUC decision drivers began as benefits and challenges to the CTUC approach. Each preliminary CTUC decision driver has been placed into a broader category, as indicated by the leftmost column. These fifteen categories provide a clear top-level description of the type of decision driver contained within (Goldman, 2005).

4.2 Suggested Process Changes Related to the CTUC Approach

4.2.1 Suggested Process Changes Related to CTUC Benefits

As Appendix B makes evident, the research team established preliminary CTUC decision drivers, and only two of the benefit-oriented decision drivers suggest the need for a process change. One example of a suggested process change is located under the "Adjustment Completion Timing" category. This decision driver states that "the conventional approach often requires that utilities pay for clearing and grubbing of the land on which the adjustment occurs." Several San Antonio–area utilities reported that because their adjustment work was very often the first one to occur on newly acquired R/Ws, they were required to pay for substantial clearing and grubbing. Their argument was that the cost burden of this clearing should not be borne by the first utility on site, but should be shared with the other utility owners, with TxDOT, or both. The utility owners interviewed reported that they would like to use the CTUC approach if this approach can include the clearing and grubbing in the TxDOT contractor's scope of work.

The other CTUC benefit that indicates the need for process change is in the "Design Format" category. This decision driver suggests the hiring of a general design consultant who is capable of performing adjustment design for all utilities involved in a project for any CTUC adjustment, as opposed to the traditional CTUC approach, in which each utility hires a separate designer or performs its own design. Both TxDOT personnel and utility owner representatives identified joint design as the preferred method for optimal design coordination. In order to extract maximum benefit from this CTUC decision driver, every effort should be made to have utility adjustment design performed by one general consultant (Goldman, 2005).

4.2.2 Suggested Process Changes Related to CTUC Challenges

Some elements of the CTUC approach present challenges to efficient utility adjustment, as indicated by the preliminary decision drivers listed in Appendix B, marked "Anti-CTUC." Of all preliminary CTUC decision drivers that make the CTUC approach an unattractive choice, five suggest a process change that could potentially eliminate the associated challenge.

The first process change suggested for a CTUC challenge falls under the "Utility Physical Characteristics or Scope" category, and refers to the need for two separate adjustment contracts when utility work must be performed inside and outside of TxDOT project R/Ws. San Antonio utility owners indicated that an inefficient, two-contract technique is often used when the CTUC approach is selected because TxDOT does not perform adjustments outside of their R/Ws. TxDOT San Antonio district officials confirmed that utility adjustment work cannot be performed by the highway contractor outside the TxDOT ROW because the agency only has environmental clearance for land inside the TxDOT ROW. The suggestion for process change is based on the improved contracting efficiency that would occur if the CTUC contract could be executed for adjustments occurring both inside and outside of the TxDOT R/Ws.

Another process change that could eliminate a problem caused by CTUC focuses on utilities involving HAZMAT. Several TxDOT districts avoid the liability associated with utilities whose adjustments include HAZMAT work by using the CTUC approach. To remedy this situation, utilities suggest that they pay TxDOT's evergreen contractor (often already in place) to perform the HAZMAT removal. Using TxDOT's evergreen contractor would speed up the utility adjustment process and allow those utilities who expect HAZMAT to adopt the CTUC approach. A San Antonio TxDOT representative reported that no such mechanism currently exists but agreed that it is a possibility for future improvement. However, the utility owners whose adjustments include HAZMAT should still retain the custody of HAZMAT after the removal.

The next CTUC decision driver that suggests the need for a process change falls under the "Utility Adjustment Funding (Non-Reimbursable)" category. This challenge is associated with a reported 10–30 percent increase in cost to the utility owner when the CTUC approach is chosen over the conventional approach. Utility owners from the Houston, San Antonio, and Dallas areas reported that the following parameters contribute to this higher cost: contractor cost front-end loading; increased change-order amount/frequency; added contractual tier; and the addition of subcontractor management contingency. TxDOT representatives noted that the cost increase may be balanced by CTUC's ability to eliminate delay costs to the utility owner, improve construction quality, and relieve utility adjustment crews during times of high demand. Empirical cost data is not available to support the opinions of either party at this time. Because several utilities declared that for non-reimbursable contracts this cost increase made the CTUC approach prohibitive, it is important that reasons for this added cost be investigated.

Under the same category, the requirement for utilities to provide the total adjustment cost in escrow prior to the beginning of work presents a challenge to adopting the non-reimbursable CTUC approach. Because state law prevents TxDOT from "pledging credit," the requirement for funding in escrow prior to adjustment is unavoidable at this point in time. This was identified as a serious challenge faced when executing the CTUC approach, particularly by private utility companies. The utility companies said that the CTUC approach would be a much more attractive option if some alternative accounting process were made available to avoid the escrow requirement.

The final suggested process change for eliminating CTUC challenges falls under the "Specification Concurrence" category. Several utilities, even within the same TxDOT districts, reported varying procedures for following utility adjustment specifications. Some utilities adopted TxDOT specifications, some reported that they provide their own for the contractor to adhere to, and a few utilities suggested that a composite spec be constructed with both utility and TxDOT influences. The CTUC approach makes it vital for TxDOT to monitor specification integration and concurrence. Complications associated with incorrect specifications could arise and be amplified by the fact that the highway contractor is responsible for multiple utility adjustments. TxDOT and utility owners must ensure effective specification coordination in order to avoid quality issues or even rework (Goldman, 2005).

4.2.3 Other Suggestions Related to the CTUC Approach

The following suggestions are adapted from TxDOT 0-4997-P1 and were the result of the preliminary research interviews:

- Based upon the information gathered through preliminary research meetings and literature review, it is evident that under some circumstances, the CTUC approach is the most beneficial contracting approach for utility adjustments. It is also evident that the CTUC approach is not the most advantageous method for some adjustments. The ability to determine whether CTUC is or is not appropriate for a given adjustment helps state DOT officials and utility owners reduce utility adjustment delays.
- TxDOT and utility owners have different perspectives regarding the preliminary CTUC decision drivers and the relative impacts of each on the CTUC decision. What might be a factor of utmost importance for a utility owner is sometimes of little to no importance to TxDOT, or vice versa.
- The eligibility ratio for reimbursement is often extremely important to the utility owner in their decision as to whether to perform the adjustment with the CTUC or conventional approach. When reimbursement eligibility is near or at 100 percent, utility owners are less concerned with the reported cost increase associated with the CTUC approach.
- TxDOT should use the CTUC advantages identified in this report to sell the CTUC approach to hesitant utility owners. By leveraging the CTUC advantages, and understanding/addressing the identified CTUC disadvantages, TxDOT will increase utility interest and participation in the CTUC approach.
- When dealing with utility owners who do not generally perform adjustments using the CTUC approach due to the physical complexity of their facilities (e.g., high voltage, extensive/complex cable connections, potentially dangerous gas facilities, etc.), TxDOT should consider the suggestion that the contractor install utility infrastructure only, e.g., conduit without wire (Goldman, 2005).

4.3 Assessment of CTUC Benefits and Challenges

As noted before, past research studies have not thoroughly characterized and quantified CTUC benefits and challenges. In order to contribute to the development of the CTUC Decision Support Tool and an implementation guide for TxDOT, the research team conducted a survey to investigate project performance on recently completed projects using the CTUC approach. The questionnaire for this survey is listed in Appendix C. The results of this survey are described in the following subsections (Sroka, 2006).

4.3.1 Overview of Assessment of CTUC Strategy on Recent Projects

Because the objective of the survey was to evaluate CTUC project performance, project performance was measured relative to the interviewee's experience with the conventional approach. To preserve consistency throughout the survey, each survey question was designed to be project-specific, with questions that presented interviewees with the following evaluative options:

- CTUC was much better than Conventional
- CTUC was better than Conventional
- CTUC and Conventional were EQUAL
- CTUC was worse than Conventional
- CTUC was much worse than Conventional
- Don’t know

For example, the first question is: “After utilities were adjusted, what was the nature of the relationship between TxDOT and the Utilities?” The interviewee could select any one of the above six options as the answer. A “Don’t know” option was offered to respondents so that no one was forced to answer a question for which he or she did not have an answer. After several iterations, the research team produced eight survey questions. Complete descriptions of each survey question are presented in Section 4.3.3.

Once the survey was completed, the response values were recorded and calculated. The qualitative measures were each assigned a value from 1 to 5 as follows:

5 - CTUC was much better than Conventional

4 - CTUC was better than Conventional

3 - CTUC and Conventional were EQUAL

2 - CTUC was worse than Conventional

1 - CTUC was much worse than Conventional

0 - Don’t know

If respondents could not evaluate the performance of a particular question, their “Don’t know” responses did not affect the analysis (Sroka, 2006).

4.3.2 Analysis of Survey Respondents

Once the survey questions were developed, TxDOT managers and engineers with CTUC project experience were informed of this research and asked to complete the questionnaire. Individuals from the TxDOT districts of Austin, Bryan, Corpus Christi, Dallas, Houston, and San Antonio all provided feedback on CTUC projects. A total of twenty respondents offered information on twenty-nine construction projects that had been completed utilizing the approach. To maintain consistency and reduce bias, no more than three questionnaires were accepted from any respondent.

Respondents averaged 15 years of experience and each had been involved in approximately ten CTUC projects. Those from the San Antonio and Austin districts had the most experience with CTUC, averaging over ten projects per respondent. In these districts, the CTUC approach was considered the norm for the majority of their TxDOT projects. Seven individuals reported that they had only been involved in one CTUC project. The participants from the Bryan and Corpus Christi districts reported experimenting with CTUC for the first time in 2005;

whereas, the Dallas and Houston district personnel reported having used this approach sporadically for over a decade. The findings suggest that CTUC is still a relatively new project execution approach in the state.

Numerous challenges were encountered as the interview process commenced. Early on, it became evident that the best sources of information were TxDOT utility coordinators, area engineers, and ROW administrators; however, their demanding schedules created coordination problems. Thus email proved to be the most effective and efficient way to conduct the survey. Approximately half of the respondents completed the questionnaire electronically. The other half filled-out the questionnaire during meetings conducted in Austin, Houston, San Antonio, and Dallas (Sroka, 2006).

4.3.3 Analysis of Survey Results

The purpose of this survey was to verify the effectiveness of the CTUC approach. This subsection reports the findings and the respondents' comments on the CTUC strategy. Each project performance criterion was measured and analyzed. The figures in the following paragraphs represent the average responses to each survey question.

- **Question 1: After utilities were adjusted, what was the nature of the relationship between TxDOT and the utilities?**

  Figure 4.1 demonstrates that the respondents believed that the proposed CTUC approach improves the quality of the relationship between TxDOT and the utilities after utility adjustments were completed. This relationship is crucial to the implementation and success of CTUC.

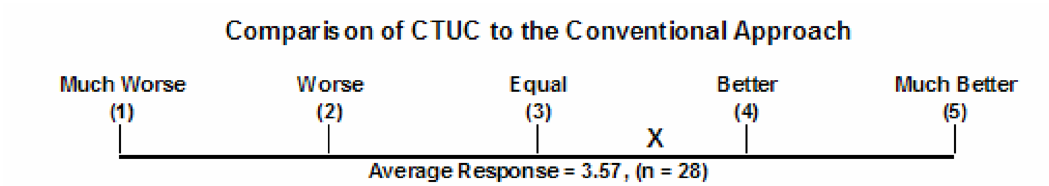

Figure 4.1: The nature of the relationship between TxDOT and utility companies after utilities were adjusted (Sroka, 2006)

- **Question 2: What was the impact of the CTUC utility adjustment on traffic flow through the project?**

  Respondents believed that, on average, the traffic flow through the project site is better with CTUC than with the conventional approach (see Figure 4.2). CTUC allows for utility adjustments to be completed with the traffic control plans instead of requiring two separate projects that affect traffic.

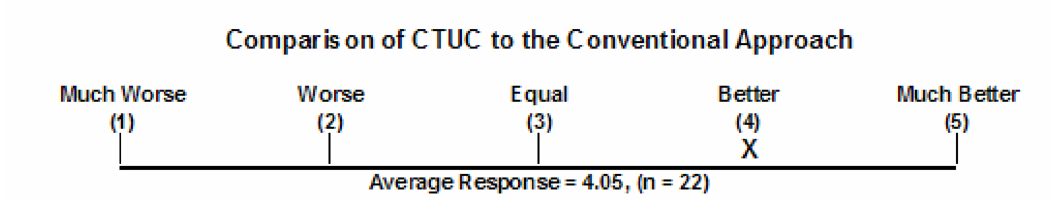

Figure 4.2: The impact of utility adjustments on traffic flow through the project (Sroka, 2006)

- **Question 3: With CTUC, what was the quality of coordination among the different utilities?**

  Respondents believed that the CTUC approach increases the quality of coordination among different utilities, as shown in Figure 4.3.

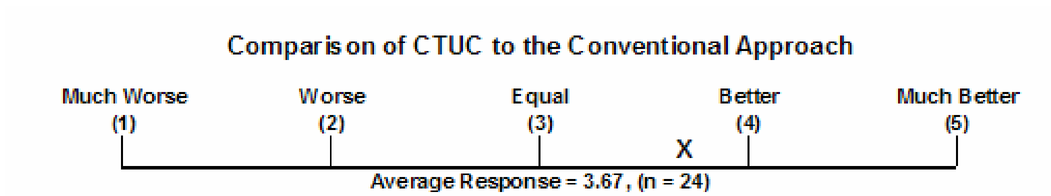

Figure 4.3: The quality of coordination among the different utilities (Sroka, 2006)

- **Question 4: Did CTUC allow you to move the letting date forward, i.e., occur earlier?**

  Because the CTUC approach allows for early coordination among TxDOT, highway contractors, and utility owners, it has the effect of speeding up the letting date (see Figure 4.4). Moreover, utilities included within CTUC do not have to be adjusted prior to the letting date. This permits projects to go to construction earlier.

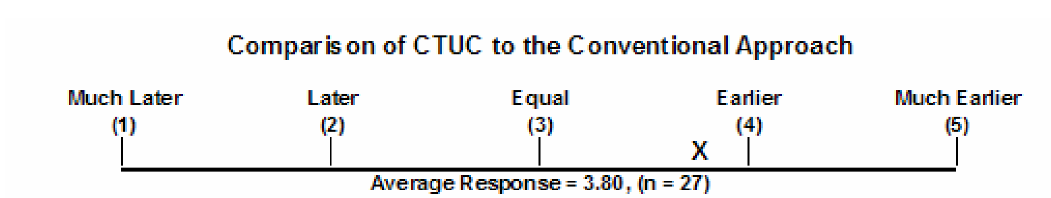

Figure 4.4: The letting date (Sroka, 2006)

- **Question 5: With CTUC, what was the frequency of utility-related change orders?**

  Figure 4.5 illustrates that there are slightly fewer utility-related change orders when the CTUC approach is used.

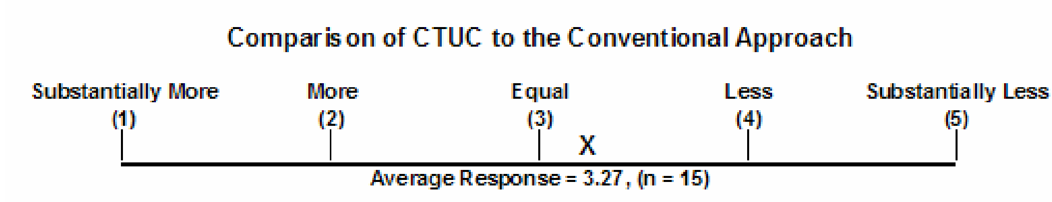

Figure 4.5: The frequency of utility-related change orders (Sroka, 2006)

- **Question 6: With CTUC, to what extent did you reduce the overall project schedule duration?**

  The increased coordination among agencies, the easing of traffic flow, and the reduction of utility change orders with CTUC allows for an overall reduction of the scheduled project duration (see Figure 4.6). CTUC tends to significantly reduce the likelihood of delays because unknown variables and/or conflicts frequently arise from utility adjustments performed with the conventional approach.

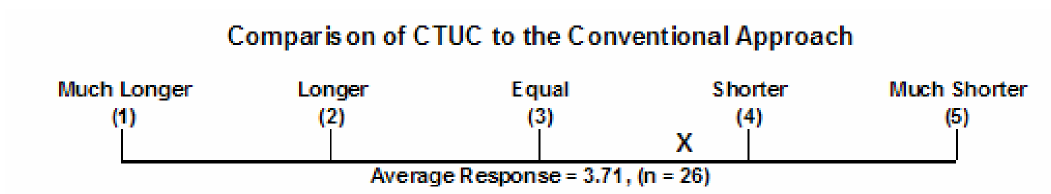

Figure 4.6: The reduction of the overall project schedule duration (Sroka, 2006)

- **Question 7: With CTUC, how did the actual utility adjustment cost compare to the planned cost?**

  The respondents indicated that the cost of the actual utility adjustment compared to the planned cost is nearly the same with both approaches (see Figure 4.7).

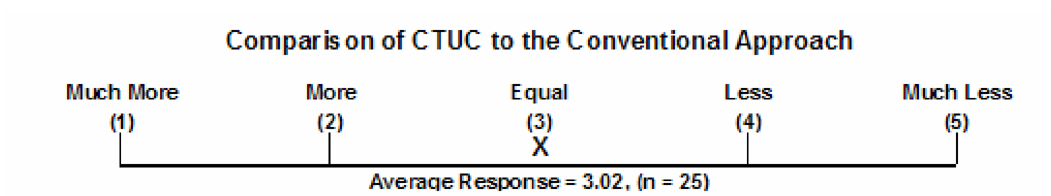

Figure 4.7: The cost comparison of the actual utility adjustment to the planned cost (Sroka, 2006)

- **Question 8: With CTUC, how satisfied were the utilities with the sub(s) doing the utility adjustment?**

  In general, utility owners were satisfied with the sub(s) performing the utility adjustments (see Figure 4.8). The state's construction contractors are usually required to select pre-qualified subs approved by the utility owners. This significantly reduces the possibility of costly re-work, claims, or time consuming litigation.

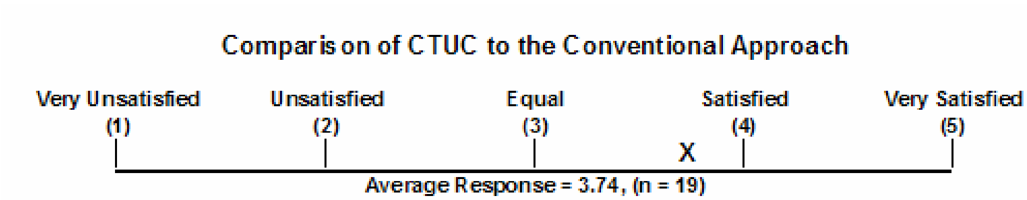

Figure 4.8: The satisfaction of the utility owners with the subcontractors' utility adjustment (Sroka, 2006)

The following is a summary of the CTUC project performance criteria, listed in order of most impact to highway constructability (Sroka, 2006):

1. Improving traffic flow through the project (4.05)
2. Moving the letting date earlier (3.80)
3. Satisfying the utilities with the sub(s) work (3.74)
4. Reducing the overall project schedule duration (3.71)
5. Improving coordination among different utilities (3.67)
6. Preserving and/or improving the relationship between TxDOT and the utilities (3.57)

4.3.4 Other Comments on the CTUC Approach

Although individuals at TxDOT refer to the CTUC approach in various ways (as "joint bidding" or as "combined contracts"), most would agree that it offers many advantages. The CTUC approach has been developed to allow for more TxDOT control over utility adjustments on highway projects. In the survey, respondents were given an opportunity to voice their opinions on the performance of the CTUC approach. According to their responses, some of the main performance advantages of the CTUC approach are:

- The CTUC approach reduces the chances of highway construction delays that are a result of unexpected conflicts with utility owners;
- Significant savings of tax-payer money are realized when highway construction delays, conflicts, claims, and disputes are factored into CTUC;
- Because the prime contractor or contractor's sub performs the utility adjustments on a CTUC utility adjustment, the likelihood of the delay caused by encountering undiscovered utility facilities during highway construction is significantly reduced;
- CTUC builds a positive working relationship with utility owners; and

- The prime contractor encounters less risk and sees fewer utility delays caused by improper utility adjustment.

CTUC allows the prime contractor to control the work without being delayed by unadjusted utilities. The highway contractor can schedule the activities and adjust them along with normal scheduled highway construction activities to establish a continuous workflow. In other words, CTUC allows the highway contractor to more easily coordinate changes in utility placement and to synchronize those changes with project work. Done this way, utility adjustments have the least impact on ongoing highway construction. This approach also ensures the accurate adjustment of the utilities.

Respondents did voice some concerns over the CTUC approach. Most of these concerns were expressed by the personnel from districts with less experience with this approach. These individuals encountered some difficulty coordinating with the multiple utility owners involved. Whereas in the conventional approach, coordination was only required between the highway contractor and the utility owner; CTUC requires effort by the city, city engineers, and the district's ROW staff. Because city funds can be involved in CTUC adjustments, more coordination is required among all the parties. Smaller cities may also have issues with CTUC, because they are forced to let TxDOT control the placement of their utilities (e.g., water and wastewater); this is problematic because historically, cities have been experienced as overly powerful in the utility adjustment process. As part of CTUC contracts, the cities are treated on a par with any other utility owner. This means that the city may be required to revise their design rather than forcing other utilities to work around it. Thus, implementing CTUC may effectively require a cultural change by all parties involved.

The fact that not all utilities are interested in the CTUC approach also disappoints some TxDOT officials. Utilities that do not get involved in CTUC tend to introduce unwanted communications challenges and project delays. TxDOT officials hope to implement some utility adjustment process changes to help these utility owners realize the benefits of the approach. However, based on the information gathered through the literature review, it is evident that the CTUC approach is not the most advantageous method for all adjustments (O'Connor et al., 2005).

Another noted disadvantage of CTUC was the need to work through the issues of having two different systems for inspection, the highway contractor's and the utility's. The survey results made it clear that TxDOT consistently attributed most, if not all, of the disadvantages of using the CTUC approach to the lack of experience with this type of agreement and work. However, TxDOT remains confident that future CTUC projects will run more smoothly because of the lessons the department has learned (Sroka, 2006).

5. CTUC Decision-Making Process

This chapter is dedicated to the proposed CTUC decision-making process. Section 5.1 presents the CTUC decision-making process and suggests activity timing and objectives. Section 5.2 discusses process differences between the process model of the CTUC approach and that of the conventional approach.

5.1 Proposed CTUC Decision-Making Process

Establishing a model for the CTUC decision-making process was the first step in developing a beneficial Decision Support Tool. Figure 5.1 shows the proposed CTUC decision-making process. Each rectangle on the diagram represents an activity and contains a description of that activity. The bottom portion of the rectangle indicates which party is responsible for each activity (i.e., utility owner or TxDOT). The two actual meetings to be held for CTUC decision-making purposes (Activities #1 and #4) are indicated with bolded rectangles. The proposed CTUC decision-making process was designed to be implemented as early in the project as possible, but it cannot begin until the decision makers have the necessary information on project parameters, constraints, etc. Consequently, Activity #1 of the process, called CTUC Phase 1 Analysis, is scheduled to occur at approximately 0 percent Plan, Specification, and Estimate (PS&E). At this point on the project timeline, it is generally assumed that TxDOT will have a rough idea of which utilities will require adjustments, the approximate level of complexity, etc. CTUC Phase 1 Analysis is performed by TxDOT alone. The goal of this analysis is for TxDOT to use the CTUC Decision Support Tool to separate utilities that are definitely not suitable for the CTUC approach from those which may be appropriate for it (Goldman, 2005).

Following CTUC Phase 1 Analysis, the utilities deemed not suitable for the CTUC approach are then adjusted by the conventional method (Activity #2). Those utilities that may be suitable for the CTUC approach are invited (Activity #3) to CTUC Phase 2 Analysis (Activity #4), at which time both TxDOT decision makers and the utility representatives are expected to negotiate with each other about the applicability of the CTUC approach.

CTUC Phase 2 Analysis is performed as a combined effort by TxDOT decision makers and the utility representatives at approximately 30 percent PS&E. This analysis activity is performed during a meeting in which both the utility representatives and TxDOT staff provide information as prompted by the CTUC Decision Support Tool. As its name suggests, this phase requires more comprehensive information input from the stakeholders than the previous phase and is thereby able to produce more thorough results. Once the CTUC Decision Support Tool has gathered the necessary information from each party, it will provide outputs to guide each utility adjustment, recommending whether the CTUC approach would be beneficial for the given adjustment.

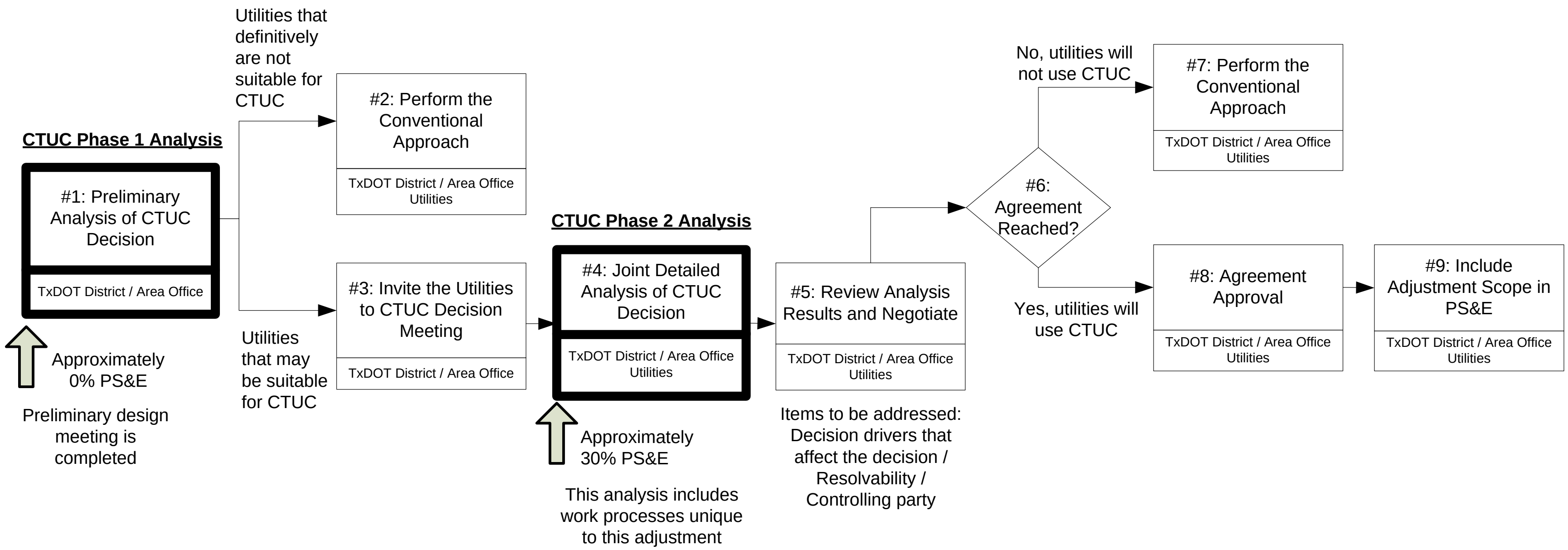

Figure 5.1: Proposed CTUC decision-making process (Goldman, 2005)

Following CTUC Phase 2 Analysis, Activity 5 requires each utility representative to meet individually with TxDOT to review CTUC analysis results and negotiate. This activity provides the utility and TxDOT the opportunity to discuss potential project-specific challenges that can be met through effective coordination. It also offers stakeholders an opportunity to rectify possible concerns associated with the CTUC approach and give participants the chance to consider any needed procedural changes. The ideal result of Activity #5 would be either a CTUC agreement between TxDOT and the utility owner, or a decision for the utility to perform the conventional adjustment approach (Activity #7). The actual CTUC decision is made during Activity #6.

Once the utility owner and TxDOT are able to establish a CTUC agreement that pleases both parties, Activities #8 and #9 are executed. These activities simply make the acceptance of the CTUC agreement official and initiate the inclusion of the utility adjustment scope in the final PS&E.

5.2 Process Differences between the Conventional and CTUC Approaches

One of the objectives in developing the CTUC decision-making process was to have the activities integrate nearly seamlessly with the current TxDOT-Utility Cooperative Management Process. This effort has resulted in a reduced number of process differences between the two approaches, particularly during the stages in which contracting techniques are chosen. The most significant process differences are presented here; other more subtle differences occur between the two approaches, but are not necessary for discussion in this section (Goldman, 2005):

- The activity called “Creating an Advance Funding Agreement (AFA)” occurs only in CTUC adjustments that are totally or partially non-reimbursable. This activity requires that the utility owner provide 100 percent of the required adjustment funding in escrow prior to the highway contractor beginning work. When the conventional approach is used, the adjustment financing is settled by the utility owner through their own agreements with subcontractors. The requirement that 100 percent of the funding be placed upfront in escrow for CTUC adjustments is an obstacle to the CTUC approach.
- When the PS&E development is complete and the information is passed to highway contractors, under the CTUC approach, the highway contractors will include utility adjustments in their development of work sequencing. If the conventional approach is in use, the contractor will receive an update on clearance dates/areas for the various utilities being adjusted.
- When the CTUC approach is used, the highway contractor bids on all work, including the utility adjustment. Under the conventional approach, the highway contractors bid only on the work originally included in the contract by TxDOT and allow the utilities to adjust themselves. For conventionally contracted projects, the possibility of project delays due to utilities not adjusted in a timely manner often motivates the highway contractor to add contingency costs in his or her bid. Since the contractor controls the work sequence under a CTUC contract, adding contingency costs to the bid is somewhat unnecessary.
- The activity called “Utility Coordination Meeting(s) during Construction” in the 2005 TxDOT Utility Manual is conducted according to the contracting technique. Under the conventional approach, these meetings are used to coordinate utility

adjustments in reference to clearance dates so that conflicts with highway construction project sequencing can be avoided. With the CTUC approach, such coordination is handled internally by the highway contractor because he or she is able to more efficiently adjust utilities while performing the construction work. The meetings still occur when the CTUC approach is used and include topics such as coordination of inspection, service interruptions, etc.

- The final major process difference occurs during the activity called “ROW and Utility Adjustment Subprocess.” This activity is the physical act of utility adjustment. Both timing and responsible party vary according to the approach taken. Under the conventional approach, the utility adjustment timing is critical because, typically, it must be completed before the highway contractor can perform the work. Project delays, which often occur because of unadjusted utilities, are costly and can be avoided using the CTUC approach. The conventional approach leaves the utility owner to either self-perform their adjustment work or hire a subcontractor to perform the adjustment. Using the CTUC approach, the highway contractor controls the work sequence and adjusts the utility accordingly.

The items discussed above are process differences between the conventional and CTUC approaches. These and other more subtle process differences have been identified by TxDOT and utility personnel, as well as through the review of literature. Each of these process differences can contribute a factor for or against the decision to use the CTUC approach.

6. Development of CTUC Decision Support Model

This chapter provides details of the development of the CTUC decision support model. The first section presents an analysis of the characteristics of the CTUC decision-making process. Following this analysis is a discussion of the CTUC decision support tool architecture. This chapter also sheds light on elements of the CTUC decision support model, descriptions of CTUC decision drivers, and offers suggestions on how to elicit knowledge from both TxDOT's and utility industry's experts. Finally, the CTUC Decision Support Tool is introduced, and the major functions of this tool are illustrated.

6.1 Characteristic Analysis of the CTUC Decision Making Process

Analyzing the characteristics of CTUC decision making could help facilitate the development of the CTUC decision support model, as well as help identify the primary functional requirements of the CTUC Decision Support Tool. The following paragraphs list the major characteristics of the CTUC decision-making process.

6.1.1 CTUC: Concurrent Decisions

As noted above, the CTUC decision should be made by decision makers (or referred to as "assessors" in the CTUC decision support model) from both the state DOT and the utility owner involved. Because one highway project often requires many utility adjustments, a state DOT assessor on any given project usually has a limited amount of time to determine which adjustments should be performed under the CTUC approach. This is a result of the expectation that most of the CTUC decisions will be determined during the highway design phase, as depicted in Figure 6.1. However, from a state DOT assessor's perspective, he or she may be confronted with the complications that arise from having to make several CTUC decisions at the same time. Figure 6.1 shows that Utility ABC and Utility DEF were identified early as requiring the utility adjustments in a highway project. The state DOT assessor performed utility coordination processes with the representatives from these two utilities. They discussed issues such as the scope of utility adjustments, the possibility of using the CTUC approach, etc. After several weeks, Utility XYZ was discovered and also required the adjustment. At this time, the state DOT assessor may find that using the CTUC approach was the best solution because physical interferences existed among the three utilities. He or she may need to reexamine the three utilities, negotiate again with all of the utility representatives, and finally make the three appropriate CTUC decisions before passing the "Point of No Return for the CTUC decision." The situation might become more complicated if the assessor is responsible for other projects or utility adjustments that have extensive coordination work at the same time.

Because one decision can distract the decision maker from another that is needed concurrently, one or both decisions can take more time than would be required in a serial context (Holsapple et al., 1996). Past research indicates that the use of a Decision Support System (DSS) application in a concurrent context might make it less effective than it would be in a serial context. Studies also suggest that by reducing the number of concurrent decisions required at the outset, DSS tools can help decision makers avoid the delays caused by so many simultaneous decisions (Holsapple et al., 1996). The complexity of CTUC decision making can be decreased if the first phase of the proposed CTUC decision-making process is pursued so as to eliminate the utility adjustments definitely not suitable for the CTUC approach. Such an early process of elimination would result in fewer concurrent CTUC decisions in the second phase of the proposed CTUC decision-making process. Once the utility adjustments that are appropriate to the CTUC approach are identified, the state DOT's negotiations with utility owners become more targeted and less time-consuming.

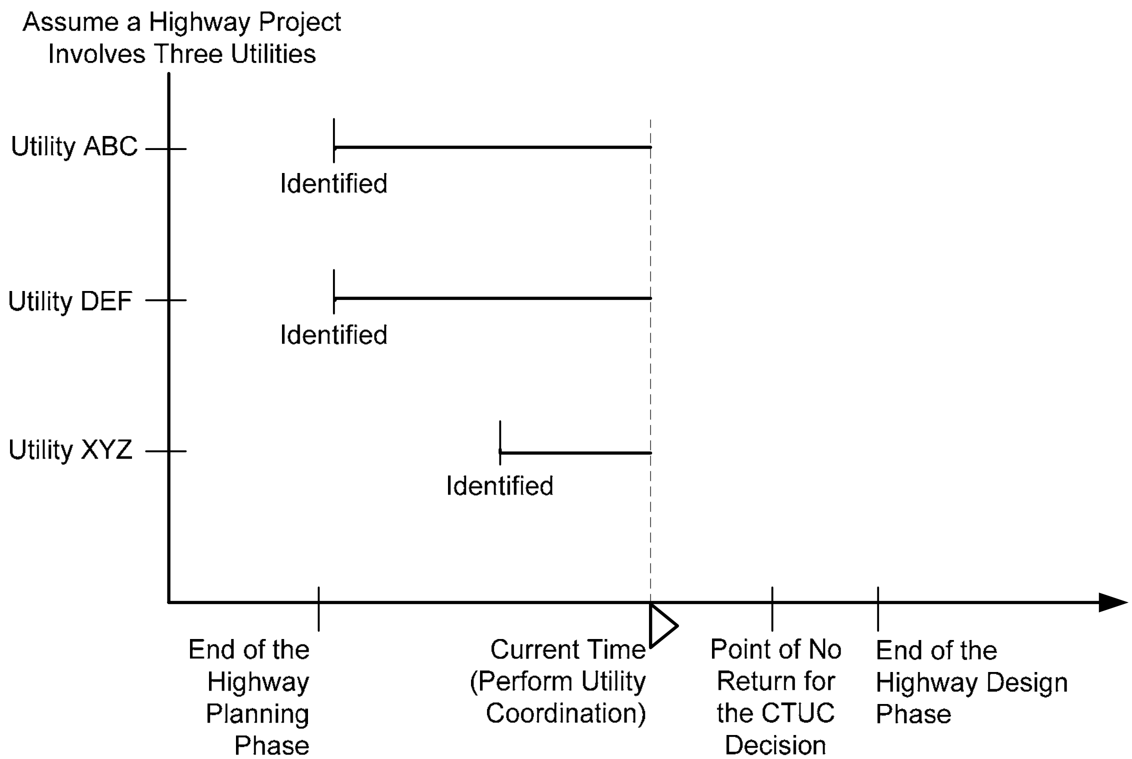

Figure 6.1: Timeframes of making several CTUC decisions from a state DOT assessor's view

6.1.2 CTUC: Multi-Party Decisions

In a typical highway project with at least two utility adjustments, coordination between utility owners is necessary not only because physical conflicts may exist among highway and utility facilities, but more importantly because utility owners may share some facilities that need to be adjusted in a special adjustment sequence. CTUC is a multi-party decision because both the state DOT and the utility owner involved have to reach an agreement in order to make the final decision. In addition, in some situations, one utility adjustment's CTUC decision might need to be examined jointly not only by the state DOT and the corresponding utility owner, but also by any other conflicting parties. Thus, all decision-related information should be stored centrally and be transferred to any involved party on demand.

6.1.3 CTUC: Negotiated Decisions

By definition, a negotiation decision entails that no single party can enforce the other parties to choose a certain alternative (Holsapple et al., 1996). Clearly, CTUC is a negotiation decision because neither the state DOT nor the utility owner involved can solely decide to use the CTUC approach without the other party's consent. Although the state DOT may have more authority and resources than the other parties, the state DOT still has to negotiate with the utility owner(s) involved in order to reach an agreement. A negotiated decision involves a give-and-take interchange among all parties until all agree on a particular alternative (Holsapple et al., 1996). This implies that extensive negotiation efforts might be needed in CTUC decision making, and that providing relevant decision recommendations might be more helpful and feasible than calculating a numerical score for the CTUC decision.

6.1.4 CTUC: Iterative Decisions

Currently in Texas, metropolitan highway projects involve more and more utility adjustments. These utility adjustments need to perform CTUC analyses because reducing utility adjustment delays in urban areas is of the utmost importance. In addition, if the best approach of one utility adjustment is CTUC, and if the other adjustment has exactly the same set of characteristics as the first adjustment, the conclusion can be made that the second adjustment should also use the CTUC approach. Research has shown that the development of routines allows decision makers to attain mastery over their choices; once a behavioral solution to a decision problem has been learned and stored in memory, individuals can use this knowledge when they re-encounter the same kind of problem (Betsch and Haberstroh, 2005).

CTUC is an iterative decision because (1) the need to perform CTUC analysis for utility adjustments always exists due to the increased number of metropolitan highway projects; and (2) the factors that influence the CTUC decision can be modeled so that the assessors can review the CTUC experts' knowledge in order to make a better decision.

6.1.5 Lack of Quantitative Data

Traditionally, most CTUC decisions have been made based on senior project stakeholders' experience. The experienced project stakeholders know whether the CTUC approach is the best choice, as long as they have the correct decision drivers information for current project circumstances. However, it is very difficult to represent the project stakeholders' knowledge in any quantitative format; it may be possible, though, to acquire and document the project stakeholders' experience in a knowledge management system.

Another possible quantitative data source is the TxDOT Utility Database. However, this database was designed to keep track of essential information for obtaining utility permits. Although the database schema might contain some important inputs to CTUC decision making, relevant information on CTUC decision drivers may still need to be collected and analyzed from other data sources. Overall, the lack of quantitative data suggests that the CTUC decision support model shall comprise more qualitative information from experts than quantitative data from numeric data sources.

6.1.6 Dynamic Environment

CTUC decisions are made in a dynamic environment, which means that external, uncontrollable events may occur and influence the CTUC decision. For example, when the CTUC decision is being considered at approximately 30 percent PS&E, assessors may be told that there is no HAZMAT in the utility adjustment work zone. Such a circumstance might have a neutral impact on the CTUC decision at that point in the process. However, when CTUC assessors revisit this decision at approximately 60 percent PS&E, a SUE contractor may discover HAZMAT in the utility adjustment zone. This circumstance quickly becomes a show-stopper for the CTUC decision from the state DOT assessors' perspective. Project circumstances that influence the CTUC decision such as the existence of HAZMAT vary as time elapses. Once assessors know more about an underlying problem context, they may change their minds and use a different approach. Therefore, the CTUC Decision Support Tool should provide a persistence service that stores the history of each CTUC decision analysis record and that allows assessors to re-examine these records at any time.

6.1.7 Miscellaneous Requirements

In addition to identifying the aforementioned characteristics, the research team also found that the following requirements should be considered for developing the CTUC Decision Support Tool:

- The CTUC Decision Support Tool should serve as a means to facilitate a decision dialogue with all parties, rather than to calculate a decision score for each approach.
- The CTUC Decision Support Tool should provide transparency in invoking assessors' judgment on the relative importance of decision drivers.
- The CTUC Decision Support Tool should help assessors sort out what decision factors drive or impede the use of the CTUC approach on the utility adjustment under consideration.

6.2 Comparison between CTUC and the General Human Decision-Making Process

Since DSS technologies are widely used in many research domains, providing better CTUC decision recommendations would need to reuse or integrate current DSS technologies. Many researchers have investigated the general human decision-making process model in order to select an appropriate DSS architecture for a given problem domain (Forgionne, 2000). This general process model was originally proposed by Simon in 1960 and is summarized as follows (Simon, 1960):

(1) Intelligence: Observe reality. Gain problem understanding. Acquire needed information.

(2) Design: Develop decision criteria. Develop decision alternatives. Identify relevant uncontrollable events. Specify the relationships between criteria, alternatives, and events.

(3) Choice: Logically evaluate the decision alternatives. Develop recommended actions that best meet the decision criteria.

(4) Implementation: Ponder the decision analyses and evaluations. Weigh the consequences of the recommendations. Gain confidence in the decision. Develop an implementation plan. Secure needed resources. Put implementation plan into action.

The proposed CTUC decision-making process (see Figure 5.1) was then compared with the general human decision-making process. The actual CTUC decision is made in the "Choice" phase, which closely parallels Activity 5 of the CTUC process, and in the "Implementation" phase, which corresponds to Activities 6-9 in the CTUC process.

In DSS, a mathematical model is developed to describe the problem domain (Holsapple et al., 1996). A model-driven DSS can then apply the mathematical model in a decision simulation under varied events in order to help decision makers evaluate the decision alternatives (Holsapple et al., 1996). A model-driven DSS can usually help decision makers in the “Choice” phase because the computation task of decision simulation may be complex and extensive (Forgionne, 2000). However, because there are not enough quantitative data to formulate a mathematical model for the CTUC decision, nor is the extensive computation work of the model needed, a model-driven DSS would not appropriate as a base framework for the development of the CTUC Decision Support Tool.

In the “Intelligence” and “Design” phases, some other DSSs can assist decision makers in identifying significant decision drivers and their relationships (Forgionne, 2000). For example, decision makers can use an Executive Information System (EIS) to analyze all business transaction records, and the EIS can extract potential factors that influence customer purchasing behavior (Holsapple et al., 1996). Similarly, the CTUC Decision Support Tool should be able to help assessors identify significant decision drivers as well. This is because CTUC is a very complex decision involving numerous decision drivers, and not all of these decision drivers assert themselves equally under the given project situations. In addition, since junior assessors may not be familiar with the CTUC approach, and senior assessors might also need the CTUC Decision Support Tool to double-check the reasonableness of their decisions, the CTUC Decision Support Tool should be designed to serve as a knowledge base in order to help assessors identify relevant decision drivers effectively and efficiently. This knowledge base should store information on significant CTUC decision drivers alongside experts’ corresponding opinions. In other words, assessors can reuse the knowledge stored in the CTUC Decision Support Tool and should be able to easily apply it in real problem contexts.

In sum, since the CTUC decision requires a multi-party negotiation process, the CTUC Decision Support Tool may need a mechanism such as the knowledge base described above to collect and arrange both the state DOT’s and the utility owners’ opinions. By making the opinions of all parties available for review to everyone involved, the tool would make it easier for state DOT and utility assessors to arrive at final decisions. The CTUC Decision Support Tool should be positioned as a DSS to help assessors isolate significant CTUC decision drivers. In order to achieve this goal, all potential CTUC decision drivers should be identified and assessed by experts from both the state DOT and the utility industry. With use of the CTUC decision support model, the learning curve of mastering the CTUC decision would be shortened for junior assessors. Senior assessors would find the CTUC Decision Support Tool to be an effective management tool to coordinate all utility adjustments involved in a project and to facilitate communication between all project stakeholders.

6.3 Design of the CTUC Decision Support Model

The CTUC decision support model should have the capability of representing all potential decision drivers that may influence the CTUC decision and to store experts’ opinions on every decision driver from both the state DOT and the utility industry. Once this CTUC decision support model and the associated knowledge base were fully conceptualized, the development of the CTUC Decision Support Tool began. Assessors could use the CTUC Decision Support Tool to quickly identify the most significant decision drivers. This section describes the basic elements and mechanisms of the CTUC decision support model.

6.3.1 Definitions of Question, Option and Decision Driver

In the CTUC decision support model, a question is defined as follows: a question asks a specific aspect of the CTUC decision, and assessors can select only one of several possible options as the answer to the question.

An option of a question is defined as follows: an option denotes a unique circumstance that is assumed to arise in the course of the highway project or the utility adjustment. The option chosen may be certain before the CTUC decision is made, or it may be uncertain with an associated probability.

Further, if the circumstance listed in an option influences the CTUC decision either in a positive way (favorable for the CTUC approach) or in a negative way (favorable for the conventional approach), this option is therefore defined as a CTUC decision driver in this research. Briefly, a CTUC decision driver expresses a unique circumstance that calls for the implementation of either the conventional or the CTUC approach. In other words, CTUC decision drivers are causal factors that trigger the use of either approach on a given utility adjustment. A decision driver is a factor that drives or impedes the CTUC decision, and a question contains an exclusive set of options. Some of the options are CTUC decision drivers while others are not. For example, the question, “Can the adjustment be performed only during the highway construction phase (e.g., permit issues or utility adjustment work are contingent upon some level of construction work completion)?” is an uncertain question with two possible options: (1) Yes; and (2) No. The answer to this question is also uncertain because it represents a future state of the project and cannot be confirmed unless the highway construction work begins. Assessors simply select the most possible option based on their understanding of the current project. In addition, if assessors select “No” as the answer to this question, i.e., the utility adjustment can be performed any time, because neither the conventional approach nor the CTUC approach will be promoted by this circumstance, this option cannot become a CTUC decision driver because of its lack of influence on the CTUC decision.

Another question, “Is the eligibility ratio of the adjustment 100% or nearly 100%?” is a certain question with two possible options: (1) Yes; and (2) No. The answer to this question is also certain because TxDOT determines this ratio before adopting the CTUC approach. Assessors simply select the correct option based on their understanding of the current project. In addition, because neither the conventional approach nor the CTUC approach will be promoted by this circumstance, if the assessors select “No” as the answer to this question, i.e., the utility owner has to pay the utility adjustment costs, this option cannot become a CTUC decision driver because of its insignificance to the CTUC decision.

6.3.2 Definition of Decision Context

Theoretically, any factor that may influence the CTUC decision should be represented as a decision driver. All of the potential CTUC decision drivers were analyzed to design appropriate questions to address every aspect of the CTUC decision. As noted before, a question can contain many options and, because some of the options influence the CTUC decision, they can be considered CTUC decision drivers. After all potential decision drivers had been identified, the research team collected the experts’ opinions on each decision drivers to begin crafting the knowledge base of the CTUC Decision Support Tool. Once the CTUC Decision Support Tool and the associated knowledge base were developed, assessors were able to use this tool to help review their CTUC decisions; the CTUC Decision Support Tool was able to show the impact levels and recommendations of decision driver from all the experts’ perspectives. In sum, the

CTUC Decision Support Tool can filter out irrelevant decision drivers and present only significant ones for a given CTUC decision.

The anterior process of developing the CTUC decision support model implies that experts' opinions on each CTUC decision driver are applicable to every project scenario. In other words, each CTUC decision driver is assumed to be independent because its associated impact level and expert recommendations remain constant. As long as assessors acknowledge the existence of the circumstance described in the CTUC decision driver, the CTUC Decision Support Tool shows the corresponding expert assessment of the decision driver.

However, there are some factors that profoundly affect the CTUC decision drivers. These factors affect the CTUC decision in an indirect way because they influence more than one decision driver at the same time. For example, the type of an assessor (state DOT or utility owner) influences almost all CTUC decision drivers. While it cannot be said that state DOT assessors always prefer the CTUC approach, it can be said that the number and duration of lane closures caused by utility adjustments is one of their paramount concerns. Conversely, because lane closures are of little concern to utility owners, they are likely to favor CTUC for different reasons. The types of assessors making the CTUC decision determines a "Decision Context," the setting in which the decision is made. The CTUC Decision Support Tool should record every decision context state for a given CTUC decision.

A decision context can change the impact level of a decision driver on the CTUC decision. For example, the CTUC decision driver called "2.9 Utility plans are unacceptable." means that the utility cannot provide a set of plans that meet the requirements of the project and the state DOT accommodation rules, and "2.9" is its assessment question number. Hence, it would be classified as Anti-CTUC and might have a high impact on the design aspect of the project. However, if the subject utility owner is a local government and has a good relationship with the state DOT, the decision driver would become CTUC-neutral because the public utility is usually willing to let the state DOT manage the utility adjustment, including hiring utility adjustment design consultants to develop the plans. The two factors, "Public utility" and "Good relationship," thus become two decision contexts because these factors indirectly influence the CTUC decision, influence more than two decision drivers at the same time, and should be recorded in the CTUC Decision Support Tool to remind assessors of possible changes in the decision drivers' impact levels.

A decision context can accept plain text and one or more pre-defined options as its current state in the CTUC Decision Support Tool. The CTUC decision support model uses decision contexts to include assessors' special considerations. Although decision contexts were identified by experts, it is the assessor that determines the final impact levels of the affected decision drivers when he or she reviews the CTUC decision. Experts were assumed to evaluate each CTUC decision driver in a project-independent way, and assessors are expected to fill in the project-specific issues in relation to decision contexts.

6.3.3 Basic Elements of a Decision Driver

CTUC decision drivers were designed to help experts express their thoughts on issues relevant to the CTUC decision. As noted above, the expert opinions recorded in the CTUC Decision Support Tool can help assessors identify and address significant CTUC issues more efficiently and effectively. The basic elements of a CTUC decision driver in the CTUC decision support model are described as follows:

- **Decision Driver Name**
  The name of a decision driver. For example, “severe schedule pressures.”

- **Circumstance Description**
  A statement that describes a hypothetical circumstance for a decision driver. For example, the complete description of “severe schedule pressures” is the following: “the project has severe schedule pressures, and the utility adjustment scope can be well defined before 60% PS&E.”

- **CTUC Preference**
  The preferred approach of a decision driver from an expert’s perspective. There are five possible choices of CTUC preference, namely: (1) Pro-CTUC; (2) sometimes Pro-CTUC and sometimes Neutral; (3) Neutral; (4) sometimes Anti-CTUC and sometimes Neutral; and (5) Anti-CTUC. Note that only an expert can select one of the above five choices.

- **Impact Level**
  The degree of the impact caused by the circumstance defined in a decision driver. If experts select “Pro-CTUC” or “sometimes Pro-CTUC and sometimes Neutral” as the answer to “CTUC Preference,” the possible impact level can be one of the following: (1) High; (2) Medium; (3) Low; and (4) No Impact.

  If experts select “Anti-CTUC” or “sometimes Anti-CTUC and sometimes Neutral” as the answer to “CTUC Preference,” the possible impact level can be one of the following: (1) Show-Stopper; (2) High; (3) Medium; (4) Low; and (5) No Impact. Note that “Show-Stopper” should be selected only when the circumstance precludes further CTUC analysis. In other words, the conventional approach would definitely be used for the subject utility adjustment.

  If experts select “Neutral” as the answer to “CTUC Preference,” they can skip this element because its answer must be “No Impact.”

- **Situation Resolvable**
  This element determines whether or not the circumstance defined in a decision driver can be improved to facilitate the CTUC approach. Because making a CTUC decision requires a series of negotiation activities, assessors may want to know whether experts believe the given circumstance can be improved to facilitate the CTUC approach. The answer may be “Yes” or “No.”

- **Responsible Parties**
  If experts select “Yes” as the answer to “Situation Resolvable,” they can further specify the party or parties since assessors may want to know who will be expected to make the necessary process changes to facilitate the CTUC approach. In the current CTUC decision support model, the potential responsible parties include: (1) the state DOT; (2) Utility; and (3) Other. Experts may select none, or more than one of the above parties. The current CTUC decision support model also provides a plain text field for this

element so that the approved practice to ameliorate this circumstance can be described in prose.

6.4 Development of the CTUC Decision Drivers Assessment Form

After assembling the basic elements of the decision drivers, the research team analyzed the results of the literature review and reviewed with the CTUC benefits and challenges table and the CTUC decision-making process in order to develop the CTUC decision drivers assessment form. This form, presented in Appendix D, includes questions, options, and decision drivers defined in the CTUC decision support model. The PMC members were first invited to review the CTUC decision drivers assessment form, and then experts from both TxDOT and the utility industry were invited to fill out this form. These experts' responses constituted the knowledge base of the CTUC decision support model.

6.4.1 Transforming Issues into the CTUC Decision Drivers Assessment Form

Figure 6.2 is the flowchart showing how an issue was transformed into a question on the CTUC decision drivers assessment form. In Step 1, issues were identified from the literature review, the CTUC benefits and challenges table, and so forth. In Steps 2-3, if the issue analyzed was deemed as having an indirect impact on the CTUC decision or as having a profound impact on many potential CTUC decision drivers, the issue was listed as a decision context and given a formal description. Experts were not expected to assess the impact level of the decision contexts. The appropriateness of listing an issue as a decision context was reviewed by PMC members. For example, they considered the issue of whether the utility adjustment includes demolition to be an important factor, but one that may not have a direct impact on the CTUC decision; hence, the issue was listed as a decision context.

However, if the issue analyzed does have a direct impact on the CTUC decision, in Steps 4-5 the corresponding question was drafted so that all related issues could be covered by this question. For example, during the preliminary research interviews with several utility companies, the issue of adopting TxDOT design specifications as their utility adjustment design specifications was identified as an important factor in selecting the CTUC approach. Further, because there are other scenarios regarding the source of the utility adjustment design specifications, the question and all of the possible options were drafted as follows:

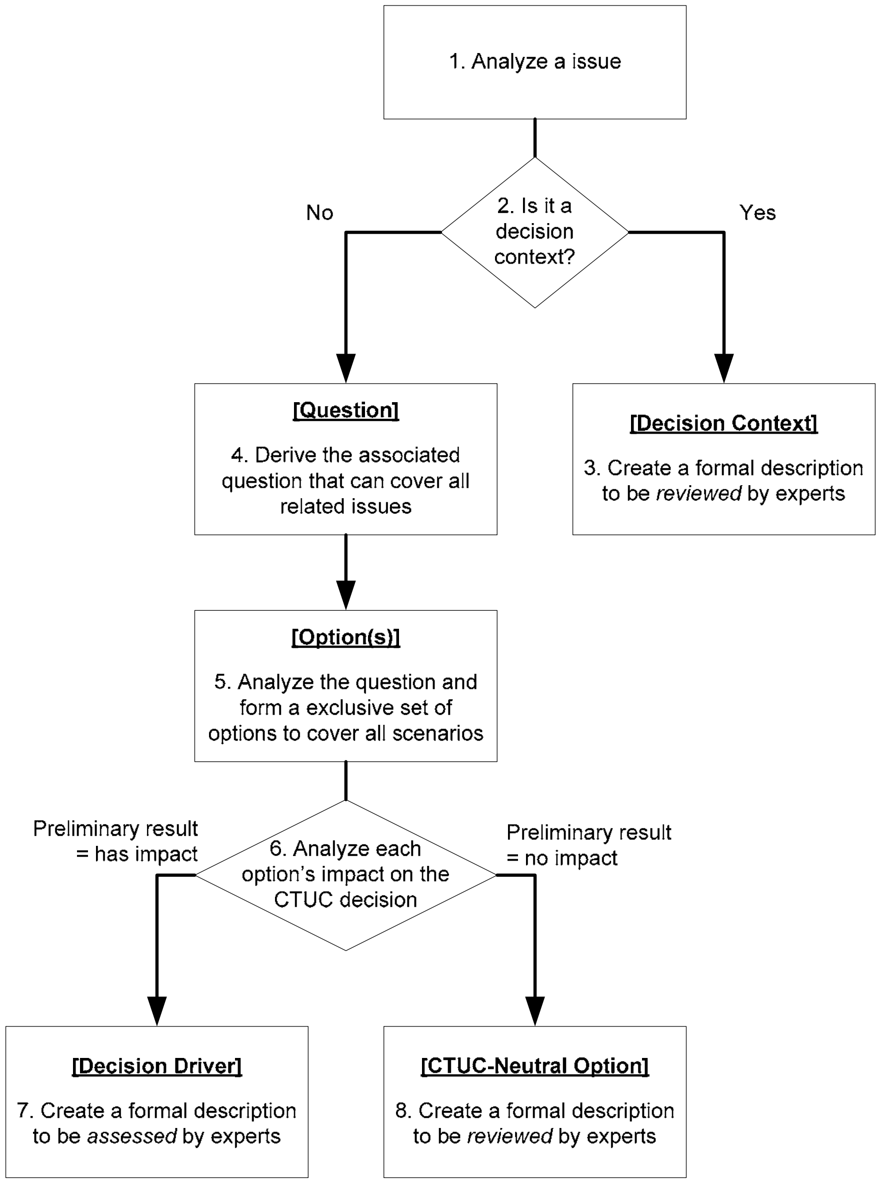

Figure 6.2: Flowchart showing how issues are translated into questions on the CTUC decision drivers assessment form

- Question: what is the utility's attitude toward design specifications for the project?
- Option 1: The utility is willing to adopt TxDOT design specifications for the project.
- Option 2: A new composite set of specifications (comprised of the utility and TxDOT provisions) is needed for the project.
- Option 3: The utility will use utility design specifications for the project.

Note that all of the options are exclusive. Assessors can select only one of the above options as the answer to the question to best describe their utility adjustment.

In Steps 6-8, the preliminary impact level of every option to each question was analyzed in order to identify the options that are definitely CTUC-neutral. These CTUC-neutral options were then verified by PMC members so that the remaining options could be classified as CTUC decision drivers. Identifying these CTUC-neutral options in advance reduced the time it took for the experts to assess the CTUC decision drivers.

For example, Option 3 of the above question is the typical approach to design utility adjustment specifications. The research team was told that both the CTUC and the conventional approaches have included the design specifications provided by utility owners. Hence, this option is CTUC-neutral and cannot qualify as a decision driver.

6.4.2 Classification of the Scope of Influence for Each Question

After the questions related to the CTUC decision were formulated and their options and decision drivers were identified, they were divided into five groups, according to their scope of influence: (1) project-level questions; (2) utility-level questions; (3) reimbursable adjustments questions; (4) non-reimbursable adjustments questions; and (5) special project configuration questions. This grouping is important because a highway project may involve many utility adjustments and the decision of whether or not to use the CTUC approach for one utility adjustment is made by both TxDOT and the corresponding utility assessor (see Figure 6.3).

- **Project-level questions**
  The project-level questions contain the decision drivers that can influence all of the CTUC decisions for a highway project. For example, the question, "do heavy traffic conditions exist at the project location (e.g., in metropolitan or urban areas)?" contains the decision driver called "2.1 The traffic condition on the project location is heavy." Suppose all TxDOT experts think that the above circumstance strongly supports the use of the CTUC approach, and a TxDOT assessor thinks that his or her project has the circumstance. Clearly, the answer to this project-level question can be applied to all CTUC decisions within the highway project; in other words, each utility adjustment within the highway project inherits the answers to project-level questions.

- **Utility-level questions**
  The utility-level questions contain the decision drivers that can influence only the given utility adjustment. For example, the question "does the utility adjustment work include extensions beyond the ROW or outside the construction project limits?" contains the decision driver "the utility adjustment work includes extensions beyond the ROW or outside the construction project limits." Suppose all experts think that the above circumstance strongly supports the use of the conventional approach, and an assessor thinks that his or her utility adjustment has this circumstance. Obviously this situation only affects one utility adjustment decision on the project and barely affects the other utility adjustment decisions; in other words, experts would only recommend that this particular utility adjustment be completed with the conventional approach.

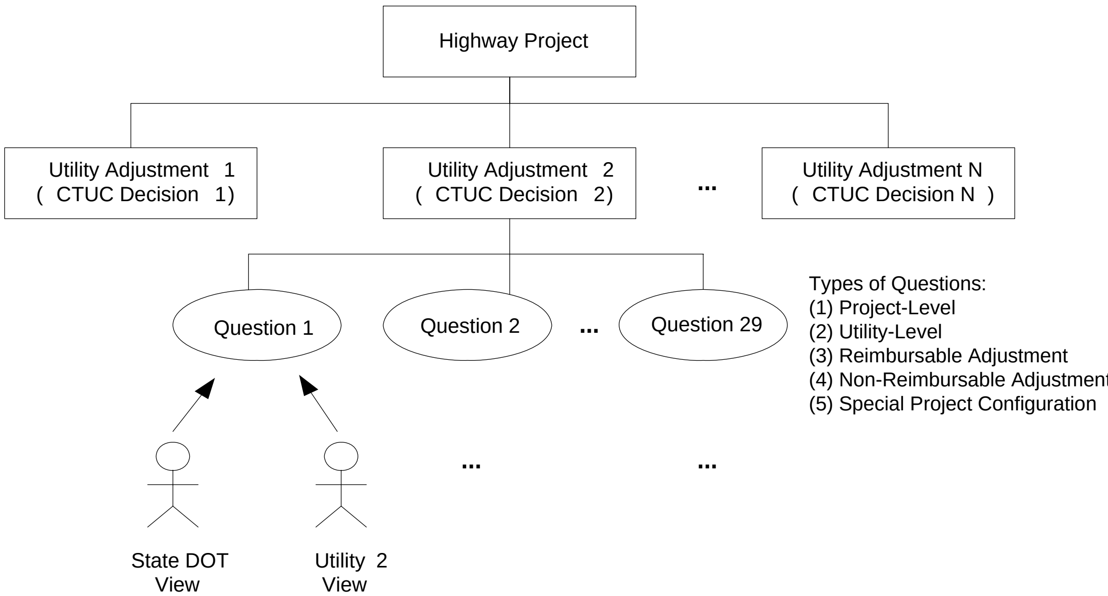

Figure 6.3: The relationships among the project, utility adjustments, and decision drivers

- **Reimbursable and non-reimbursable adjustments questions**
  Cost-oriented questions definitely influence the CTUC decision. During the preliminary research interviews with utility companies, experts strongly indicated that the cost-related questions pertaining to reimbursable adjustments play a less important role in CTUC decision making from their perspective. Therefore, two categories were designed to accommodate the requirements, i.e., one for reimbursable adjustments questions and the other for non-reimbursable adjustments questions. For example, the question "will possible utility delay costs be reduced due to the adjustment schedule controlled by the CTUC contractor?" contains the decision driver "possible utility delay costs could be reduced due to the adjustment schedule controlled by the CTUC contractor." Clearly, the above circumstance may motivate utility owners to use the CTUC approach under a non-reimbursable adjustment. However, under a reimbursable adjustment, only TxDOT would be motivated to use the CTUC approach if the above circumstance is likely to happen.

- **Special project configuration questions**

Some utility owners affected by a highway project may share the same set of physical underground or overhead facilities. In this case, the group of utility owners involved can be regarded as a single utility owner as long as these utility owners agree to share the facilities after the adjustments are complete. For example, utility vaults, trenches at different depths, multi-duct conduits, or utility corridors are all underground physical facilities that may be shared by different utility owners. Poles may be owned by a power company and shared by a cable company and a telephone company. Because some of the questions pertain to such special project configuration issues, the associated decision drivers influence only those CTUC decisions whose utility adjustments are in the special project configuration. For example, the question, "if some utilities in the project share the same poles, what is the tendency of using the CTUC approach?" contains the decision driver called "2.14 The pole owner is not willing to join CTUC, but the others are." Clearly not only the pole owner's CTUC decision but the pole tenants' are influenced by the answer to this question.

6.4.3 Classification of the Expression of Each Decision Driver

It is necessary to clearly describe the circumstance defined in a decision driver so that each question's decision driver is unique. All of the decision drivers' descriptions can be categorized to three types of expressions: (1) descriptive; (2) hypothetical; (3) comparative. These three types are explained below.

- **Descriptive Decision Driver**
  In general, experts can assess the impact level of a descriptive decision driver directly without considering other issues at the same time because the descriptive decision driver represents a single, unique phenomenon in a project. For example, "heavy traffic conditions," "physical utility interferences," and "the existence of HAZMAT" are all descriptive decision drivers.

- **Hypothetical Decision Driver**
  The description of a hypothetical decision driver includes a statement presuming use of either the conventional or the CTUC approach. Experts were expected to assess the impact level of a hypothetical decision driver with the assumption that either the conventional or CTUC approach would be pursued. For example, the decision driver called "5.11 The pool of likely TxDOT contractors is willing to hire a subcontractor from a list of pre-qualified contractors provided by the utility." implies that the CTUC approach will be used. Experts must be informed of the assumption or an incorrect assessment result would be obtained.

- **Comparative Decision Driver**
  The description of a comparative decision driver includes a statement regarding the performance comparison of the conventional and the CTUC approaches for a given circumstance. Experts can assess the impact level of a comparative decision driver by considering the consequences of both approaches for a given circumstance. For example, the decision driver called "2.2 CTUC will require substantially fewer lane closures than the conventional approach during the project execution." is a comparative decision driver for the lane closure circumstance. Experts were expected to understand the consequences of substantially fewer lane closures during the project execution in both approaches and assess their impact level on the CTUC decision. Comparative decision drivers are difficult for experts to assess because experts must have extensive experience in using both approaches and be aware of the outcome of the given circumstance.

6.4.4 Complete List of All CTUC Decision Drivers and Attributes

The final version of the CTUC decision drivers assessment form is included in Appendix D. The complete properties of all CTUC decision drivers, including their questions, etc., are listed in Appendix E. Table 6.1 only lists the basic attributes of all the decision drivers.

In Table 6.1, the column title labeled "Decision Driver" means the complete description of a given decision driver. The column title labeled "Assessment Question #" means this decision driver's question number of the question which is assessed by the experts and is defined in the CTUC decision drivers assessment form. The column title labeled "Question # (CTUC Phase 1 Analysis)" means this decision driver's question number of the question which is answered by the TxDOT assessors and is defined in CTUC Phase 1 Analysis. The column title labeled "Question # (Phase 2 TxDOT Analysis)" means this decision driver's question number of the question which is answered by the TxDOT assessors and is defined in CTUC Phase 2 TxDOT Analysis. The column title labeled "Question # (Phase 2 Utility Analysis)" means this decision driver's question number of the question which is answered by the utility assessors and is defined in CTUC Phase 2 Utility Analysis. Note that not all questions are asked in CTUC Phase 1 Analysis because some questions are not answerable due to insufficient information during 0 percent – 15 percent PS&E. In addition, some reimbursable adjustments questions are inappropriate for utility owners to answer.

The column title labeled "Scope of Influence" means the scope of influence of a given question, which can be the following: (1) Prj: a project-level question; (2) Util: a utility-level question; (3) R: a reimbursable adjustments question; (4) NR: a non-reimbursable adjustments question; and (5) Special: a special project configuration question.

The final column title labeled "Type of Decision Driver" means the expression type of a given decision driver. The expression type of a decision driver can be the following: (1) D: a descriptive decision driver; (2) H: a hypothetical decision driver; and (3) C: a comparative decision driver.

6.4.5 Complete List of All CTUC Decision Contexts

The complete descriptions of all CTUC decision contexts are shown in Table 6.2. The column title labeled "Question" is the definition of each decision context in a question format. These questions were derived from the results of the literature review and the preliminary research meetings with TxDOT and utility owners. The column title labeled "Possible Answers" lists all of the possible answers to a given question. In addition, CTUC assessors can use plain text to describe the current project circumstance regarding the given question.

Table 6.1: List of all CTUC decision drivers and attributes

#	Decision Driver	Assessment Question #	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Scope of Influence	Type of Decision Driver
1	The traffic condition at the project location IS HEAVY.	2.1	2.1	2.1	2.1	Prj	D
2	CTUC WILL require substantially FEWER lane closures than the Conventional approach during the project execution.	2.2	2.2	2.2	2.2	Prj	C
3	Physical interferences EXIST between 2 or more adjusted utilities on the project.	2.3	2.3	2.3	2.3	Prj	D
4	The adjustment can be performed ONLY DURING the construction phase.	2.4	2.4	2.4	2.4	Util	D
5	The project HAS severe schedule pressures, and CTUC can lead to EARLIER project completion.	2.5	2.5	2.5	2.5	Prj	H
6	The project HAS severe schedule pressures, and the utility adjustment scope CANNOT be well defined at approximately 60% PS&E.	2.6					D
7	The project DOES NOT HAVE schedule pressures.	2.7					D
8	The utility CAN provide a set of plans that meet the requirements of the project and the TxDOT accommodation rules.	2.8		3.18	3.18	Util	H
9	The utility CANNOT provide a set of plans that meet the requirements of the project and the TxDOT accommodation rules.	2.9					H
10	The utility CAN provide a set of specifications that are acceptable to TxDOT in terms of assignment of responsibility, liability, and risk.	2.10		3.19	3.19	Util	H

#	Decision Driver	Assessment Question #	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Scope of Influence	Type of Decision Driver
11	The utility CANNOT provide a set of specifications that are acceptable to TxDOT in terms of assignment of responsibility, liability, and risk.	2.11					H
12	CTUC WILL increase utility adjustment coordination and provide benefits to all involved utilities.	2.12		3.9	3.9	Special	H
13	Both the pole owner and tenant utilities are willing to join CTUC.	2.13					H
14	The pole owner IS NOT willing to join CTUC, but the others ARE.	2.14					H
15	The pole owner IS willing to join CTUC but the pole tenants ARE NOT.	2.15		3.11	3.11	Special	H
16	All utilities ARE NOT willing to comply with the CTUC schedule.	2.16					H
17	The eligibility ratio of the adjustment IS 100% or NEARLY 100%.	3.1	4.0	4.0	4.1	R	D
18	CTUC adjustment costs will be more than 15% CHEAPER than the Conventional approach for the project.	3.2					C
19	CTUC adjustment costs will be 5%-15% CHEAPER than the Conventional approach for the project.	3.3		4.5	4.2	R	C
20	CTUC adjustment costs will be 5%-15% MORE EXPENSIVE than the Conventional approach for the project.	3.4					C
21	CTUC adjustment costs will be more than 15% MORE EXPENSIVE than the Conventional approach for the project.	3.5					C
22	Increased utility adjustment costs WILL likely occur due to the TxDOT contractor's FRONT-END LOADING with CTUC.	3.6	4.1	4.1		R	H

#	Decision Driver	Assessment Question #	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Scope of Influence	Type of Decision Driver
23	Increased contractor CHANGE ORDER frequencies and markups WILL likely occur with CTUC.	3.7	4.2	4.2		R	H
24	Increased costs due to the ADDED CONTRACTUAL TIER of subcontractors WILL result from CTUC.	3.8		4.3		R	H
25	Possible UTILITY DELAY COSTS could be reduced due to the adjustment schedule controlled by the CTUC contractor.	3.9		4.4	4.3	R	H
26	The utility IS NOT able or willing to pay for adjustments in advance.	4.1	5.2	5.2	5.2	NR	H
27	The utility CANNOT QUALIFY for State Infrastructure Bank funding for the project.	4.2	5.3	5.3	5.3	NR	H
28	CTUC adjustment costs will be more than 15% CHEAPER than the Conventional approach for the project.	4.3					C
29	CTUC adjustment costs will be 5%-15% CHEAPER than the Conventional approach for the project.	4.4		5.9	5.9	NR	C
30	CTUC adjustment costs will be 5%-15% MORE EXPENSIVE than the Conventional approach for the project.	4.5					C
31	CTUC adjustment costs will be more than 15% MORE EXPENSIVE than the Conventional approach for the project.	4.6					C
32	Increased utility adjustment costs WILL likely occur due to the TxDOT contractor's FRONT-END LOADING with CTUC.	4.7	5.4	5.4	5.4	NR	H
33	Increased contractor CHANGE ORDER frequencies and markups WILL likely occur with CTUC.	4.8	5.5	5.5	5.5	NR	H

#	Decision Driver	Assessment Question #	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Scope of Influence	Type of Decision Driver
34	Increased costs due to the ADDED CONTRACTUAL TIER of subcontractors WILL result from CTUC.	4.9		5.6	5.6	NR	H
35	Possible UTILITY DELAY COSTS could be reduced due to the adjustment schedule controlled by the CTUC contractor.	4.10		5.7	5.7	NR	H
36	Increased INDIRECT COSTS to utilities from TxDOT charges for Engineering and Contingency fees WILL result from CTUC.	4.11		5.8	5.8	NR	H
37	The utility adjustment work includes extensions BEYOND the TxDOT ROW or outside the construction project limits.	5.1	3.1	3.12	3.12	Util	D
38	The CTUC contractor WILL be significantly more EFFECTIVE at controlling traffic for the project (vs. Conventional).	5.2		3.16	3.16	Util	C
39	The CTUC approach will have better safety control.	5.3		3.17	3.17	Util	C
40	The Conventional approach will have better safety control.	5.4					C
41	The utility-adjustment-related site clearing and grubbing is SUBSTANTIAL on the project.	5.5		3.13	3.13	Util	D
42	HAZMAT-related work ONLY applies to the utility adjustment work.	5.6	3.8	3.15	3.15	Util	D
43	The utility is willing to ADOPT TxDOT design specifications for the project.	5.7		3.20	3.20	Util	H
44	A new COMPOSITE set of specifications (comprised of the utility and TxDOT provisions) is needed for the project.	5.8					H
45	Only the UTILITY's crew can perform the utility adjustment.	5.9	3.9	3.8	3.8	Util	D

#	Decision Driver	Assessment Question #	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Scope of Influence	Type of Decision Driver
46	With CTUC the utility's crews will be FREED UP for other projects.	5.10		3.21	3.21	Util	H
47	The utility adjustment includes an extensive amount of utility facility upgrades in relation to the transportation work.	5.12		3.22	3.22	Util	D
48	The utility adjustment work includes a detrimental change to the project's environmental clearance.	5.13	3.10	3.23	3.23	Util	D
49	The pool of likely TxDOT contractors IS WILLING to HIRE a subcontractor from a list of pre-qualified contractors provided by the water/wastewater type of utility.	5.11	3.7	3.7	3.7	Util	H
50	The pool of likely TxDOT contractors IS WILLING to HIRE a subcontractor from a list of pre-qualified contractors provided by the communication type of utility.						
51	The pool of likely TxDOT contractors IS WILLING to HIRE a subcontractor from a list of pre-qualified contractors provided by the distribution power type of utility.						
52	The pool of likely TxDOT contractors IS WILLING to HIRE a subcontractor from a list of pre-qualified contractors provided by the transmission power type of utility.						
53	The pool of likely TxDOT contractors IS WILLING to HIRE a subcontractor from a list of pre-qualified contractors provided by the natural gas type of utility.						

Table 6.2: Complete list of all decision contexts

#	Question	Possible Answers
1	Do physical interferences EXIST between 2 or more adjusted utilities on the project? If so, which ones?	(Plain Text)
2	If the project HAS schedule pressures BUT not severely, please elaborate:	(Plain Text)
3	Please indicate which of the listed utility adjustment scope descriptions are applicable to this project: (1) Any extended casing?	Yes / No / Don't Know
4	Please indicate which of the listed utility adjustment scope descriptions are applicable to this project: (2) Any demolition/removal?	Yes / No / Don't Know
5	Please comment on this adjustment scope.	(Plain Text)
6	To what degree does the utility have PAST CTUC EXPERIENCE?	None / Some / Only Recently / Extensive
7	What is the likelihood that the utility will PARTICIPATE in CTUC for this adjustment?	High / Medium / Low / Don't Know
8	Will this utility likely allow the TxDOT contractor to ONLY install utility INFRASTRUCTURE (e.g., manholes, poles, conduit, etc.)?	Yes / No / Don't Know
9	Which elements of this adjustment can the pool of likely TxDOT contractors perform?	(Plain Text)
10	Which elements can they not perform?	(Plain Text)
11	Does the utility share the same underground physical facilities (e.g., utility vaults, trenches at different depths, multi-duct conduits, or utility corridors) with other utilities?	Yes / No / Don't know yet
12	If the utility being analyzed is sharing a physical facility, which utility(s) share that facility?	(Plain Text)
13	Does the utility share a set of poles with other utilities?	Yes / No / Don't know yet
14	If the utility being analyzed is sharing a set of poles, which utility(s) share that facility?	Selection
15	Are HAZMAT conditions expected for this utility adjustment? (1) Asbestos (2) Leaking underground storage tanks (3) Contaminated soils (4) Contaminated groundwater (5) Other (Plain Text)	No / Small / Medium / Large / Don't know yet
16	Please list any ADDITIONAL APPROVAL required prior to utility adjustment (e.g., Transmission adjustments need to get approval from Electric Reliability Council of Texas before beginning adjustment work.):	(Plain Text)
17	If some of the adjustment work is reimbursable, what is the ELIGIBILITY RATIO for this utility adjustment?	(Percentage)

6.5 Data Collection and Analysis

After the design of the CTUC decision support model and the development of the CTUC decision drivers assessment form were completed, CTUC decision drivers assessment data were then collected. Basically, the CTUC decision support model forms the structure of the knowledge base, while the assessment data provided by experts constitute the contents of the knowledge base. This knowledge base can assist assessors not only in identifying significant decision drivers relevant to their current projects but in understanding the variety of opinions on a particular issue in advance.

6.5.1 Data Collection

Six CTUC decision drivers assessment workshops were conducted in San Antonio, Houston, and Dallas areas. Three of the workshops were conducted for TxDOT experts who are knowledgeable in the CTUC approach, with twenty-eight experts in attendance with an average of 13.8 years of work experience among them. Table 6.3 lists additional information for these three workshops. The other three workshops were conducted for utility experts who have pursued the CTUC approach, with twenty-four experts in attendance with an average of 12.1 years of work experience among them. The expertise of these attendees covered all five utility types (water/wastewater, communication, distribution power line, transmission power line, and natural gas). Table 6.4 lists additional information for these three workshops.

Table 6.3: Information on CTUC decision drivers assessment workshops for TxDOT

District	# of Experts	Avg. Yr. of Adj. Experience
San Antonio	15	13.4
Houston	7	15.6
Dallas	6	12.8
	(Ttl.) = 28	(Avg.) = 13.8

Table 6.4: Information on CTUC decision drivers assessment workshops for utilities

District	# of Experts	Avg. Yr. of Adj. Experience
San Antonio	9	9.6
Houston	6	10.7
Dallas	9	15.7
	(Ttl.) = 24	(Avg.) = 12.1

Experts were asked to follow the instructions on the CTUC decision drivers assessment form to assess decision drivers in a project-independent context. Although the assessment forms given to the TxDOT and utility experts were basically identical (only varying on questions pertaining to whether adjustments were reimbursable or non-reimbursable), TxDOT's workshops were conducted separately from the utilities' in order to gather frank opinions from each individual party.

The following scheme was employed to calculate a numeric value to represent the "Impact Level" of each decision driver:

- Use “-4” to represent “Show-Stopper”
- Use “-3” to represent “Anti-CTUC and high impact”
- Use “-2” to represent “Anti-CTUC and medium impact”
- Use “-1” to represent “Anti-CTUC and low impact”
- Use “ 0” to represent “Neutral”
- Use “ 1” to represent “Pro-CTUC and low impact”
- Use “ 2” to represent “Pro-CTUC and medium impact”
- Use “ 3” to represent “Pro-CTUC and high impact”
- Do not include the experts who chose “Impact Level = Don’t Know”

The following subsections present the experts’ assessment results of the CTUC decision drivers at the state level. The assessment results at the district level are listed in Appendix F.

6.5.2 Analysis Results of CTUC Preference

The complete comparison results of both parties’ “CTUC Preference” are listed in Table 6.5. Basically, “P%” means the percentage of experts who selected “Pro-CTUC” or “sometimes Pro-CTUC and sometimes Neutral.” “N%” means the percentage of experts who selected “Neutral.” “A%” means the percentage of experts who selected “Anti-CTUC” or “sometimes Anti-CTUC and sometimes Neutral.” If most experts of the same party thought that a given decision driver should have “Anti-CTUC” impact on the CTUC decision, the corresponding cell was marked dark gray ( ). “Pro-CTUC” cells were marked gray ( ) and “Neutral” cells were marked light gray ( ). Finally, in the column entitled “Discrepancy?,” a solid triangle signified that the majority of TxDOT experts selected “Pro-CTUC,” while the majority of utility experts selected “Anti-CTUC” (or vice versa). A hollow triangle signified that the majority of TxDOT experts selected “Anti-CTUC” while the majority of utility experts selected “Neutral” (or vice versa).

Note that the assessment Questions 2.13-2.16 were designed for utility companies who may include pole adjustments. Therefore, the assessment results of the experts from water, wastewater, and natural gas utilities were not considered in these questions. In addition, TxDOT answer to Question 5.11 on the assessment form is not shown in Table 6.5 because TxDOT experts were asked to assess five utility types individually.

Hence, the majority of experts from both parties selected the same CTUC preference for almost all decision drivers. The most significant difference between TxDOT’s and the utilities’ assessment results was for the decision driver called “5.6 HAZMAT.” Its circumstance is the following: “hazardous materials-related work only applies to the utility adjustment work.” The research team was told that because hazardous materials are extremely difficult to handle, if only the utility adjustment include such work, utility owners tend to use the CTUC approach because handling the hazardous materials becomes the highway contractor’s responsibility. However, the TxDOT experts indicated that TxDOT usually prefers not to allow highway contractors to handle the hazardous materials.

Table 6.5: Assessment results of CTUC preference (TxDOT vs. utilities)

(follows on next page)

Table 6.5 Assessment results of CTUC preference (TxDOT vs. utilities)

Decision Driver	TxDOT (n=28)			Utility (n=24)			Discrepancy?
	P%	N%	A%	P%	N%	A%	
2.1 Traffic is heavy	96.4	3.6	0.0	87.5	12.5	0.0	
2.2 Fewer lane closures in CTUC	100.0	0.0	0.0	91.7	8.3	0.0	
2.3 Physical interferences exist	92.9	7.1	0.0	66.7	16.7	16.7	
2.4 Adj. only happen in constr.	100.0	0.0	0.0	91.7	8.3	0.0	
2.5 Severe schedule pressures	100.0	0.0	0.0	95.8	4.2	0.0	
2.6 Ill-def.adj.scope at 60%PS&E	7.1	7.1	85.7	0.0	8.3	91.67	
2.7 No schedule pressures	7.1	10.7	82.1	8.3	37.5	54.17	
2.8 Utility plans are acceptable	96.4	3.6	0.0	83.3	16.7	0.0	
2.9 Utility plans are unacceptable	3.6	0.0	96.4	4.2	4.2	91.67	
2.10 Utility specs are acceptable	96.4	3.6	0.0	91.7	8.3	0.0	
2.11 Utility specs are unacceptable	3.6	0.0	96.4	0.0	4.2	95.83	
2.12 Shared underground fac.: all CTUC	96.4	3.6	0.0	95.8	4.2	0.0	
2.13 For pole utilities: all join CTUC	100.0	0.0	0.0	53.8	7.7	38.5	
2.14 Pole owner opt out of CTUC	14.3	21.4	64.3	0.0	30.8	69.2	
2.15 Pole tenant opt out of CTUC	3.6	**64.3**	32.1	0.0	30.8	69.2	△
2.16 Pole tenant sch. conflict w/ CTUC	0.0	3.6	96.4	0.0	7.7	92.3	
3. REIMBURSABLE PROJECT							
3.1 Adj. are 100% reimbursable	85.7	14.3	0.0	91.7	8.3	0.0	
3.2 CTUC > 15% Cheaper	96.4	3.6	0.0	95.8	4.2	0.0	
3.3 CTUC 5%-15% Cheaper	96.4	3.6	0.0	95.8	4.2	0.0	
3.4 CTUC 5%-15% Expensive	7.1	14.3	78.57	0.0	8.3	91.67	
3.5 CTUC >15% Expensive	3.6	3.6	92.86	0.0	8.3	91.67	
3.6 Front-end loading: incr. cost w/ CTUC	3.6	7.1	89.29				
3.7 Change order: incr. cost w/ CTUC	3.6	3.6	92.86				
3.8 Added contr. tier: incr. cost w/ CTUC	3.6	3.6	92.86				
3.9 Reduced delay costs due to CTUC	96.4	3.6	0.0	95.8	4.2	0.0	
4. NON-REIMBURSABLE PROJECT							
4.1 Utility cannot pay in advance	3.6	0.0	96.43	0.0	4.2	95.83	

Decision Driver	TxDOT (n=28)			Utility (n=24)			Discrepancy?
	P%	N%	A%	P%	N%	A%	
4.2 Utility not qualify for SIB	3.6	3.6	92.86	0.0	4.2	95.83	
4.3 CTUC >15% Cheaper	92.9	7.1	0.0	95.8	4.2	0.0	
4.4 CTUC 5%-15% Cheaper	92.9	7.1	0.0	95.8	4.2	0.0	
4.5 CTUC 5%-15% Expensive	7.1	7.1	85.71	0.0	8.3	91.67	
4.6 CTUC >15% Expensive	3.6	7.1	89.29	0.0	4.2	95.83	
4.7 Front-end loading: incr. cost w/ CTUC	0.0	3.6	96.43	0.0	0.0	100.00	
4.8 Change order: incr. cost w/ CTUC	0.0	0.0	100.00	0.0	4.2	95.83	
4.9 Added contr. tier: incr. cost w/ CTUC	3.6	7.1	89.29	0.0	0.0	100.00	
4.10 Reduced delay costs due to CTUC	100.0	0.0	0.0	100.0	0.0	0.0	
4.11 Indirect costs b/c of CTUC	3.6	0.0	96.43	0.0	4.2	95.83	
5. UTILITY-SPECIFIC ISSUES							
5.1 Util work beyond ROW	3.6	3.6	92.86	0.0	37.5	62.50	
5.2 Traffic ctrl. better in CTUC	92.9	7.1	0.0	91.7	8.3	0.0	
5.3 Better safety ctrl. w/ CTUC	96.4	3.6	0.0	91.7	8.3	0.0	
5.4 Better safety ctrl. w/ Conv.	3.6	3.6	92.86	0.0	8.3	91.67	
5.5 Substantial clearing & grubbing on util.	92.9	7.1	0.0	95.8	4.2	0.0	
5.6 HAZMAT: only apply to this adj.	7.1	3.6	89.29	79.2	12.5	8.3	▲
5.7 Use TxDOT's specs	100.0	0.0	0.0	95.8	4.2	0.0	
5.8 Develop composite specs	7.1	14.3	78.57	0.0	25.0	75.00	
5.9 Only utility crew can do	0.0	0.0	100.00	0.0	8.3	91.67	
5.10 CTUC frees up utility crews	89.3	10.7	0.0	87.5	12.5	0.0	
5.11 Contr. can hire pre-qualify subs				83.3	8.3	8.3	
5.12 Extensive utility upgrade	28.6	28.6	42.86	8.3	**45.8**	45.83	△
5.13 Detrimental environment change	10.7	25.0	64.29	25.0	**41.7**	33.3	△

Note:

P% = the percentage of "Pro-CTUC" — Gray: the Pro-CTUC cell is the maximum value

N% = the percentage of "Neutral" — **Light Gray:** the Neutral cell is the maximum value

A% = the percentage of "Anti-CTUC" — Dark Gray: the Anti-CTUC cell is the maximum value

Discrepancy: △ = the majority of TxDOT select “Anti-CTUC” while the majority of Utility select “Neutral” (or vice versa)

▲ = the majority of TxDOT select “Pro-CTUC” while the majority of Utility select “Anti-CTUC” (or vice versa)

6.5.3 Analysis Results of Impact Level

Table 6.6 lists the analysis results of impact level from both parties. The meaning of each column is described as follows:

- AS: the percentage of experts from one party who thought that the given decision driver has "Anti-CTUC" and "Show-Stopper" impact
- AH: the percentage of experts from one party who thought that the given decision driver has "Anti-CTUC" and "High" impact
- AM: the percentage of experts from one party who thought that the given decision driver has "Anti-CTUC" and "Medium" impact
- AL: the percentage of experts from one party who thought that the given decision driver has "Anti-CTUC" and "Low" impact
- N: the percentage of experts from one party who thought that the given decision driver has "Neutral" impact
- PL: the percentage of experts from one party who thought that the given decision driver has "Pro-CTUC" and "Low" impact
- PM: the percentage of experts from one party who thought that the given decision driver has "Pro-CTUC" and "Medium" impact
- PH: the percentage of experts from one party who thought that the given decision driver has "Pro-CTUC" and "High" impact
- DK: the percentage of experts from one party who did not know the impact of the given decision driver
- Discrepancy?: a solid triangle signifying that the difference between the impact levels selected by the majority of TxDOT experts and by the majority of utility experts is greater than two slots. A hollow triangle signifying that the difference between the impact levels selected by the majority of TxDOT experts and by the majority of utility experts is two slots, or "Don't Know" is involved

The majority of the experts from TxDOT and utilities selected the same CTUC preference for almost all decision drivers. Aside from "5.6 HAZMAT: only apply to this adj.," there are two decision drivers whose impact levels are significantly different between the two parties:

- 3.1 Adj. are 100% reimbursable: 43 percent of the TxDOT experts thought that it is "Pro-CTUC" and has "High" impact on the CTUC decision, while 33 percent of the utility experts thought that it is "Neutral." This result is consistent with the conclusion of the preliminary research meetings with the utility industry. It shows that performing utility adjustments requested from TxDOT is not utility owners' primary business.
- 5.13 Detrimental environment change: 46 percent of the TxDOT experts thought that it is "Anti-CTUC" and has "Show-Stopper" impact on the CTUC decision,

while 29 percent of the utility experts thought that it is “Neutral.” Including a detrimental change of the utility adjustment work to the highway project’s environmental clearance would undoubtedly delay the entire project schedule. This result reflects the fact that utility owners would like TxDOT to handle the utility’s environmental clearance.

Table 6.6: Assessment results of impact level (TxDOT vs. utilities)

(follows on next page)

Table 6.6 Assessment results of impact level (TxDOT vs. utilities)

Decision Driver	TxDOT (n=28)									Utility (n=24)									Discrepancy?
	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK	
2.1 Traffic is heavy	0	0	0	0	11	0	36	46	7	0	0	0	0	13	17	29	17	25	
2.2 Fewer lane closures in CTUC	0	0	0	0	7	11	25	54	4	0	0	0	0	8	25	4	38	25	
2.3 Physical interferences exist	0	0	0	0	18	7	29	36	11	0	17	0	0	17	8	17	21	**21**	
2.4 Adj. only happen in constr.	0	0	0	0	0	7	11	75	7	0	0	0	0	8	0	8	58	25	
2.5 Severe schedule pressures	0	0	0	0	0	0	18	79	4	0	0	0	0	8	0	17	50	25	
2.6 Ill-def.adj.scope at 60%PS&E	11	43	21	7	4	0	4	4	7	25	38	0	0	17	0	0	0	21	
2.7 No schedule pressures	7	0	4	39	**43**	0	4	0	4	4	17	4	8	**54**	0	0	0	13	
2.8 Utility plans are acceptable	0	0	0	0	14	11	25	43	7	0	0	0	0	29	8	13	33	17	
2.9 Utility plans are unacceptable	21	50	14	4	0	0	0	0	11	29	21	17	13	4	4	0	0	13	
2.10 Utility specs are acceptable	0	0	0	0	14	7	21	46	11	0	0	0	0	17	8	8	50	17	
2.11 Utility specs are unacceptable	21	39	14	7	4	0	0	4	11	29	21	8	21	8	0	0	0	13	
2.12 Shared underground fac.: all CTUC	0	0	0	0	7	7	25	57	4	0	0	0	0	4	8	17	42	29	
2.13 For pole utilities: all join CTUC	0	0	0	0	18	4	32	36	11	0	21	0	0	0	4	8	21	**46**	△
2.14 Pole owner opt out of CTUC	21	29	0	4	**29**	0	4	11	4	13	8	4	8	21	0	0	0	**46**	△
2.15 Pole tenant opt out of CTUC	4	21	4	0	7	0	0	4	**61**	17	17	0	8	17	0	0	0	**42**	△
2.16 Pole tenant sch. conflict w/ CTUC	32	29	14	7	7	0	0	0	11	25	13	0	0	13	0	0	0	**50**	
3.1 Adj. are 100% reimbursable	0	0	0	0	25	18	11	43	4	0	0	0	0	**33**	8	13	25	21	▲
3.2 CTUC > 15% Cheaper	0	0	0	0	11	14	25	46	4	0	0	0	0	17	4	8	46	25	
3.3 CTUC 5%-15% Cheaper	0	0	0	0	11	29	43	14	4	0	0	0	0	21	13	17	21	**29**	△
3.4 CTUC 5%-15% Expensive	11	4	39	14	21	0	0	7	4	21	21	8	0	**29**	0	0	0	21	△
3.5 CTUC >15% Expensive	18	29	18	14	14	0	0	4	4	21	21	17	0	**21**	0	0	0	**21**	△
3.6 Front-end loading: incr. cost w/ CTUC	11	29	14	14	21	0	0	0	11										
3.7 Change order: incr. cost w/ CTUC	11	29	14	18	11	0	0	0	18										
3.8 Added contr. tier: incr. cost w/ CTUC	11	18	25	18	14	0	0	0	14										
3.9 Reduced delay costs due to CTUC	0	0	0	0	11	4	14	68	4	0	0	0	0	4	4	8	58	25	
4.1 Utility cannot pay in advance	57	25	4	4	4	0	0	0	7	42	25	8	0	0	0	0	0	25	
4.2 Utility not qualify for SIB	39	29	11	4	7	0	0	0	11	29	29	13	0	0	0	0	0	**29**	△
4.3 CTUC >15% Cheaper	0	0	0	0	11	7	32	46	4	0	0	0	0	13	0	25	42	21	
4.4 CTUC 5%-15% Cheaper	0	0	0	0	14	18	39	25	4	0	0	0	0	13	4	25	33	25	
4.5 CTUC 5%-15% Expensive	11	21	32	11	14	0	0	7	4	33	21	4	13	8	0	0	0	21	△
4.6 CTUC >15% Expensive	21	39	18	0	14	0	0	0	7	42	25	8	0	4	0	0	0	21	
4.7 Front-end loading: incr. cost w/ CTUC	25	21	25	4	7	0	0	0	18	50	25	8	0	0	0	0	0	17	
4.8 Change order: incr. cost w/ CTUC	14	39	18	7	4	0	0	0	18	50	25	0	0	4	0	0	0	21	

Decision Driver	TxDOT (n=28)									Utility (n=24)									Discrepancy?
	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK	
4.9 Added contr. tier: incr. cost w/ CTUC	14	18	21	18	11	0	0	4	14	42	25	13	0	0	0	0	0	21	△
4.10 Reduced delay costs due to CTUC	0	0	0	0	4	4	18	68	7	0	0	0	0	8	4	13	58	17	
4.11 Indirect costs b/c of CTUC	11	18	29	14	4	0	0	0	25	46	21	4	8	4	0	0	0	17	△
5.1 Util work beyond ROW	68	18	7	0	4	0	0	4	0	38	17	0	4	29	0	0	0	13	
5.2 Traffic ctrl. better in CTUC	0	0	0	0	11	4	39	43	4	0	0	0	0	13	25	13	29	21	
5.3 Better safety ctrl. w/ CTUC	0	0	0	0	14	4	25	54	4	0	0	0	0	17	25	13	25	21	
5.4 Better safety ctrl. w/ Conv.	11	25	29	11	18	0	0	0	7	8	21	17	8	21	0	0	0	**25**	△
5.5 Substantial clearing & grubbing on util.	0	0	0	0	11	7	32	39	11	0	0	0	0	0	8	21	42	29	
5.6 HAZMAT: only apply to this adj.	54	25	11	0	4	0	4	4	0	8	0	0	0	8	0	8	58	17	▲
5.7 Use TxDOT's specs	0	0	0	0	14	14	29	36	7	0	0	0	0	13	17	0	29	**42**	△
5.8 Develop composite specs	7	7	29	14	25	0	0	7	11	25	8	8	4	**33**	0	0	0	21	△
5.9 Only utility crew can do	82	14	0	4	0	0	0	0	0	54	25	0	0	8	0	0	0	13	
5.10 CTUC frees up utility crews	0	0	0	0	18	21	18	32	11	0	0	0	0	13	13	17	29	**29**	
5.11 Contr. can hire pre-qualify subs										4	4	0	0	4	4	17	42	25	
5.12 Extensive utility upgrade	21	14	0	0	**29**	4	0	21	11	13	0	4	8	**50**	0	0	8	17	
5.13 Detrimental environment change	46	14	0	0	14	0	0	11	14	13	4	4	4	**29**	0	8	13	25	▲

Note:

AS = the percentage of "Anti-CTUC" and "Show Stopper"
AH = the percentage of "Anti-CTUC" and "High Impact"
AM = the percentage of "Anti-CTUC" and "Medium Impact"
AL = the percentage of "Anti-CTUC" and "Low Impact"
N = the percentage of "Neutral" + the percentage of "No Impact"
PL = the percentage of "Pro-CTUC" and "Low Impact"
PM = the percentage of "Pro-CTUC" and "Medium Impact"
PH = the percentage of "Pro-CTUC" and "High Impact"
DK = the percentage of "Don't Know"

Gray: the Pro-CTUC cell is the maximum value
Light Gray: the Neutral or "Don't Know" cell is the maximum value
Dark Gray: the Anti-CTUC cell is the maximum value

Discrepancy:

△ = the difference between the impact levels selected by the majority of TxDOT and the majority of Utility is two slots, or "Don't Know" is involved
▲ = the difference between the impact levels selected by the majority of TxDOT and the majority of utility is greater than two slots

6.5.4 Analysis Results of Resolvability

Table 6.7 lists the analysis results of resolvability for each Anti-CTUC decision driver. If the average impact level of a decision driver is negative, and if most experts agree that the circumstance defined in this decision driver can be improved to facilitate the CTUC approach, the responsible party, the way to improve the circumstance, and any suggestions for process changes should be conveyed to the actual CTUC assessor facing that circumstance. On the other hand, if the average impact level of a decision driver is zero or positive, its resolvability is not shown in Table 6.7. Hence, if the average impact level of a decision driver is negative, the corresponding cell in Table 6.7 shows the percentage of the experts from one group who thought that the given decision driver is resolvable. If more than 65 percent of the experts thought that the given decision deriver is resolvable, the corresponding cell is marked light gray ( ). In addition, if fewer than 35 percent of the experts thought that the given decision deriver is resolvable, the corresponding cell is marked dark gray ( ). The rest of the Anti-CTUC cells are marked white ( ), which means the percentage should be between 35 percent - 65 percent.

The cells of the final column entitled "Discrepancy" show that a hollow triangle if the gray code of one party's average resolvability is "dark gray" whiles the other party's is "white." Note that there is no case in which the gray code of one party's average resolvability is "dark gray" while the other party's is "light gray." This shows that the analysis results of resolvability are consistent between both parties.

From the TxDOT experts' perspective, the Anti-CTUC decision driver most resistant to improvement is "5.13 Detrimental environment change." This decision driver's average impact level is -2.29, and only 21.4 percent of the experts thought that it could be improved to facilitate the CTUC approach.

From the utility experts' perspective, the Anti-CTUC decision driver most resistant to improvement is "2.7 No schedule pressures." This decision driver's average impact level is -0.95, and none of the experts thought that it could be improved to facilitate the CTUC approach. There are other decision drivers that are considered resistant to improvement. For example, "5.13 Detrimental environment change" (the average impact level is -0.28; 4.2 percent of the experts considered it resolvable), "5.12 Extensive utility upgrade" (the average impact level is -0.5; 12.5 percent of the experts considered it resolvable), etc. Generally, if the circumstance defined in a decision driver reflects a physical project or utility adjustment characteristic, fewer experts would consider the decision driver resolvable. Conversely, if the circumstance defined in a decision driver reflects a potential situation that needs both parties' involvement, more experts would consider the decision driver resolvable.

Table 6.7: Assessment results of resolvability (TxDOT vs. utilities)

(follows on next page)

Table 6.7 Assessment results of resolvability (TxDOT vs. utilities)

Decision Driver	TxDOT				Utility				Discrepancy?
	San Antonio(n=15)	Houston(n=7)	Dallas(n=6)	**All(n=28)**	San Antonio(n=9)	Houston(n=6)	Dallas(n=9)	**All(n=24)**	
2.1 Traffic is heavy									
2.2 Fewer lane closures in CTUC									
2.3 Physical interferences exist									
2.4 Adj. only happen in constr.									
2.5 Severe schedule pressures									
2.6 Ill-def.adj.scope at 60%PS&E	**60.0**	28.6	83.3	**57.1**	33.3	16.7	11.1	20.8	△
2.7 No schedule pressures	26.7	14.3	33.3	25.0	0.0	0.0	0.0	0.0	
2.8 Utility plans are acceptable									
2.9 Utility plans are unacceptable	73.3	71.4	**50.0**	67.9	**55.6**	16.7	**44.4**	**41.7**	△
2.10 Utility specs are acceptable									
2.11 Utility specs are unacceptable	73.3	**42.9**	66.7	**64.3**	88.9	16.7	**55.6**	**58.3**	
2.12 Shared underground fac.: all CTUC									
2.13 For pole utilities: all join CTUC									
2.14 Pole owner opt out of CTUC	**40.0**	**42.9**	66.7	**46.4**	11.1	33.3	11.1	16.7	△
2.15 Pole tenant opt out of CTUC	0.0	**42.9**	66.7	25.0	22.2	**50.0**	22.2	29.2	
2.16 Pole tenant sch. conflict w/ CTUC	**53.3**	**42.9**	**50.0**	**50.0**	11.1	16.7	11.1	12.5	△
3.1 Adj. are 100% reimbursable									
3.2 CTUC > 15% Cheaper									
3.3 CTUC 5%-15% Cheaper									
3.4 CTUC 5%-15% Expensive	33.3	14.3	66.7	**35.7**	11.1	33.3	**44.4**	29.2	△
3.5 CTUC >15% Expensive	33.3	14.3	66.7	**35.7**	11.1	16.7	33.3	20.8	△
3.6 Front-end loading: incr. cost w/ CTUC	**46.7**	28.6	83.3	**50.0**					
3.7 Change order: incr. cost w/ CTUC	**60.0**	14.3	83.3	**53.6**					
3.8 Added contr. tier: incr. cost w/ CTUC	26.7	14.3	83.3	**35.7**					
3.9 Reduced delay costs due to CTUC									
4.1 Utility cannot pay in advance	100.0	100.0	100.0	100.0	100.0	83.3	100.0	95.8	
4.2 Utility not qualify for SIB	100.0	100.0	100.0	100.0	100.0	83.3	100.0	95.8	
4.3 CTUC >15% Cheaper									
4.4 CTUC 5%-15% Cheaper									
4.5 CTUC 5%-15% Expensive	33.3	14.3	66.7	**35.7**	11.1	33.3	33.3	25.0	△
4.6 CTUC >15% Expensive	33.3	14.3	66.7	**35.7**	22.2	33.3	33.3	29.2	△

Decision Driver	TxDOT				Utility				Discrepancy ?
	San Antonio(n=15)	Houston(n=7)	Dallas(n=6)	**All(n=28)**	San Antonio(n=9)	Houston(n=6)	Dallas(n=9)	**All(n=24)**	
4.7 Front-end loading: incr. cost w/ CTUC	26.7	28.6	**50.0**	32.1	33.3	**50.0**	**55.6**	**45.8**	△
4.8 Change order: incr. cost w/ CTUC	33.3	14.3	83.3	**39.3**	**55.6**	33.3	**44.4**	**45.8**	
4.9 Added contr. tier: incr. cost w/ CTUC	**40.0**	14.3	83.3	**42.9**	**44.4**	33.3	**55.6**	**45.8**	
4.10 Reduced delay costs due to CTUC									
4.11 Indirect costs b/c of CTUC	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
5.1 Util work beyond ROW	93.3	100.0	100.0	96.4	100.0	100.0	100.0	100.0	
5.2 Traffic ctrl. better in CTUC									
5.3 Better safety ctrl. w/ CTUC									
5.4 Better safety ctrl. w/ Conv.	**40.0**	14.3	**50.0**	**35.7**	11.1	16.7	22.2	16.7	△
5.5 Substantial clearing & grubbing on util.									
5.6 HAZMAT: only apply to this adj.	86.7	14.3	66.7	**64.3**	100.0	16.7	22.2	**50.0**	
5.7 Use TxDOT's specs									
5.8 Develop composite specs	**40.0**	28.6	**50.0**	**39.3**	**55.6**	16.7	33.3	**37.5**	
5.9 Only utility crew can do	**46.7**	14.3	66.7	**42.9**	33.3	33.3	22.2	29.2	△
5.10 CTUC frees up utility crews									
5.11 Contr. can hire pre-qualify subs									
5.12 Extensive utility upgrade	26.7	14.3	83.3	**35.7**	0.0	16.7	22.2	12.5	△
5.13 Detrimental environment change	13.3	14.3	**50.0**	21.4	0.0	0.0	11.1	4.2	

Note: The number in each cell is the PERCENTAGE of the experts who thought the given situation could be resolved to facilitate CTUC by process changes

Light Gray:	If more than 65% of the experts thought that the given decision deriver is resolvable
White:	If the percentage of the experts who thought the given decision deriver is resolvable is between 35% and 65%
Dark Gray:	If fewer than 35% of the experts thought that the given decision deriver is resolvable

Discrepancy: △ = the majority of TxDOT's gray code is "Dark Gray" while the majority of Utility's gray code is "White" (or vice versa)

6.5.5 Ranking of Decision Drivers by Impact Levels

Table 6.8 lists the top twenty Pro-CTUC decision drivers from both the TxDOT experts' and the utility experts' perspectives. Table 6.9 lists the top twenty Anti-CTUC decision drivers. Note that if a decision driver belongs to the reimbursable adjustments type, "(R)" is appended to this decision driver's name. If a decision driver belongs to the non-reimbursable adjustments type, "(NR)" is appended to this decision driver's name. The number preceding each decision driver's name corresponds to that question number on the CTUC decision drivers assessment form. Generally, TxDOT's ranking of decision drivers is different than the utilities' ranking. The decision driver called "2.5 Severe schedule pressures" is the most Pro-CTUC decision driver from the TxDOT experts' perspective; however, it is the fifth most Pro-CTUC decision driver from the utility experts' perspective. In addition, traffic-related decision drivers, e.g., "2.2 Fewer lane closures in CTUC," "2.1 Traffic is heavy," and "5.2 Traffic ctrl. better in CTUC," were ranked as the top ten Pro-CTUC decision drivers from the TxDOT experts' perspective, while utility experts did not find these decision drivers as important as cost-related decision drivers.

Table 6.8: Top 20 Pro-CTUC decision drivers

Rank	TxDOT		Utility	
	Decision Driver	**Impact Level**	**Decision Driver**	**Impact Level**
1	2.5 Severe schedule pressures	2.81	3.9 Reduced delay costs due to CTUC (R)	2.61
2	2.4 Adj. only happen in constr.	2.73	2.4 Adj. only happen in constr.	2.56
3	4.10 Reduced delay costs due to CTUC (NR)	2.62	5.5 Substantial clearing & grubbing on util.	2.47
4	3.9 Reduced delay costs due to CTUC (R)	2.44	4.10 Reduced delay costs due to CTUC (NR)	2.45
5	2.12 Shared underground fac.: all CTUC	2.37	2.5 Severe schedule pressures	2.44
6	2.2 Fewer lane closures in CTUC	2.3	2.12 Shared underground fac.: all CTUC	2.35
7	2.1 Traffic is heavy	2.27	4.3 CTUC >15% Cheaper (NR)	2.21
8	5.3 Better safety ctrl. w/ CTUC	2.22	3.2 CTUC > 15% Cheaper (R)	2.11
9	4.3 CTUC >15% Cheaper (NR)	2.19	2.10 Utility specs are acceptable	2.1
10	5.2 Traffic ctrl. better in CTUC	2.19	4.4 CTUC 5%-15% Cheaper (NR)	2.06
11	2.10 Utility specs are acceptable	2.12	2.2 Fewer lane closures in CTUC	1.94
12	5.5 Substantial clearing & grubbing on util.	2.12	5.6 HAZMAT: only apply to this adj.	1.9
13	3.2 CTUC > 15% Cheaper (R)	2.11	5.10 CTUC frees up utility crews	1.88
14	2.8 Utility plans are acceptable	2.04	5.7 Use TxDOT's specs	1.79
15	2.13 For pole utilities: all join CTUC	1.96	5.11 Contr. can hire pre-qualify subs	1.78
16	2.3 Physical interferences exist	1.92	5.2 Traffic ctrl. better in CTUC	1.74
17	5.7 Use TxDOT's specs	1.92	2.1 Traffic is heavy	1.67
18	4.4 CTUC 5%-15% Cheaper (NR)	1.78	2.8 Utility plans are acceptable	1.6
19	3.1 Adj. are 100% reimbursable	1.74	5.3 Better safety ctrl. w/ CTUC	1.58
20	5.10 CTUC frees up utility crews	1.72	3.3 CTUC 5%-15% Cheaper (R)	1.53

Table 6.9: Top 20 Anti-CTUC decision drivers

Rank	TxDOT		Utility	
	Decision Driver	**Impact Level**	**Decision Driver**	**Impact Level**
1	5.9 Only utility crew can do	-3.75	4.7 Front-end loading: incr. cost w/ CTUC (NR)	-3.5
2	4.1 Utility cannot pay in advance (NR)	-3.38	4.8 Change order: incr. cost w/ CTUC (NR)	-3.47
3	5.1 Util work beyond ROW	-3.29	4.1 Utility cannot pay in advance (NR)	-3.44
4	2.9 Utility plans are unacceptable	-3	4.9 Added contr. tier: incr. cost w/ CTUC (NR)	-3.37
5	4.2 Utility not qualify for SIB (NR)	-3	5.9 Only utility crew can do	-3.33
6	5.6 HAZMAT: only apply to this adj.	-2.93	4.6 CTUC >15% Expensive (NR)	-3.26
7	2.16 Pole tenant sch. conflict w/ CTUC	-2.8	4.2 Utility not qualify for SIB (NR)	-3.24
8	4.7 Front-end loading: incr. cost w/ CTUC (NR)	-2.65	4.11 Indirect costs b/c of CTUC (NR)	-3.15
9	4.8 Change order: incr. cost w/ CTUC (NR)	-2.65	2.16 Pole tenant sch. conflict w/ CTUC	-2.75
10	4.6 CTUC >15% Expensive (NR)	-2.58	4.5 CTUC 5%-15% Expensive (NR)	-2.74
11	2.11 Utility specs are unacceptable	-2.56	2.6 Ill-def.adj.scope at 60%PS&E	-2.68
12	5.13 Detrimental environment change	-2.29	2.9 Utility plans are unacceptable	-2.52
13	4.11 Indirect costs b/c of CTUC (NR)	-2.24	2.11 Utility specs are unacceptable	-2.48
14	2.6 Ill-def.adj.scope at 60%PS&E	-2.19	5.1 Util work beyond ROW	-2.33
15	3.7 Change order: incr. cost w/ CTUC (R)	-2.13	3.5 CTUC >15% Expensive (R)	-2.26
16	3.5 CTUC >15% Expensive (R)	-2.04	2.15 Pole tenant opt out of CTUC	-2.14
17	5.4 Better safety ctrl. w/ Conv.	-2	3.4 CTUC 5%-15% Expensive (R)	-2.05
18	3.6 Front-end loading: incr. cost w/ CTUC (R)	-1.92	5.8 Develop composite specs	-1.84
19	3.8 Added contr. tier: incr. cost w/ CTUC (R)	-1.92	5.4 Better safety ctrl. w/ Conv.	-1.83
20	2.15 Pole tenant opt out of CTUC	-1.91	2.14 Pole owner opt out of CTUC	-1.69

Utility experts considered the reduced delay costs due to the use of the CTUC approach in a reimbursable adjustment as the most Pro-CTUC decision driver. Utility experts preferred to select the CTUC approach when more calculable benefits are foreseeable. For example, the third most Pro-CTUC decision drivers "5.5 Substantial clearing & grubbing on util." can release the utility's burden of performing advance roadway work if the utility owners are willing to adopt the CTUC approach.

In Table 6.9, the TxDOT experts' ranking of Anti-CTUC decision drivers is different than that of the utility experts'. There are three Anti-CTUC decision drivers that most TxDOT experts considered as having more than the high impact level, i.e., as close to the show-stopper impact level. However, eight Anti-CTUC decision drivers were identified as having more than the high impact level by most utility experts. In fact, among the top ten Anti-CTUC decision drivers, only two of them are not cost-related decision drivers from utility experts' perspective. They are "5.9 Only utility crew can do," and "2.16 Pole tenant sch. conflict w/ CTUC." It should be noted that the decision driver called "4.6 CTUC >15% Expensive (NR)" is more Anti-CTUC than the decision driver called "3.5 CTUC >15% Expensive (R)" from most utility experts' perspective because some utility owners explicitly stated that they would not consider using the CTUC approach at all if the utility adjustment were non-reimbursable.

6.6 Experts Assessment and the Structure of the CTUC Knowledge Base

Except for the reimbursable adjustments questions, experts from TxDOT and the utility industry were expected to similarly assess the CTUC decision drivers in a project-independent context. Thus, the assessment of each group was expected to be comparable. The mechanism of the CTUC decision support model described in previous subsections prompts an assessor to select the option that best describes the circumstance he or she is facing, as the answer to each CTUC question. The CTUC Decision Support Tool then displays the assessment results for a given decision driver from a specific group of experts. Each assessor may want to review the opinions only from those experts who are in the same group as the assessor. For example, an assessor from a utility owner may want to review the knowledge derived from the same type of utility experts because different types of utility adjustments often require different sets of adjusting practices. Moreover, an assessor from a TxDOT area office may want to review the knowledge derived from his or her district's experts. Hence, the CTUC knowledge base should be able to provide the flexibility to render the knowledge from the entire scope of expert groups.

In this research, the opinions of the TxDOT experts from the three TxDOT districts (San Antonio, Houston, and Dallas) were entered into the CTUC knowledge base. The opinions of the utility experts from the following five types of utilities were also entered into the CTUC knowledge base:

- Water and wastewater (W/WW) type, including adjustment of facilities such as water lines, wastewater lines, wastewater pump stations, and water wells;
- Communication (Comm.) type, including adjustment of facilities such as overhead communication poles, underground communication lines, and microwave towers;
- Distribution power (Distr.) type, including adjustment of facilities such as overhead distribution power lines and underground distribution power lines;

- Transmission power (Trans.) type, including adjustment of facilities such as transmission poles, underground transmission power lines, and transmission towers; and
- Natural gas (Gas) type, including adjustment of facilities such as high pressure gas lines, low pressure gas lines, and liquid petroleum lines.

For example, if the service area of a large communication company includes all counties in Texas, a utility assessor of this company can review the knowledge from all experts of the communication type of utility companies in Texas. For a more focused view, a utility assessor of a small natural gas company can review the knowledge from all experts of the natural gas type of utility companies in his or her district only. Figure 6.4 shows the hierarchy of expert groups currently implemented in the CTUC knowledge base.

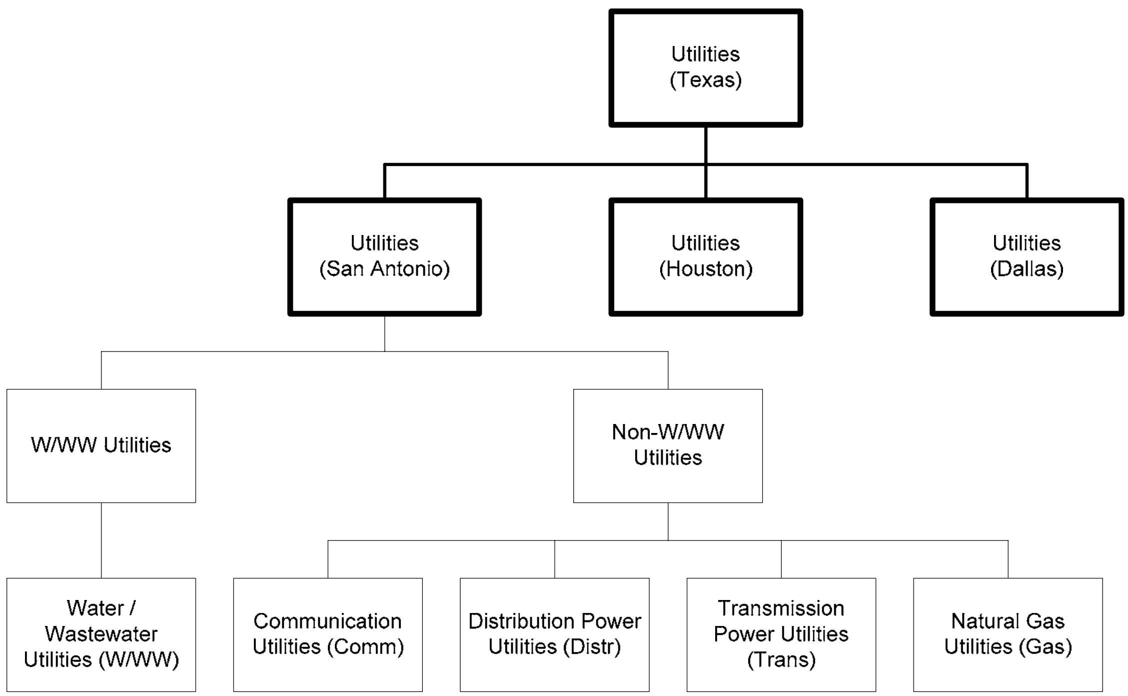

Figure 6.4: The hierarchy of the groups of utility experts

Note that reviewing the knowledge from all utility experts is useful from TxDOT's perspective because a TxDOT assessor may want to review the top Anti-CTUC decision drivers for a given utility adjustment from all utility experts' perspective. Furthermore, because past research indicated that the highway contractor can perform nearly all adjustment work for the water and wastewater types of utilities under the CTUC approach (GAO, 1999), the CTUC knowledge base should be able to render the knowledge from all types of non-water and wastewater (Non-W/WW) utility experts as well. For example, a TxDOT assessor might like to identify a utility adjustment that is not the water and wastewater type but that might be the second most Pro-CTUC type of utility. In this case, the assessor can first enter this utility adjustment's data into the CTUC Decision Support Tool. Then he or she can retrieve the knowledge from the experts on non-water and wastewater types of utilities. Finally, he or she can retrieve the experts' opinions on the given utility adjustment type. By having such information on hand, the assessor can quickly identify the decision drivers that are not only Pro-CTUC but unique to this type of utility adjustments.

6.7 Development of the CTUC Decision Support Tool

Developed with Microsoft® Visual Basic for Application (VBA) and Microsoft® Excel, the CTUC Decision Support Tool aims to create an interactive decision support environment into where both TxDOT and utility assessors can easily enter analysis data of their utility adjustments. The CTUC Decision Support Tool can then isolate significant issues relevant to the given utility adjustment and can display the corresponding opinions from both groups of experts in order to facilitate communication and coordination between both parties.

6.7.1 Overview of the CTUC Decision Support Tool Analysis Process

The CTUC Decision Support Tool's general process model for analyzing decision drivers of a utility adjustment is shown in Figure 6.5. This process model is the core algorithm of the CTUC Decision Support Tool and was designed to govern the interaction between an assessor and the CTUC Decision Support Tool, and to collect the information needed to generate the CTUC decision analysis reports for a given utility adjustment. Note that each utility adjustment within a project has its corresponding CTUC decision. However, in order to make one CTUC decision, this process model must be executed more than once because one CTUC decision needs both parties' participation. Descriptions of each step are summarized as follows:

1. **The assessor enters project and utility adjustment information.**
   The CTUC Decision Support Tool shows a blank form and prompts an assessor to fill out the information fields required for a project and its utility adjustments. The CTUC Decision Support Tool selects the first utility adjustment that has not been analyzed before as the current analysis subject.

2. **The CTUC tool displays a question.**
   The CTUC Decision Support Tool generates appropriate questions for the given utility adjustment based on the information provided by the assessor. For example, if the type of the given utility adjustment is natural gas, the questions pertaining to pole adjustments should not be shown by the CTUC Decision Support Tool. After all of the questions have been answered, the CTUC Decision Support Tool displays one question with all of its possible options at a time.

3. **The assessor selects one of the options.**
   After reading the question, the assessor selects the option that best describes his or her current project situation. Note that every question in the CTUC Decision Support Tool at least has three options. Hence, the CTUC Decision Support Tool makes one of three different determinations according to the assessor's response: (1) the selected option will not influence the CTUC decision; (2) the selected option will influence the CTUC decision; and (3) the selected option represents the "Don't Know" case.

4. **The CTUC tool adds the answer to the "Neutral" section if the selected option will not influence the CTUC decision.**

In such a case, the impact level of this option should be zero.

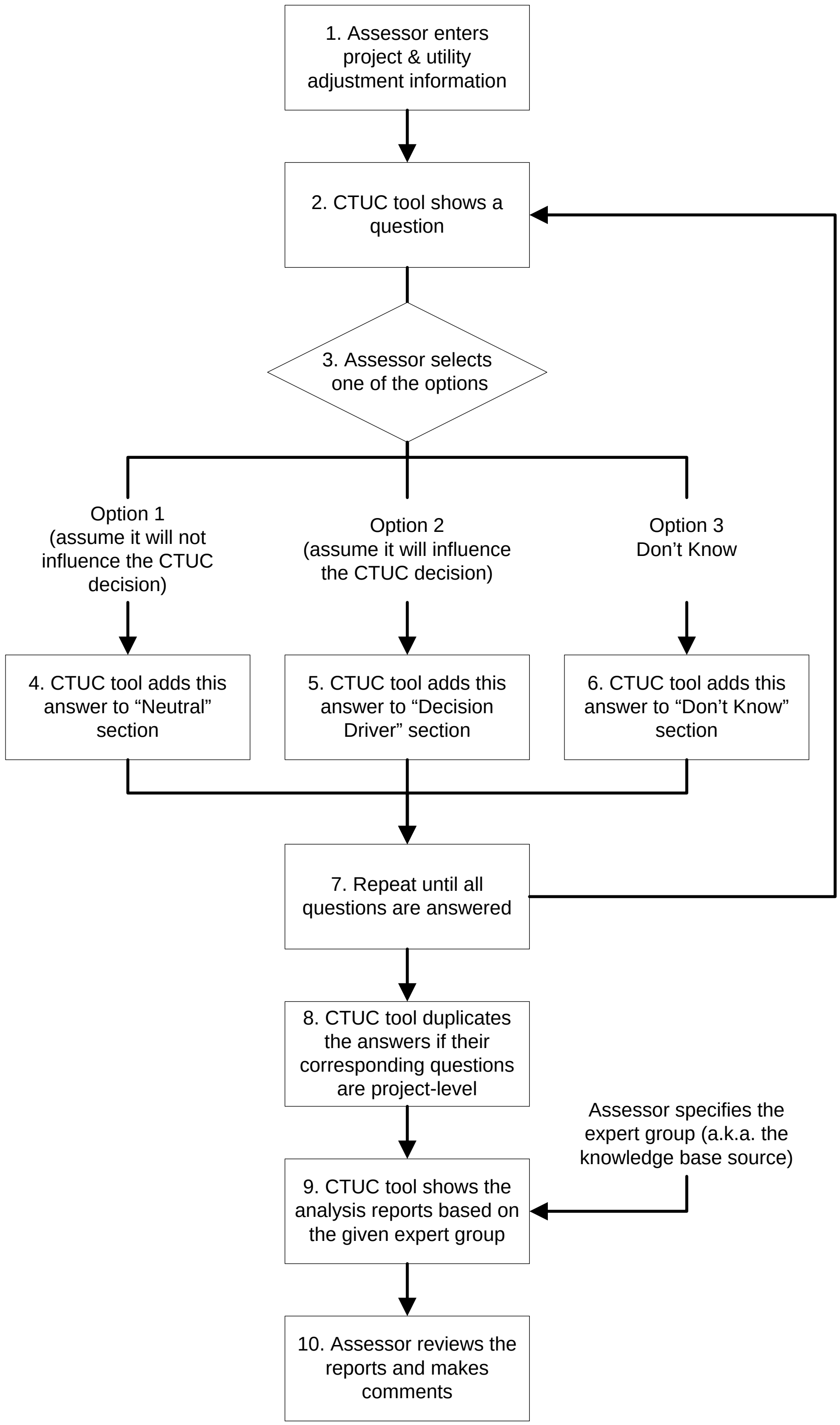

Figure 6.5: CTUC Decision Support Tool analysis process model

5. **The CTUC tool adds the answer to the "Decision Driver" section if the selected option will influence the CTUC decision.**
   In such a case, if the impact level of this option is negative, the option (or decision driver) is added to the "Anti-CTUC" section. If the impact level of this option is positive, the option (or decision driver) is added to the "Pro-CTUC" section.

6. **The CTUC tool adds the answer to the "Don't Know" section if the selected option is "Don't Know."**
   In such a case, all of the other options of the same question are added to the "Don't Know" section with the associated impact levels and resolvability data.

7. **The assessor repeats this process until all questions are answered.**
   Since one utility adjustment has many questions to be answered by the assessor, Steps 2-6 are repeated until all are answered.

8. **The CTUC tool duplicates the answers if the corresponding questions are project-level.**
   Since one highway project may involve many utility adjustments, the answers to the project-level questions for a particular utility adjustment should be applied to the other utility adjustments' project-level questions.

9. **The CTUC tool shows the analysis reports based on the given expert group.**
   The assessor first specifies the district scope of the expert group, which can be one of the following options:
   a. State-wide
   b. The TxDOT San Antonio, Houston, or Dallas district, depending on the assessor's current TxDOT district. If the assessor is not from one of the three TxDOT districts, the tool uses (a) instead.

   If the assessor is a utility representative, one of the following additional options regarding the utility type represented by experts can be selected:
   a. All types of utilities
   b. The assessor's type of utilities
   c. Either the water and wastewater types of utilities or the non-water and wastewater types of utilities.

10. **The assessor reviews the reports and makes comments.**
    The CTUC Decision Support Tool shows the analysis reports to the assessor, according to the knowledge base source the assessor specified. Note that the assessor can only determine the option or the existence of the decision driver of a question. Each decision driver's impact level and resolvability are determined by the experts of a specified expert group. The assessor can change the expert group in order to have a different set of impact levels and resolvability data for the same decision drivers. The assessor reviews the correctness of the impact level and resolvability data defined for each decision driver.

From the CTUC tool's perspective, both TxDOT and the utility owner follow the same analysis process model. However, in real-world CTUC analysis in which each party must apply the CTUC decision-making process described in Chapter 5, this decision-making process involves two phases. The first phase, called CTUC Phase 1 Analysis, was designed for a TxDOT assessor to identify the utility adjustments definitely not suitable for the CTUC approach. The second phase, called CTUC Phase 2 Analysis, was designed for both parties to isolate the decision drivers of the given utility adjustment. The following subsections describe how the CTUC Decision Support Tool was designed to accommodate the requirements of the CTUC decision-making process.

6.7.2 CTUC Phase 1 Analysis

CTUC Phase 1 Analysis is geared primarily for TxDOT assessors but is a part of the entire CTUC decision-making process. The user's manual for the CTUC Decision Support Tool is in the document produced for TxDOT 0-4997-P2 (O'Connor et al., 2006). Briefly, the first step of CTUC Phase 1 Analysis involves creating a new project. Once a new project has been initiated, the CTUC Decision Support Tool guides the assessor to the configuration form for all utility adjustments involved in the highway project. After completing these project information forms, the assessor is asked a series of project-specific questions, utility-specific questions, reimbursable adjustments questions, and/or non-reimbursable adjustments questions. Note that there are fewer questions in CTUC Phase 1 Analysis than in CTUC Phase 2 Analysis because some questions may not be answerable during 0 percent-15 percent PS&E.

After answering all of the questions, the assessor then specifies the knowledge base source and the CTUC Decision Support Tool shows the graphical analysis results. The assessor can see experts' opinions regarding the applicability of the CTUC approach for the given utility adjustment in a series of bar charts. In addition, the CTUC Decision Support Tool shows the text report listing all decision drivers ranked according to their impact levels. Finally, the assessor needs to specify which utilities are to be analyzed further in CTUC Phase 2 Analysis. The CTUC analysis reports for a sample project are listed in Appendix G.

6.7.3 CTUC Phase 2 Utility Analysis

CTUC Phase 2 Utility Analysis is conducted solely by utility assessors. The first step involves retrieving one of the CTUC analysis records created by TxDOT assessors in CTUC Phase 1 Analysis. Then, the CTUC Decision Support Tool guides the utility assessor to the questionnaire forms. The assessor is asked a series of project-specific questions, utility-specific questions, special project configuration questions, reimbursable adjustments questions, or non-reimbursable adjustments questions.

After answering all of the questions, the assessor then specifies the knowledge base source and the CTUC Decision Support Tool shows the graphical analysis results. The assessor can see experts' opinions regarding the applicability of the CTUC approach for the given utility adjustment in a series of bar charts. In addition, the CTUC Decision Support Tool shows the text report listing all decision drivers ranked according to their impact levels.

6.7.4 CTUC Phase 2 TxDOT Analysis

CTUC Phase 2 TxDOT Analysis is primarily operated by TxDOT assessors. The first step is to retrieve one CTUC Phase 2 TxDOT Analysis record and review the project configuration information. After completing these project information forms, the TxDOT assessor is asked a series of project-specific questions, utility-specific questions, special project configuration questions, reimbursable adjustments questions, or non-reimbursable adjustments questions.

Since the results of CTUC Phase 2 TxDOT Analysis may need to be compared with the results of CTUC Phase 2 Utility Analysis, generating comparison reports requires that the utility assessor finish CTUC Phase 2 Utility Analysis first. Hence, the TxDOT assessor should check to see each utility assessor has responded to all of the questions, and then select the appropriate utility analysis record for comparison. The TxDOT assessor can then specify the knowledge base sources, and the CTUC Decision Support Tool shows the graphical analysis results for both parties. The assessor can see the experts' opinions from both parties regarding the applicability of the CTUC approach for the given utility adjustment in the bar charts. Finally, the CTUC Decision Support Tool shows the text report listing all decision drivers in accordance with the experts' the rankings of their impact levels. The complete descriptions are in the document produced for TxDOT 0-4997-P2 (O'Connor et al., 2006).

6.7.5 Sample Project Analysis Results

In this subsection, a sample project with two utility adjustments is used to demonstrate the CTUC Decision Support Tool. The first assessor is from TxDOT, the second assessor is from Utility ABC (W/WW type of utility), and the third assessor is from Utility DEF (distribution power type of utility). All assessors choose to use all experts from either TxDOT or all types of utilities. Figures 6.7 and 6.8 show the graphical reports of CTUC analysis results only for the distribution power type of utility adjustment. Figure 6.6 shows the top six Pro-CTUC and Anti-CTUC decision drivers from the TxDOT experts' perspective, and compares them to the utility experts' assessments of the same decision drivers. Conversely, Figure 6.7 shows the top six Pro-CTUC and Anti-CTUC decision drivers from the utility experts' perspective, and compares them to the TxDOT experts' assessments of the same decision drivers.

TxDOT and utility experts may assign different impact levels for the same decision driver, e.g., the decision driver "(NR) Utility Delay Cost" is ranked as the second most Pro-CTUC decision driver in Figure 6.6, and it is ranked third in Figure 6.7. Both TxDOT and utility experts thought that "(NR) Utility Delay Cost = Less cost b/c CTUC ctrl" is Pro-CTUC; however, the TxDOT experts rated its impact level at +2.6 while the utility experts rated its impact level at +2.5. Note that "N" in each decision driver's bar chart means the total number of experts included in the average impact level calculation.

Sometimes TxDOT and utility assessors choose different decision drivers to answer the same question, e.g. in "(NR) Cost Comparison," the TxDOT assessor chose "CTUC > 15% cheaper" as the decision driver while the utility assessor chose "CTUC > 15% expensive." In this case, their utility adjustment cost estimates are not consistent. Finally, as noted above, even if both TxDOT and utility assessors chose the same decision driver called "HAZMAT," the impact levels assigned by both parties' experts may be very different. Greatly varying impact levels on a given decision driver indicate that both parties need more negotiation on that issue.

In addition, the CTUC Decision Support Tool can sort these decision drivers by the impact levels assigned by one party's experts show the impact levels assigned by the other party's experts. Figure 6.6 displays the comparison report if assessors want to see the top six Pro-CTUC and the top six Anti-CTUC decision drivers from the TxDOT experts' perspective. Figure 6.7 displays the comparison report if assessors want to see the top six Pro-CTUC and the top six Anti-CTUC decision drivers from the utility experts' perspective. Assessors can clearly and quickly identify the decision drivers that have different impact levels. For example, TxDOT experts thought that the decision driver called "Utility Crew Limitations = Only utility crew can do the adjustment" is the top Anti-CTUC decision driver, having given it a -3.8 impact level. However, the utility experts thought that the decision driver called "4.7 (NR) Front End Loading = Incr. cost b/c front-end loading" is the top Anti-CTUC decision driver, having given it a -3.5 impact level while TxDOT experts only gave it a -2.7 impact level.

Figure 6.8 shows the complete list of both parties' decision drivers. The "Don't Know" table can assist assessors in identifying unknown but important CTUC decision drivers. The "TxDOT/ Utility Misalignment" table can display every circumstance that should be discussed further by both parties due to misalignment circumstances, i.e., one party's experts judged the decision driver as Pro-CTUC while the other party's experts judged it as Anti-CTUC, or both parties' assessors chose different options as the answers to the same question.

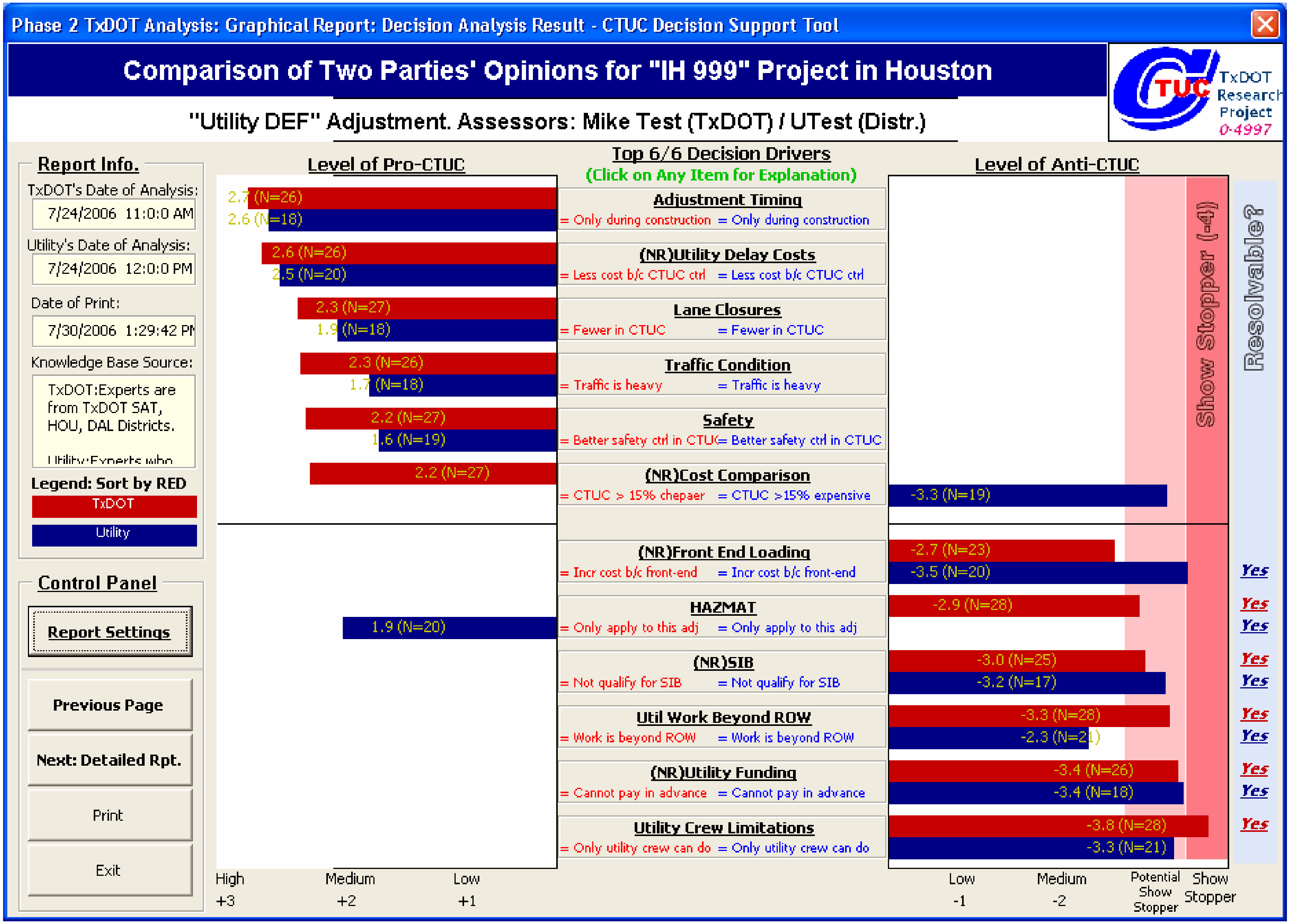

Figure 6.6: Comparison between TxDOT and Utility DEF: TxDOT-first perspective

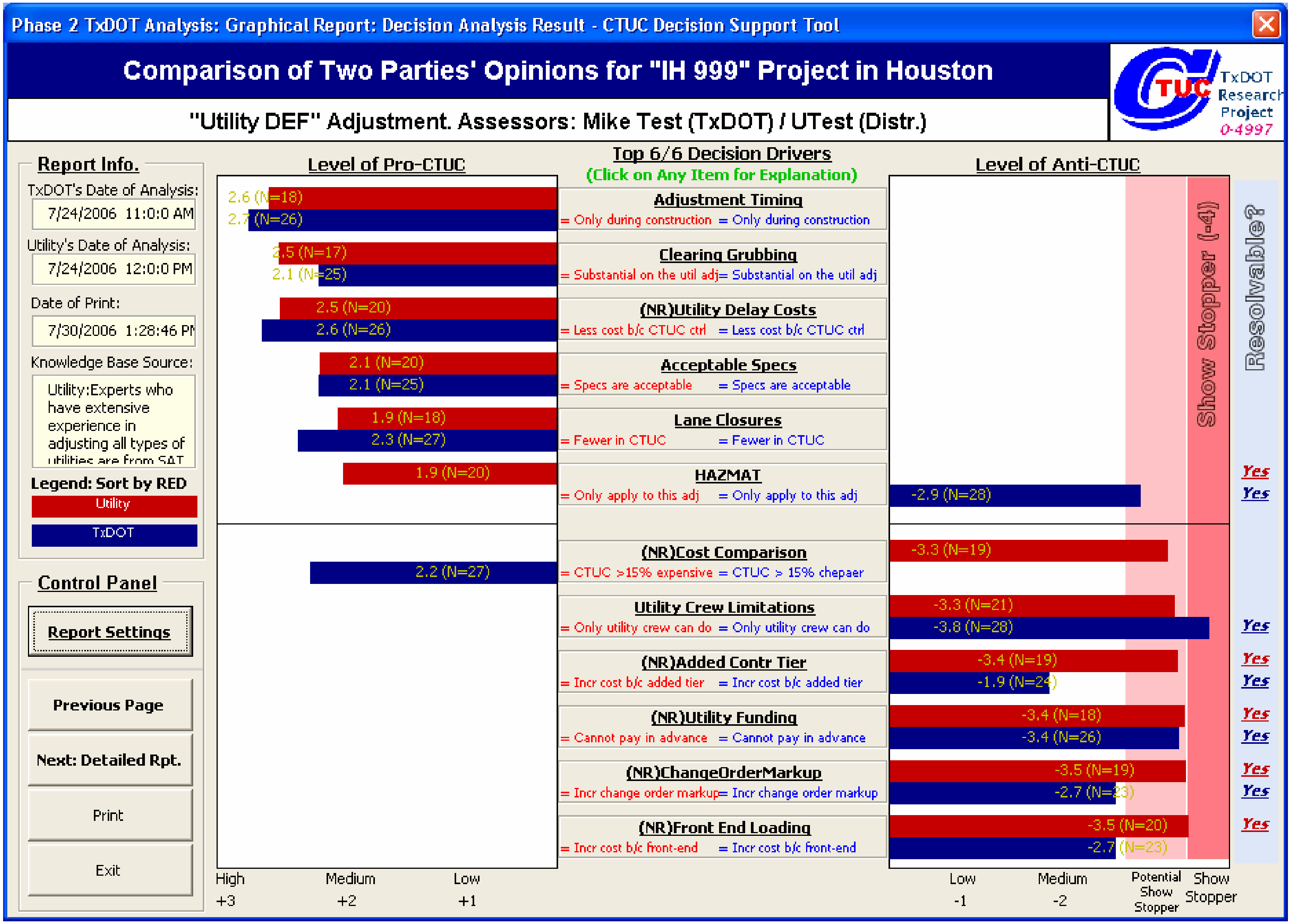

Figure 6.7: Comparison between TxDOT and Utility DEF: Utility-first perspective

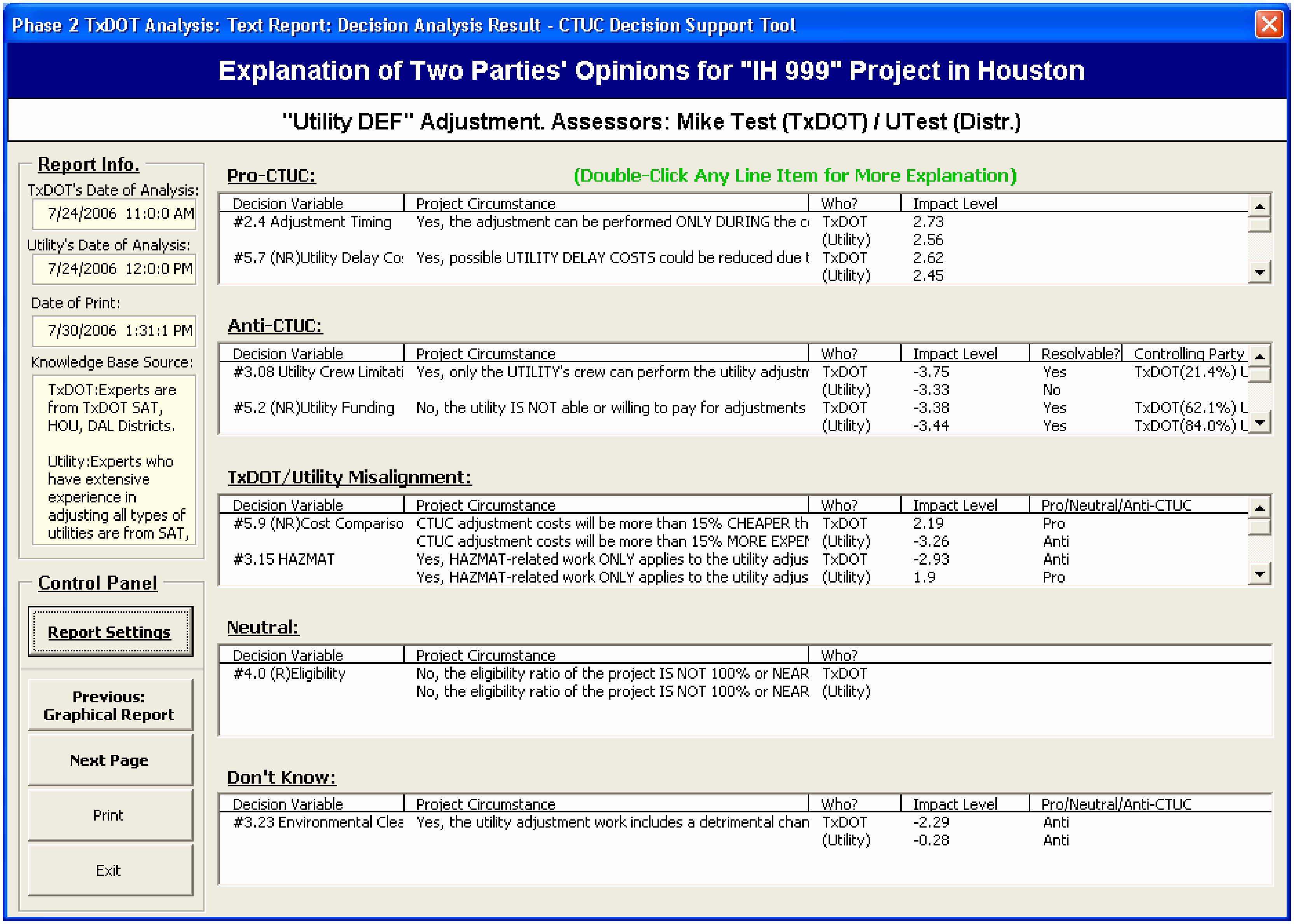

Figure 6.8: Five comparison tables listing both parties' decision drivers

6.8 Validation of the CTUC Decision Support Model

This chapter provides a summary of the validation results of the CTUC decision support model. Based on the proposed CTUC decision-making process, three types of test cases were designed, naming: (1) Test Case for CTUC Phase 1 Analysis; (2) Test Case for CTUC Phase 2 TxDOT Analysis; and (3) Test Case for CTUC Phase 2 Analysis. The research team then invited actual project stakeholders who may or may not be familiar with the CTUC approach for each test case. Project stakeholders from TxDOT were asked to provide actual utility adjustment information in the TxDOT projects that were between 0 percent and 60 percent PS&E completion. If the PS&E completion of a utility adjustment's TxDOT project was between 0 percent and 30 percent, the Test Case for CTUC Phase 1 Analysis was performed. Similarly, if the PS&E completion of a utility adjustment's TxDOT project was between 30 percent and 60 percent, the Test Case for CTUC Phase 2 Analysis was performed.

Project stakeholders from various utilities were also asked to provide actual utility adjustment information in the TxDOT projects that were between 30 percent and 60 percent PS&E completion. A total of 12 CTUC Tool Demonstration Meetings had been held. Seven of the 12 meetings were conduced for TxDOT project stakeholders. Table 6.10 lists each test case detailed information and evaluation results.

The first row entitled "# of utility adjustments" shows the number of utility adjustments collected for a test case. The second row entitled "# of TxDOT projects" presents the number of these utility adjustments' corresponding TxDOT projects. The third row entitled "# of evaluators" shows how many evaluators that provided input for a given test case. The row entitled "Participant of organizations" lists the names of the participant organizations. The row entitled "Distribution of the utility types" lists the numbers of the water / wastewater type, the communication type, the power type, and the natural gas type of utility adjustments for a test case. The row entitled "# of reimbursable / non-reimbursable adjustments" shows how many reimbursable and non-reimbursable utility adjustments for a test case.

The row entitled "Avg. # of decision drivers" shows how many decision drivers had been presented to an evaluator by the CTUC Decision Support Tool. Note that since not all of the decision drivers are applicable to a given utility type, the CTUC Decision Support Tool dynamically prepares the assessment questions based on an evaluator's input. The next row entitled "Avg. unknown %" shows that what was the percentage of the questions presented whose current statuses were unknown. In other worlds, the evaluator selected "Don't Know" as the answers to these questions. Table 6.10 shows that more unknown questions exist in CTUC Phase 1 Analysis than in CTUC Phase 2 Analysis. The research team was told that TxDOT project stakeholders usually do not have much information pertaining to utility adjustments if the project's PS&E completion is below 30 percent.

The next row entitled "Avg. disagree %" shows that among the decision drivers that were not selected as "Don't Know," what was the percentage of the decision drivers in which an evaluator did not agree with the associated impact levels and resolvability. Since the assessment of decision drivers' impact levels and resolvability were provided by the same groups as the evaluators, fewer evaluators modified the impact levels and/or resolvability of the decision drivers identified by the CTUC Decision Support Tool for the given utility adjustment.

The final row entitled "Overall evaluation" presents the overall evaluation of the CTUC Decision Support Tool. The evaluators were asked to assess how the CTUC Decision Support

Tool improves the quality of CTUC decision making. The qualitative measures were each assigned a value from 1 to 5 as follows:

- 5 Strongly agree
- 4 Agree
- 3 Neutral
- 2 Disagree
- 1 Strongly disagree

Table 6.10 shows that the evaluators of CTUC Phase 2 TxDOT Analysis gave a higher average score for the CTUC Decision Support Tool while evaluators of CTUC Phase 2 Utility Analysis gave a lower average score. The complete list of these modified decision drivers and the evaluators' comments are summarized in Chou's dissertation.

Table 6.10: Evaluation summary of the CTUC decision support model

Test Case	CTUC Phase 1 Analysis	CTUC Phase 2 TxDOT Analysis	CTUC Phase 2 Utility Analysis
# of utility adjustments	10	12	10
# of TxDOT projects	6	7	10
# of evaluators	6	15	11
Participant organizations	TxDOT DAL/SAT/WAC districts	TxDOT AUS/DAL/HOU/SAT/WAC districts	- Atmos Energy - Grande Communications - SAWS - City of Sugar Land - CenterPoint Energy
Distribution of the utility types	W/WW: 3 Comm: 2 Power: 3 Gas: 2	W/WW: 4 Comm: 2 Power: 2 Gas: 4	W/WW: 5 Comm: 1 Power: 1 Gas: 3
# of reimbursable / non-reimbursable adjustments	Reimbursable: 2 Non-Reimbursable: 6 Don't Know: 2	Reimbursable: 4 Non-Reimbursable: 8	Reimbursable: 4 Non-Reimbursable: 6
Avg. # of decision drivers	15.0	30.9	27.7
Avg. unknown %	35.33%	15.47%	11.27%
Avg. disagree %	2.06%	4.02%	4.82%
Overall evaluation	4.20	4.36	3.30

7. Conclusions and Recommendations

This chapter reviews the objectives of this research and provides conclusions and recommendations for improving the effectiveness of the CTUC approach.

7.1 Conclusions

This section presents a review of how the research objectives were successfully met and draws conclusions from the results of the research activities conducted in this study. The following conclusions are related to the research objective to characterize CTUC benefits and challenges:

- Based upon the information gathered through preliminary research meetings and from the literature review, it is evident that the CTUC approach is, under some circumstances, the most beneficial contracting approach for utility adjustments. It is also evident that the CTUC approach is not always the most advantageous method.
- TxDOT and utility owners have different perspectives regarding the CTUC decision drivers and the relative impact levels of each on the CTUC decision. What might be a factor of utmost importance to a utility owner is sometimes of little to no importance to TxDOT, or vice versa.
- In order for TxDOT and utility owners to enjoy the benefits associated with the CTUC approach, some utility adjustment process changes may be necessary. Many of these process changes will aid utility owners in realizing the benefits involved with the CTUC approach.
- As the assessment surveys by TxDOT on completed CTUC projects have verified, the CTUC approach can be beneficial to TxDOT. The project performance criteria, listed in order of most to least positive impact to highway constructability, are: (1) improving traffic flow through the project; (2) moving the letting date earlier; (3) satisfying the utility owners with the sub(s) work; (4) reducing the overall project schedule duration; (5) improving coordination among different utility owners; and (6) preserving and/or improving the relationship between TxDOT and the utility owners.

The following conclusions are related to the research objective to develop the CTUC Decision Support Tool:

- The decision drivers that promote or impede the use of the CTUC approach have been identified and assessed by both TxDOT and utility experts. The assessment results of CTUC decision drivers are consistent with the findings of the preceding characterization report of CTUC benefits and challenges.
- Successful implementation of the CTUC approach requires a systematic analysis based on CTUC decision drivers in the early stage of the PS&E development. Both the conventional and CTUC approaches should be treated without bias. The CTUC Decision Support Tool was designed to isolate significant decision drivers that need to be addressed before the final CTUC decision is made for a given utility

adjustment. The CTUC Decision Support Tool itself also serves as an intelligence tool that assists both TxDOT and utility assessors in evaluating the project and utility adjustment circumstances. Having such a tool furthers negotiation between the two parties.

- The CTUC Decision Support Tool has been demonstrated and validated with actual project stakeholders from several TxDOT districts and utility owners. The validation results show that the impact levels and resolvability data associated with the CTUC decision drivers are appropriate for their utility adjustments. Overall, with the assistance of the CTUC Decision Support Tool, the assessors can make better CTUC decisions.

7.2 Recommendations

From the information gathered during the researching into the CTUC approach and the demonstration of the CTUC Decision Support Tool, the following recommendations may be made to TxDOT:

- To ensure that the appropriate contracting technique is consistently selected, TxDOT should make use of the CTUC Decision Support Tool and consider adopting the proposed CTUC decision-making process presented in this report.
- TxDOT should use the CTUC benefits identified in this report to promote the CTUC approach to hesitant utility owners. By leveraging the CTUC benefits, and addressing the identified CTUC challenges, TxDOT will increase utility interest and participation in the CTUC approach.
- In order to obtain the full benefits of the CTUC approach, TxDOT should consider developing a centralized knowledge base to continuously collect both TxDOT and utility experts' opinions on the CTUC approach. In addition, TxDOT should also consider implementing a web-based, lessons-learned system to educate and further enable the sharing of information between the more experienced districts and the less experienced ones.

7.3 Research Contributions

This research has contributed to the enhancement of CTUC decision making. Firstly, decision drivers that affect the CTUC decision were identified in this research. A systematic approach to designing the CTUC decision support model and the knowledge base were employed in order to develop the CTUC Decision Support Tool. By transforming both TxDOT and utility experts' opinions into the knowledge base, the CTUC Decision Support Tool facilitates communication and coordination among TxDOT and the utility owners involved. Additional research contributions are listed as follows:

- Past studies have not thoroughly investigated decision drivers that influence the CTUC decision. The decision variables identified in this research help complete the knowledge of CTUC decision making.
- By understanding the concerns and opinions of the other party in advance, the CTUC Decision Support Tool help both the TxDOT and utility owners involved negotiate with each other in a more efficient and effective way. The agreement

reflecting the best contracting approach for a given utility adjustment can be reached so as to shorten overall highway project duration.

- Future researchers can rely on the decision support model developed to devise a similar decision framework to be applied in contexts in which multiple parties need to negotiate and numerous decision drivers need to be considered simultaneously, e.g., city streets expansion projects.

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Appendix A: Questionnaires for Preliminary Research Interviews

1. Has your company participated in any joint bid utility relocation contracts with TxDOT?

IF YES (If NO, Proceed to question #11)**:**

2. How many projects have you performed by joint bid with TxDOT?

3. What benefits do you feel that your company realized from using the combined approach?

4. What challenges did your company face as a result of the joint bidding?

5. Please briefly describe the type of work included in the joint bid, and what type of work was not included?

6. Who generally initiates the joint bid process (utility or TxDOT), and at what point (% design complete) are utility companies usually involved?

7. What criteria help you decide if joint bidding is appropriate? In other words, under what circumstances would you definitely/definitely-not consider joint bidding?

8. What do you view as major process or implementation differences between the conventional and combined approaches? Please explicitly address funding (Joint bid requirement for upfront payment), design, and responsibility for inspection.

9. Is shortage of inspectors a limiting factor for your relocation progress? If so, would you be willing to train TxDOT inspectors and allow them to inspect joint bid relocation work?

10. When utility facilities are located directly above or below one-another underground, or overhead (poles), does multi-utility participation in joint bidding become a complication due to relocation timing? For instance, if several companies are located on a single pole which requires relocation and the owner company decides to joint bid their relocation with TxDOT, are the other companies forced to joint bid or face serious complication?

IF NO:

11. Has your utility company been approached by TxDOT to execute a combined contract?

    11.1 If yes, why didn't the contract get executed as joint bid?

12. What is the primary reason(s) that your company has not completed a joint bid project? What do you see as the major challenge to the joint bid approach?

13. Has the upfront funding requirement for joint bid contracts helped to deter you from entering such an agreement? If payments could be made incrementally, would you be more likely to enter a joint bid contract?

14. If inspector shortage is an issue for your company, would you be willing to train TxDOT inspectors and allow them to inspect the joint bid work?

15. Under what circumstances would you consider joint bidding?

16. At what point (% design complete) does TxDOT generally involve/inform utilities of the need for relocation?

Appendix B: Benefits and Challenges of the CTUC Approach

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Line	Decision Parameter Category	Decision Parameter	Pro - CTUC	Anti - CTUC	Importance (H/M/L) Acc. To TxDOT Dallas	Explanation/Opinion	Process Change Needed?	Controlling Party (TxDOT, Sate, Utility, etc.)
1	Contract Type	Reimbursable Utility adjustment Contract.	√		H	TXU Distribution didn't see any significant benefit. For non-reimbursable projects, TXU Distribution does not expect any benefit whatsoever from the use of CTUC. TXU Transmission does not expect any benefit in either contract type.	N	TxDOT, Utility
2		Non-Reimbursable Utility Adjustment Contract.		√	H	Utility companies want to see concrete financial benefits before committing to CTUC. In non-reimbursable contracts, it is harder to convince utility companies of the joint bid benefits.		
3	Utility Type	Water	√		H	In Dallas, joint-bidding of water and sewer began a long time ago (North Central Expressway ~ mid 90's), and now other utility companies want to use this approach. The IH 635 project will be 100% CTUC (let in Oct 2005) for all utilities. The IH-635 project is the City of Mesquite's first joint bid utility adjustment with TxDOT and is 100% reimbursable. TxDOT contracted with an engineering consultant firm for designing all utilities involved, and the consultant firm has sub-consultants to design specialized utility adjustments. The City of Mesquite is responsible for the management and coordination of all utility design work, and several coordination meetings have been held with TxDOT, utility companies, and consultants. These meetings are held on a monthly-basis, and the resulting design progress has been very good. The City of Mesquite also reports that, under the conventional approach, such great progress is not feasible. Hence, they highly recommend that future projects use the CTUC approach.	N	N/A
4		Wastewater	√		H	In Houston, all W/WW adjustment contracts are CTUC including adjustment through connection and chlorination, excluding lines >24", lift stations, pumps, and pressure reducer stations. City of Sugar Land W/WW reports that they joint bid all adjustment work through the TxDOT contractor.	N	N/A

Appendix B: Benefits and Challenges of the CTUC Approach (Cont'd)

Line	Decision Parameter Category	Decision Parameter	Pro - CTUC	Anti - CTUC	Importance (H/M/L) Acc. To TxDOT Dallas	Explanation/Opinion	Process Change Needed?	Controlling Party (TxDOT, Sate, Utility, etc.)
5	Utility Type	Wastewater Pump Station	√		H	San Antonio Water and Sewer (SAWS) does about 99% joint bid contracts with TxDOT.	N	N/A
6		Conduit, no wire included	√		H	The IH635 contract required the TxDOT contractor to purchase TXU (electric utility company)'s equipment and materials, with a few exceptions. TXU Transmission (Electric power is transmitted at very high voltages) has no CTUC experience. TXU transmission has its own ROWs for the facilities, e.g., towers. TXU transmission adjustment projects are usually reimbursable. TXU Distribution has both overhead poles and underground lines in TxDOT ROWs, but TXU does own some easements. If the projects are reimbursable, like the IH635 project with the City of Mesquite, TXU would be interested in considering the CTUC approach. TXU facilities are never adjustd by the TxDOT contractor if the project is non-reimbursable. For the SBC adjustment work in the IH-635 project, the TxDOT road contractor will do all utility adjustment, including conduit, male hole, cable, splice, blocking, etc.		
7		Manholes for data, cable, telephone, etc.	√		H			
8		Telephone and Power Poles, no wire included.	√		H			
9		Microwave Tower	√	√	H	In Houston, CenterPoint electric reports that they have not joint bid power line adjustment, but would be open to some infrastructure adjustment if proof of financial benefit was available.		
10		Overhead Communications	√	√	H			
11		Overhead Power	√	√	H			
12		Transmission Pole		√	H			

Appendix B: Benefits and Challenges of the CTUC Approach (Cont'd)

Line	Decision Parameter Category	Decision Parameter	Pro - CTUC	Anti - CTUC	Importance (H/M/L) Acc. To TxDOT Dallas	Explanation/Opinion	Process Change Needed?	Controlling Party (TxDOT, Sate, Utility, etc.)
13	Utility Type	Transmission Tower		√	H	In SAT, CPS electric has not performed joint bid contracts with TxDOT, but has with other utility companies in the past. They are interested in executing joint bid contracts for overhead and underground distribution infrastructure (poles, manholes & conduit; no 'hot' work) only. They do not anticipate joint bidding any element of Transmission in the future.	N	N/A
14		Underground Communications	√	√	H			
15		Underground Power	√	√	H			
16		High Pressure Gas		√	H	In Dallas the IH 635 project is 100% CTUC, including ATMOS Gas facilities.	Y	
17		Liquid Petroleum Lines		√	H	In Houston, CenterPoint Gas has never joint bid any adjustment contracts. They are not particularly interested in joint bidding. They perform 100% in-house design; schedule flexibility associated with CTUC to accommodate the 6 month consultant acquisition process is not required. Direct cost savings would need to be proven before CenterPoint Gas would be interested. Too many safety issues exist. They do joint trench with other utility companies. CenterPoint has 5 prequalified subs for such work.		
18		Low Pressure Gas		√	H	In SAT, CPS gas joint bid over 50% of their adjustment projects with TxDOT. They now joint bid very few projects because of a reported 30% higher cost versus the conventional approach. For non-reimbursable projects, CPS now only joint bids with TxDOT when under significant schedule constraints (e.g. Toyota).		
19		Irrigation Pipeline	√	√	H	Abandoned pipes		
20		Extend Casing	√	√	H			

Appendix B: Benefits and Challenges of the CTUC Approach (Cont'd)

Line	Decision Parameter Category	Decision Parameter	Pro - CTUC	Anti - CTUC	Importance (H/M/L) Acc. To TxDOT Dallas	Explanation/Opinion	Process Change Needed?	Controlling Party (TxDOT, Sate, Utility, etc.)
21	Design Format	When joint bidding occurs, it is desirable to have the option of joint design as well. TxDOT often hires a design consultant which is capable of handling the engineering of several utilities to be adjusted. When a separate design consultant must be hired by each utility (TxDOT's consultant is sometimes not prepared to perform all design), engineering/coordination costs rise, and the benefits of CTUC are diminished.	√			Many public utility companies report that the design consultant hiring process takes 4-6 months; this time is eliminated if joint design can be performed. In the IH635 project, each utility company provided a list of qualified design consultants. The City of Mesquite nominated a General Design Consultant (GDC) to coordinate each specific consultant. Utility companies approved the GDC, and the GDC used qualified subs from the lists provided by the utility companies. TXU Distribution reported that they are happy with underground design, but are not satisfied with overhead design. The City of Mesquite expects that the GDC firm will provide a comprehensive design because they understand the 'big picture'. In SAT, several utilities (SAWS, CPS, SBC) all agreed that if TxDOT plans to continue joint bidding, they need to consider hiring consultants capable of performing the designs for all utilities involved. CTUC does not offer any savings in the design phase unless joint design is utilized.	Y	TxDOT
22	Utility Phys. Characteristics or Scope	When gas lines need to be adjustd inside of TxDOT ROW, the CTUC contract includes only the portions of the lines which require adjustment within ROW limits. If the adjustment requires further work outside of the ROW, the gas company must execute a separate contract.		√		CPS gas in SAT identified private gas service lines which require reconnection, and new mains requiring placement outside of TxDOT ROW as major inhibiting factors for CTUC. This inefficient, two-contract adjustment technique sharply diminishes the advantages of joint bidding. This may apply to other utility types as well. Implications of utility modifications on non-TxDOT ROW?	Y	TxDOT
23		Utilities with HAZMAT. (e.g. asbestos) If HAZMAT has been previously identified and included in the contract documents, contractors will bid accordingly. If unexpected HAZMAT is found on the site, contractors will typically request a change order.		√	M	In Houston, TxDOT often refuses to joint bid with W/WW if material containing asbestos will be included in the adjustment work. In SAT, utility companies identified HAZMAT environmental mitigation as a serious problem. The TxDOT contractor will perform no hazardous material removal even though they have an 'evergreen' subcontractor in place. Utility companies are willing to pay for mitigation efforts, and see this as a potential process improvement as opposed to the complication of each utility hiring their own environmental consultant/contractor.	Y	TxDOT

Appendix B: Benefits and Challenges of the CTUC Approach (Cont'd)

Line	Decision Parameter Category	Decision Parameter	Pro - CTUC	Anti - CTUC	Importance (H/M/L) Acc. To TxDOT Dallas	Explanation/Opinion	Process Change Needed?	Controlling Party (TxDOT, Sate, Utility, etc.)
24	Utility Adjustment Funding (Non-Reimbursable)	Some utility companies may exceed annual budgeted utility adjustment funding level, particularly when large corridor projects require significant simultaneous adjustments.		√	M	When this occurs, the SIB can negotiate loan terms. Houston W/WW, SBC, and CenterPoint reported that this was not usually an issue.	N	Utility
25		The total adjustment cost can increase by as much as 30% when performed by the TxDOT contractor rather than a contractor hired by the utility company. The lowest bidder for the entire road construction project may save TxDOT money at the expense of the utility companies. The following items contribute to the 30% cost increase: Front End Loading, Increased Change Order Amount/Frequency, Added Contractual Tier, and the addition of Subcontractor Management Contingency.		√		City of Houston W/WW identified this as a major issue when the contract is non-reimbursable. They attribute the increase in cost to contractor inexperience and feel that it proves the need for prequalification. In SAT, all utilities agree that cost increase is a major disincentive for joint bidding. CPS gas identified it as the single greatest factor, confirming the 30% increase. SAWS agreed that there was some cost increase, but stated that they experienced less than 30%. The accountability of contractors needs to be questioned here; public entities may continue to use a contractor because of the low bid requirement even when that contractor has used change orders to increase costs in the past.	Y	TxDOT
26		When non-reimbursable CTUC adjustments occur, the utility company must make funding available for the entire adjustment up front in an escrow account.		√	M	Houston W/WW does this on all of their projects. SBC and CenterPoint said that they would not agree to paying the full amount in advance. In the City of Mesquite, the IH635 project is reimbursable, no such issue exists. In the past, for non-reimbursable projects, the City of Mesquite suggested alternative payment methods be used, i.e., monthly payment according to progress. This suggested approach has not been performed to date. In SAT, this was identified as a major issue. Grande communications refuses to pay this amount upfront due to budget constraints. CPS gas, and SAWS mentioned that they have paid the 100% escrow amount in the past, but feel that it is poor practice. Several of the utilities also mentioned that the accounting process as a whole needs to be tied more closely to the construction process. For example, when scope is reduced, refunds do not occur until after the entire roadway construction process is complete (> 2 year waiting period).	Y	State (TxDOT?)

Appendix B: Benefits and Challenges of the CTUC Approach (Cont'd)

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27	Utility Adjustment Management Resources	The CTUC process can alleviate demand for the utility companies to supply adjustment crews because the work is performed by the TxDOT contractor.	√			In SAT, SBC and CPS electric mentioned that the joint bidding process alleviated some resource constraints and allowed them to focus on 'new service' projects rather than adjustments.	N	Utility
28	Adjustment Completion Timing	Because the utility adjustment effort is often among the first construction activities to occur on TxDOT ROW, the utility is often required to pay for ROW clearing.		√		SAT utilities indicated that they were often required to cover ROW clearing costs. Their argument is that because this ROW would need to be cleared anyway, the cost should be shared by TxDOT and all applicable utilities, not just the first one present.	Y	TxDOT
29		Using the conventional approach, utility adjustment should precede contract letting. The CTUC approach allows the utility adjustment to occur following contract letting.	√		H	If projects are complex, using CTUC may prevent the utility adjustment from delaying the entire project because utilities will be adjustd under the road contractor's schedule. The CTUC approach is valuable when utility adjustment is likely to delay the project under the conventional approach. CTUC benefits: Not waiting on utilities. Houston W/WW reported that it takes 6 months from the time they are informed of the adjustment need (at 60% design complete) to get a design consultant on board. When this occurs, CTUC is their best alternative in order to avoid delaying the construction schedule. SAT utilities also identified the delay associated with hiring a consultant as problematic. They also suggested that joint design using one consultant who is capable of performing all types of utility design would be the most efficient way to capitalize on the advantage of joint bidding.	N	TxDOT, Utility

Appendix B: Benefits and Challenges of the CTUC Approach (Cont'd)

Line	Decision Parameter Category	Decision Parameter	Pro - CTUC	Anti - CTUC	Importance (H/M/L) Acc. To TxDOT Dallas	Explanation/Opinion	Process Change Needed?	Controlling Party (TxDOT, Sate, Utility, etc.)
30	Specification Concurrence	The CTUC approach may introduce complication due to disjointed specs between TxDOT and utility companies resulting in misunderstanding. If the CTUC approach is to be used, TxDOT will need to update their specs more frequently in order to accommodate rapidly changing adjustment specifications.		√	L	Two issues arise regarding specs: Current Specs, and Integration. It is common for utilities to adopt TxDOT specs, or to provide their own. This solves the problem of having ensuring that specs are not outdated, but does not ensure proper integration. Dallas utilities define their own specs. They also include a list of qualified designers, subcontractors, and sometimes even material suppliers. In the IH635 project, TxDOT Dallas reported that their specifications showed no major conflicts with individually provided utility adjustment specifications. The City of Mesquite and TXU Distribution reported that the CTUC approach requires increased communication/coordination efforts in the design phase. The City of Houston W/WW provides their own specs and seems pleased with the result. The City of Sugar Land W/WW reported that they use specs provided, and often do not agree with them. SAT utilities either supply their own specs or did not identify this as a problem.	Unknown	TxDOT
31	Multi-Utility Participation	When the CTUC approach is used, it is likely that one or more utilities will elect to proceed WITHOUT joint bidding. Any delay caused by non-CTUC utilities will diminish the advantages of the CTUC approach for those utilities who are "on board", and have money placed in escrow accounts.		√	M	It diminishes but does not eliminate the advantages. Again, this is only valid for the projects in which CTUC makes sense, based on complexity and constructability. CTUC benefits: Improved work sequencing and constructability (criticality of utility facility to be adjustd in relation to the preferred work sequence). Some benefit can be realized from TxDOT's contractor controlling the work sequence, even if some companies elect not to joint bid. In Dallas/Mesquite/Fort Worth, if TXU Distribution owns the utility pole, they will send pre-notifications to all utility companies attached to that pole. It is up to each utility company whether to use the CTUC approach or not. Usually, utility companies will negotiate with TxDOT, and if they get reimbursement agreements, they will use the CTUC approach. TXU cannot guarantee that all attached utility facilities will be moved simultaneously. In SAT, CPS electric identified this as a challenge when telecom companies are attached to their distribution poles; if they were to joint bid, the telecom companies would need to be encouraged to follow suit in order to realize the maximum benefit.	N	Utility

Appendix B: Benefits and Challenges of the CTUC Approach (Cont'd)

Line	Decision Parameter Category	Decision Parameter	Pro - CTUC	Anti - CTUC	Importance (H/M/L) Acc. To TxDOT Dallas	Explanation/Opinion	Process Change Needed?	Controlling Party (TxDOT, Sate, Utility, etc.)
32	Management Responsibility and Coordination	CTUC creates some extra coordination and paperwork for the DOT by addition of management, record keeping, processing of the Contract Item Agreement, and managing funding and payments.		√	L	Dallas reports little difference in DOT work between the two approaches. TxDOT will be involved in either way.	N	N/A
33	E & C Fees	Engineering, Contingency, and Mobilization fees are charged at different rates depending on the TxDOT district.	√	√		Houston currently uses an E&C fee rate ranging from 7.5% (contract amount >$25MM) to 16% (contract <$1MM). They also mentioned that there are indirect costs associated with some agreements charged at a state average of 6.58%, or 5.12% in the Houston District. Houston traditionally omits the indirect cost from AFAs for local governments. The E&C rate in Dallas is approximately 9%. This fee rate depends on the overall contract amount. The fee rate is determined by considering the entire road construction contract, including utility adjustment. The E&C fees from other districts are currently being collected. San Antonio TxDOT reports that they "Try to use 2%". This rate is per their advanced funding agreement.	Unknown	TxDOT
34	Contractor Contingency	With the conventional contracting approach, construction contractors will bid with contingencies built in for delays due to unadjustd utilities. The CTUC approach requires no utility delay contingency because the contractor will control the adjustment. However, other contingencies for issues such as subcontractor management may increase.	√		M	Yes, theoretically, but (according to TxDOT Dallas District) this cannot yet be confirmed. Further investigation needs to be conducted including the collection of contingency and management costs from future projects, including IH635.	N	Contractor

Appendix B: Benefits and Challenges of the CTUC Approach (Cont'd)

Line	Decision Parameter Category	Decision Parameter	Pro - CTUC	Anti - CTUC	Importance (H/M/L) Acc. To TxDOT Dallas	Explanation/Opinion	Process Change Needed?	Controlling Party (TxDOT, Sate, Utility, etc.)
35	State Law Limitations	When the adjustment contract is conventional and non-reimbursable, the utility companies may choose adjustment subcontractors without justifying selection (e.g. low bid or best value). When the CTUC approach is used, TxDOT must ensure that their highway contractor receives the legal minimum number of bids, and that they justify their subcontractor selection. Complication may arise if, for example, SBC names the sub that they would like to perform the adjustment, but a lower bid is available that does not involve the SBC specified sub.		√	H	SAT utility companies mentioned that they are able to provide TxDOT with a list of their prequalified contractors and TxDOT has no problem selecting the low bidder from that prequal list.	N	State
36	Work Sequence	With CTUC, the opportunity exists for the contractor to optimize the work sequence without concern for adjustment delay.	√		H	If the work sequence is complex, even for a single utility, CTUC might still be beneficial.	N	Contractor

Appendix B: Benefits and Challenges of the CTUC Approach (Cont'd)

Line	Decision Parameter Category	Decision Parameter	Pro - CTUC	Anti - CTUC	Importance (H/M/L) Acc. To TxDOT Dallas	Explanation/Opinion	Process Change Needed?	Controlling Party (TxDOT, Sate, Utility, etc.)
37	Claims and Risk	In theory, the use of CTUC can lead to reduced change orders and risk of delay and claims.	√		M	In SAT, CPS gas reported increased change order quantity and dollar amount due to the adjustment contract execution by a more 'change order minded' large general contractor as opposed to the specialty sub typically hired by the utility company under the conventional adjustment contracting approach. The City of Mesquite reported that less litigation can be expected due to the positive relationships developed with utility companies resulting from the CTUC approach. Although CTUC doesn't eliminate all litigation, the majority are removed.	?	All
38	Utility Inspection Resources	Adjustment projects within a large corridor program may require more simultaneous adjustments than some utilities have available inspectors. For such projects, accelerating schedules with CTUC may be difficult to achieve.	√		M	TXU reported that this has not been an issue in the past. They have a sufficient number of inspectors to manage all of their simultaneous projects.	N	Utility
39	Inspection Party	Responsibility for Inspection differs by district. SAT requires utility companies to perform all inspections. TxDOT Houston self performs some inspection.	√	√	H	Inspection responsibility is a decision parameter because the benefit of the CTUC approach is far greater for a utility company when the TxDOT district performs the inspection so that company inspection resources can be utilized elsewhere. When the district provides no inspection, the CTUC schedule may strain utility inspection resources. Dallas only performs alignment inspection. SAT utility companies contradicted TxDOT by reporting that TxDOT inspectors do some or all of the inspection.	N	TxDOT, Utility

Appendix B: Benefits and Challenges of the CTUC Approach (Cont'd)

Line	Decision Parameter Category	Decision Parameter	Pro - CTUC	Anti - CTUC	Importance (H/M/L) Acc. To TxDOT Dallas	Explanation/Opinion	Process Change Needed?	Controlling Party (TxDOT, Sate, Utility, etc.)
40	Inspection Party	The type of utility adjustd determines whether TxDOT is qualified to perform the inspection. For example, TxDOT is comfortable installing and inspecting SBC conduit and manholes, but does not pull/connect any cable.	√	√	M	In Dallas, TxDOT performs alignment inspection (horizontal and vertical) and utilities perform operation inspection. In the IH635 project, TXU Distribution reports that they expect more inspection (5 times more) because the CTUC approach is being used; both cost and time increased. In SAT, SBC mentioned that TxDOT inspectors do a good job. This allows more SBC inspectors to focus on non-adjustment projects.	N	TxDOT, Utility
41	Ownership and Warranty Issues	The ownership of the facility should be transferred from the contractor to the utility company after construction completion. However, the warranty cannot be transferred.		√		Usually, the TxDOT contractor provides no warranty period while TXU requires its contractor to provide 1-2 years. When the CTUC approach is used, the general contractor has a fiduciary relationship with TxDOT, not with TXU. Therefore, the utility company cannot expect the same warranty as provided under the conventional approach. They also mentioned that the utility owner cannot transfer liability to TxDOT, and only the utility owner can legally assume the risk. So they guessed that gas companies are in the same situation because they have more regulations to follow.	Y	TxDOT, Contractor

Appendix B: Benefits and Challenges of the CTUC Approach (Cont'd)

Line	Decision Parameter Category	Decision Parameter	Pro - CTUC	Anti - CTUC	Importance (H/M/L) Acc. To TxDOT Dallas	Explanation/Opinion	Process Change Needed?	Controlling Party (TxDOT, Sate, Utility, etc.)
42	Improved Traffic Control Plan and Improved Field Productivity	With CTUC, simplified or better coordinated construction including site preparation, traffic control, and combined work activities lead to higher productivity. Further, when utility adjustment involves required lane/road closures, TxDOT is more experienced in traffic management than most utility companies. When multiple utilities perform their own adjustment, road closures will occur on several occasions. The CTUC approach allows one road closure for all involved utilities.	√		H	In the IH635 project, the City of Mesquite reported that CTUC facilitates better communication and coordination among utility companies. In the construction phase, each utility company is not dependent on the other because the work sequence is managed by the general contractor. Subcontractors do the adjustment work as before while the general contractor manages and integrates them. Hence, less communication is required between utility companies and their subcontractors in the construction phase. The City of Mesquite reported that CTUC requires less staff time during the construction phase. In the construction phase, the general contractor does the management/coordination work. Utility companies do only the inspection work. In the conventional approach, different organizations do the work; hence, less efficiency can be expected. Houston and Sugar Land W/WW both identified this as a significant benefit; inconvenience to the traveling public need only occur once for several utilities when CTUC is used, as opposed to once for each utility when the conventional adjustment approach is executed. SAT utilities cited this as a major benefit in terms of convenience to the utility, and as a way to avoid any bad PR due to excessive inconvenience to the traveling public.	N	TxDOT, Contractor

Appendix C: Questionnaire for Assessment of Completed CTUC Project Performance Criteria

Research Introduction & Project Confidentiality

The Center for Transportation Research at the University of Texas at Austin (CTR – UT) and the Texas Department of Transportation (TxDOT) are currently working on a research endeavor to verify the effectiveness of combined utility relocation/highway construction projects. This approach is referred to as Combined Transportation and Utility Construction (CTUC). Research on this project (TxDOT No. 0-4997) commenced in the fall of 2004 and is scheduled to conclude with the presentation of project deliverables to TxDOT in August of 2006. Presently, the CTR staff is in the process of obtaining information from various TxDOT districts and individuals that focuses on how actual recent applications of CTUC have impacted project performance.

The results of this questionnaire will help evaluate the effectiveness, issues and concerns of projects completed utilizing CTUC. Moreover, it can provide insight on strategies for recommendation and possible process changes as well.

All responses to this and any other questionnaire related to this research will be held confidential. Any personal information collected will solely be used to contact the individual in the case that any further questions arise and/or to clarify any response(s).

General Information:

- Recent Project (CSJ #) ______________________________
- Individual Interviewed ______________________________
- Individual's Phone ______________________________
- Individual's Email ______________________________
- Interview Date ______________________________

Personal Professional Information:

1) Could you give us a brief introduction on your current position with TxDOT:
    - Title?
    - Years with TxDOT?
    - How many CTUC (Combined Transportation and Utility Construction) projects have you been involved in?

Appendix C: Questionnaire for Assessment of Completed CTUC Project Performance Criteria (Cont'd)

Information About Recent Projects Completed Utilizing CTUC:

The following questions will assess how utility adjustments using the conventional construction method compared to using the CTUC method. Please select the option that best describes the given circumstance.

1) After utilities were adjusted, what was the nature of the relationship between TxDOT and the Utilities?
   a) CTUC was Much Better than Conventional
   b) CTUC was Better than Conventional
   c) CTUC and Conventional were approximately EQUAL
   d) CTUC was Worse than Conventional
   e) CTUC was Much Worse than Conventional
   f) Don't know

2) What was the impact of the CTUC utility adjustment on traffic flow through the project?
   a) CTUC was Much Better than Conventional
   b) CTUC was Better than Conventional
   c) CTUC and Conventional were approximately EQUAL
   d) CTUC was Worse than Conventional
   e) CTUC was Much Worse than Conventional
   f) Don't know

3) With CTUC, what was the quality of coordination among the different utilities?
   a) With CTUC coordination was Much Better than Conventional
   b) With CTUC coordination was Better than Conventional
   c) With CTUC coordination and Conventional were approximately EQUAL
   d) With CTUC coordination was Worse than Conventional
   e) With CTUC coordination was Much Worse than Conventional
   f) Don't know

4) Did CTUC allow you to move the letting date forward (i.e. occur earlier)?
   a) The CTUC letting date was Much Earlier than Conventional
   b) The CTUC letting date was Earlier than Conventional
   c) The CTUC and Conventional letting dates were approximately the SAME
   d) The CTUC letting date was Later than Conventional
   e) The CTUC letting date was Much Later than Conventional
   f) Don't know

5) With CTUC, what was the frequency of utility-related change orders?
   a) With CTUC the frequency of change orders was Substantially Less than Conventional
   b) With CTUC the frequency of change orders was Less than Conventional
   c) The frequency of change orders with CTUC and Conventional were approximately EQUAL
   d) With CTUC the frequency of change orders was More than Conventional
   e) With CTUC the frequency of change orders was Substantially More than Conventional
   f) Don't know

6) With CTUC, to what extent did you reduce the overall project schedule duration?
   a) With CTUC the overall duration was Much Shorter than Conventional
   b) With CTUC the overall duration was Shorter than Conventional
   c) The overall duration with CTUC and Conventional were approximately EQUAL
   d) With CTUC the overall duration was Longer than Conventional
   e) With CTUC the overall duration was Much Longer than Conventional
   f) Don't know

Appendix C: Questionnaire for Assessment of Completed CTUC Project Performance Criteria (Cont'd)

7) With CTUC, how did the actual utility adjustment cost compare to the planned cost?
   a) With CTUC the utility adjustment cost was Much Less than Conventional
   b) With CTUC the utility adjustment cost was Less than Conventional
   c) The utility adjustment cost of CTUC and Conventional were approximately EQUAL
   d) With CTUC the utility adjustment cost was More than Conventional
   e) With CTUC the utility adjustment cost was Much More than Conventional
   f) Don't know

8) With CTUC, how satisfied were the utilities with the sub(s) doing the utility adjustment?
   a) Generally with CTUC, the utilities were Very Satisfied compared to Conventional
   b) Generally with CTUC, the utilities were Satisfied compared to Conventional
   c) Generally CTUC and Conventional were approximately EQUAL
   d) Generally with CTUC, the utilities were Unsatisfied compared to Conventional
   e) Generally with CTUC, the utilities were Very Unsatisfied compared to Conventional
   f) Don't know

9) In your opinion, what were the main performance **advantages** of the CTUC process?

10) In your opinion, what were the main performance **disadvantages** of the CTUC process?

11) In summary, was the CTUC approach good for the project?
   a) Yes
   b) No
   c) Don't know

Please feel free to make any additional comments that you feel could be beneficial to this project or that pertain to this survey. Thank-you.

Appendix D: CTUC Decision Drivers Assessment Form

(TxDOT Version)

The purpose of this assessment form is to assist in developing a decision support tool to provide guidance to TxDOT and utility decision-makers as to when the Combined Transportation and Utility Construction (CTUC) approach should be applied. In the assessment process, you will go through the following steps:

- **Assess the project circumstance impact on the decision (Pro-CTUC / Neutral / Anti-CTUC).**
- **Evaluate the relative significant level (High / Medium / Low / No Impact / Don't Know) on the CTUC decision.**
  - **The box, "Show Stopper," should be marked only when the circumstance precludes further analysis of the CTUC option. (In other words, the Conventional approach would definitely be used for the project.)**
- **Determine whether the project circumstance could be altered by means of any process change so that the circumstance could become more "Pro-CTUC", or "Neutral" from "Anti-CTUC".**
  - **If so, identify the potential controlling party/ies (TxDOT / Utility / Others) responsible for the process changes.**

Section #1 - Information Source

1.1 Name:		1.5 TxDOT District:	
1.2 Date Completed:		1.6 Office:	☐ ROW ☐ Design ☐ Construction ☐ Area Office:_______________ ☐ Other:____________________
1.3 Phone Number:		1.7 Job Title:	
1.4 Email Address:		1.8 Years of Work Experience in Utility Adjustments:	Years

Section #2 - Project Scope Issues Assessment

(A) Decision Driver	(B) Assessment Issue (Project Circumstance)	(C) CTUC Pro/Con			(D) Impact on Go/No-Go Decision						(E)	(F) Ctrl. Party		
		Pro-CTUC	Neutral	Anti-CTUC	"Show Stopper"	High	Medium	Low	No Impact	Don't Know	Could Process Changes Facilitate CTUC?	TxDOT	Utility	Others
TRAFFIC CONDITION	2.1 When the traffic condition on the project location is HEAVY (e.g. in metropolitan or urban areas)													
LANE CLOSURES	2.2 When CTUC requires substantially FEWER lane closures than the Conventional approach during the project execution													
PHYSICAL INTERFERENCES	2.3 When physical interferences EXIST between 2 or more adjusted utilities on the project													
ADJUSTMENT TIMING	2.4 When the adjustment can only happen during the CONSTRUCTION PHASE (e.g. permit issues or utility adjustment work is contingent upon some level of construction work completion.)													
SCHEDULE PRESSURES	2.5 When the project HAS severe schedule pressures, and CTUC can lead to EARLIER project completion													
	2.6 When the project HAS severe schedule pressures, and the utility adjustment scope CANNOT be well defined at approximately 60% PS&E													
	2.7 When the project DOES NOT HAVE severe schedule pressures													

Appendix D: CTUC Decision Drivers Assessment Form (Cont'd)

(A) Decision Driver	(B) Assessment Issue (Project Circumstance)	(C) CTUC Pro/Con			(D) Impact on Go/No-Go Decision						(E)	(F) Ctrl. Party		
		Pro-CTUC	Neutral	Anti-CTUC	"Show Stopper"	High	Medium	Low	No Impact	Don't Know	Could Process Changes Facilitate CTUC?	TxDOT	Utility	Others
ACCEPTABLE PLANS	2.8 When the utility CAN provide a set of plans that meets the requirements of the project and the TxDOT accommodation rules													
	2.9 When the utility CANNOT provide a set of plans that meets the requirements of the project and the TxDOT accommodation rules													
ACCEPTABLE SPECIFICATIONS	2.10 When the utility CAN provide a set of specifications that is acceptable to TxDOT in terms of assignment of responsibility, liability, and risk													
	2.11 When the utility CANNOT provide a set of specifications that is acceptable to TxDOT in terms of assignment of responsibility, liability, and risk													

For the following project circumstance, assume that some utility companies in the project share the same underground physical facilities (e.g. utility vaults, trenches at different depths, multi-duct conduits, or utility corridors).

(A) Decision Driver	(B) Assessment Issue (Project Circumstance)	(C) CTUC Pro/Con			(D) Impact on Go/No-Go Decision						(E)	(F) Ctrl. Party		
		Pro-CTUC	Neutral	Anti-CTUC	"Show Stopper"	High	Medium	Low	No Impact	Don't Know	Could Process Changes Facilitate CTUC?	TxDOT	Utility	Others
SHARED UNDERGROUND PHYSICAL FACILITIES	2.12 When CTUC increases utility adjustment coordination and provides benefits from all involved utilities' perspectives													

For the following project circumstances (2.13-2.16), assume that some utility companies in the project share the same poles.

(A) Decision Driver	(B) Assessment Issue (Project Circumstance)	(C) CTUC Pro/Con			(D) Impact on Go/No-Go Decision						(E)	(F) Ctrl. Party		
		Pro-CTUC	Neutral	Anti-CTUC	"Show Stopper"	High	Medium	Low	No Impact	Don't Know	Could Process Changes Facilitate CTUC?	TxDOT	Utility	Others
SHARED POLES	2.13 When the utility company that OWNS the pole IS willing to join CTUC													
	2.14 When the pole owner IS NOT willing to join CTUC, but the others ARE													
	2.15 When the pole owner IS willing to join CTUC but the pole tenants ARE NOT													
	2.16 When the pole tenant utilities ARE NOT willing to comply with the CTUC schedule													

Appendix D: CTUC Decision Drivers Assessment Form (Cont'd)

Section #3 - *100% REIMBURSABLE* Project Issues Assessment

100% REIMBURSABLE

(A) Decision Driver	(B) Assessment Issue (Project Circumstance)	(C) CTUC Pro/Con			(D) Impact on Go/No-Go Decision						(E)	(F) Ctrl. Party		
		Pro-CTUC	Neutral	Anti-CTUC	"Show Stopper"	High	Medium	Low	No Impact	Don't Know	Could Process Changes Facilitate CTUC?	TxDOT	Utility	Others
ELIGIBILITY (100% Reimbursable)	3.1 When the eligibility ratio of the reimbursable project IS 100% or NEARLY 100%													
COST COMPARISON (100% Reimbursable)	3.2 When CTUC adjustment costs are more than 15% CHEAPER than the Conventional approach for the project													
	3.3 When CTUC adjustment costs are 5%-15% CHEAPER than the Conventional approach for the project													
	3.4 When CTUC adjustment costs are 5%-15% MORE EXPENSIVE than the Conventional approach for the project													
	3.5 When CTUC adjustment costs are more than 15% MORE EXPENSIVE than the Conventional approach for the project													
FRONT-END LOADING (100% Reimbursable)	3.6 When increased utility adjustment costs occur due to the TxDOT contractor's FRONT-END LOADING with CTUC													
CHANGE ORDERS (100% Reimbursable)	3.7 When increased contractor CHANGE ORDER frequency and costs occur due to CTUC													
ADDED CONTRACTUAL TIER (100% Reimbursable)	3.8 When increased costs due to the ADDED CONTRACTUAL TIER of subcontractors result from CTUC													
UTILITY DELAY COSTS (100% Reimbursable)	3.9 When possible UTILITY DELAY COSTS could be reduced due to the adjustment schedule controlled by the CTUC contractor													

Section #4 - *NON-REIMBURSABLE* Project Issues Assessment

NON-REIMBURSABLE

(A) Decision Driver	(B) Assessment Issue (Project Circumstance)	(C) CTUC Pro/Con			(D) Impact on Go/No-Go Decision						(E)	(F) Ctrl. Party		
		Pro-CTUC	Neutral	Anti-CTUC	"Show Stopper"	High	Medium	Low	No Impact	Don't Know	Could Process Changes Facilitate CTUC?	TxDOT	Utility	Others
UTILITY FUNDING (Non-Reimbursable)	4.1 When the utility DOES NOT WANT to pay for adjustments in advance													
	4.2 When the utility is NOT ABLE to make 100% of the funding available in escrow before construction, and CANNOT QUALIFY for State Infrastructure Bank funding for the project													
COST COMPARISON (Non-Reimbursable)	4.3 When CTUC adjustment costs are more than 15% CHEAPER than the Conventional approach for the project													
	4.4 When CTUC adjustment costs are 5%-15% CHEAPER than the Conventional approach for the project													
	4.5 When CTUC adjustment costs are 5%-15% MORE EXPENSIVE than the Conventional approach for the project													
	4.6 When CTUC adjustment costs are more than 15% MORE EXPENSIVE than the Conventional approach for the project													
FRONT-END LOADING (Non-Reimbursable)	4.7 When increased utility adjustment costs occur due to the TxDOT contractor's FRONT-END LOADING with CTUC													
CHANGE ORDERS (Non-Reimbursable)	4.8 When increased contractor CHANGE ORDER frequency and costs occur due to CTUC													

Section #4 - *NON-REIMBURSABLE* Project Issues Assessment (continued)

NON-REIMBURSABLE

(A) Decision Driver	(B) Assessment Issue (Project Circumstance)	(C) CTUC Pro/Con			(D) Impact on Go/No-Go Decision						(E)	(F) Ctrl. Party		
		Pro-CTUC	Neutral	Anti-CTUC	"Show Stopper"	High	Medium	Low	No Impact	Don't Know	Could Process Changes Facilitate CTUC?	TxDOT	Utility	Others
ADDED CONTRACTUAL TIER (Non-Reimbursable)	4.9 When increased costs due to the ADDED CONTRACTUAL TIER of subcontractors result from CTUC													
UTILITY DELAY COSTS (Non-Reimbursable)	4.10 When possible UTILITY DELAY COSTS could be reduced due to the adjustment schedule controlled by the CTUC contractor													
E&C FEES (Non-Reimbursable)	4.11 When increased INDIRECT COSTS to utilities from TxDOT charges for Engineering and Contingency fees result from CTUC													

Section #5 - Utility Scope Issues Assessment

(A) Decision Driver	(B) Assessment Issue (Project Circumstance)	(C) CTUC Pro/Con			(D) Impact on Go/No-Go Decision						(E)	(F) Ctrl. Party		
		Pro-CTUC	Neutral	Anti-CTUC	"Show Stopper"	High	Medium	Low	No Impact	Don't Know	Could Process Changes Facilitate CTUC?	TxDOT	Utility	Others
BEYOND TxDOT ROW	5.1 When the utility adjustment work includes extensions BEYOND the TxDOT ROW or outside the construction project limits													
TRAFFIC CONTROL	5.2 When the CTUC contractor is significantly more EFFECTIVE at controlling traffic for the project (vs. Conventional)													
SAFETY	5.3 When the CTUC approach has better safety control (e.g. better use of barricades, traffic control, etc.)													
	5.4 When the CONVENTIONAL approach has better safety control													
CLEARING & GRUBBING	5.5 When the utility-adjustment-related site clearing and grubbing is SUBSTANTIAL on the project													
HAZMAT	5.6 When HAZMAT-related work (e.g. asbestos, leaking underground storage tanks, contaminated soils, contaminated groundwater, or unknown substances) ONLY applies to the utility adjustment work													
DESIGN SPECIFICATION	5.7 When the utility is willing to ADOPT TxDOT design specifications for the project													
	5.8 When a new COMPOSITE set of specifications (comprised of the utility and TxDOT provisions) is needed for the project													
UTILITY CREW	5.9 When only the UTILITY company's crew can perform the utility adjustment													
UTILITY CREW AVAILABILITY for OTHER PROJECTS	5.10 When the utility crews are FREED UP for other projects as a result of CTUC													

Appendix D: CTUC Decision Drivers Assessment Form (Cont'd)

5.11 When the TxDOT contractor IS NOT generally capable of performing the utility adjustment work but IS WILLING to HIRE a subcontractor from a list of pre-qualified contractors provided by the utility, assess the following utility types:	(C) CTUC Pro/Con			(D) Impact on Go/No-Go Decision						(E)	(F) Ctrl. Party		
	Pro-CTUC	Neutral	Anti-CTUC	"Show Stopper"	High	Medium	Low	No Impact	Don't Know	Could Process Changes Facilitate CTUC?	TxDOT	Utility	Others
(1) WATER													
(2) WASTEWATER													
(3) WASTEWATER PUMP STATION													
(4) WATER WELL													
(5) OVERHEAD COMMUNICATION													
(6) UNDERGROUND COMMUNICATION													
(7) MICROWAVE TOWER													
(8) OVERHEAD DISTRIBUTION POWER LINE													
(9) UNDERGROUND DISTRIBUTION POWER LINE													
(10) TRANSMISSION POLE													
(11) UNDERGROUND TRANSMISSION POWER LINE													
(12) TRANSMISSION TOWER													
(13) HIGH PRESSURE GAS LINE													
(14) LOW PRESSURE GAS LINE													
(15) LIQUID PETROLEUM LINE													
(16) IRRIGATION PIPELINE													
(17) IRRIGATION CANAL													

Appendix D: CTUC Decision Drivers Assessment Form (Cont'd)

(A) Decision Driver	(B) Assessment Issue (Project Circumstance)	(C) CTUC Pro/Con			(D) Impact on Go/No-Go Decision						(E)	(F) Ctrl. Party		
		Pro-CTUC	Neutral	Anti-CTUC	"Show Stopper"	High	Medium	Low	No Impact	Don't Know	Could Process Changes Facilitate CTUC?	TxDOT	Utility	Others
UTILITY UPGRADES	5.12 When the utility adjustment includes an extensive amount of utility facility upgrades in relation to the transportation work													
ENVIRONMENTAL CLEARANCE	5.13 When the utility adjustment work includes a detrimental change to the project's environmental clearance													

Comments:

Thank you for your participation!

This assessment was conducted by the UT/CTR 0-4997 team.

Appendix E: Descriptions and Attributes of CTUC Decision Drivers

#	Question Abbr.	Question	Option (Abbr.)	Option (or Decision Driver)	Scope of Influence	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Assessment Question #	Type of Decision Driver
1	Traffic Condition	Do you expect HEAVY traffic conditions at the project location (e.g. in metropolitan or urban areas)?	Traffic is heavy	Yes, the traffic condition at the project location IS HEAVY.	Project-Level	2.1	2.1	2.1	2.1	Descriptive
2			Traffic is not heavy	No, the traffic condition at the project location IS NOT HEAVY.						
3			Don't know yet	Don't know yet.						
4	Lane Closures	Will CTUC require substantially FEWER lane closures than the Conventional approach during the project execution?	Fewer in CTUC	Yes, CTUC WILL require substantially FEWER lane closures than the Conventional approach during the project execution.	Project-Level	2.2	2.2	2.2	2.2	Comparative
5			Not fewer in CTUC	No, CTUC WILL NOT require substantially FEWER lane closures than the Conventional approach during the project execution.						
6			Don't know yet	Don't know yet.						

Appendix E: Descriptions and Attributes of CTUC Decision Drivers (Cont'd)

#	Question Abbr.	Question	Option (Abbr.)	Option (or Decision Driver)	Scope of Influence	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Assessment Question #	Type of Decision Driver
7	Physical Interferences	Do physical interferences EXIST between 2 or more adjusted utilities on the project?	Phys. interferences exist	Yes, physical interferences EXIST between 2 or more adjusted utilities on the project.	Project-Level	2.3	2.3	2.3	2.3	Descriptive
8			No phys. interferences	No, physical interferences DO NOT EXIST between 2 or more adjusted utilities on the project.						
9			Don't know yet	Don't know yet.						
10	Utility Adjustment Timing	Can the adjustment be performed ONLY during the CONSTRUCTION PHASE (e.g. permit issues or utility adjustment work is contingent upon some level of construction work completion)?	Only during construction	Yes, the adjustment can be performed ONLY DURING the construction phase.	Utility-Level	2.4	2.4	2.4	2.4	Descriptive
11			Prior to construction	No, the adjustment can be performed PRIOR to the construction phase.						
12			Don't know yet	Don't know yet.						

Appendix E: Descriptions and Attributes of CTUC Decision Drivers (Cont'd)

#	Question Abbr.	Question	Option (Abbr.)	Option (or Decision Driver)	Scope of Influence	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Assessment Question #	Type of Decision Driver
13	Schedule Pressures	Does the project HAVE severe schedule pressures?	Severe schedule pressures	Yes, the project HAS severe schedule pressures, and CTUC can lead to EARLIER project completion.	Project-Level	2.5	2.5	2.5	2.5	Hypothetical
14			Ill-def.adj.scope at 60%PS&E	Yes, the project HAS severe schedule pressures, and the utility adjustment scope CANNOT be well defined at approximately 60% PS&E.					2.6	Descriptive
15			Ordinary sched. pressures	Yes, the project HAS schedule pressures, BUT not severely.						
16			No sched. pressures	No, the project DOES NOT HAVE schedule pressures.					2.7	Descriptive
17			Don't know yet	Don't know yet.						

Appendix E: Descriptions and Attributes of CTUC Decision Drivers (Cont'd)

#	Question Abbr.	Question	Option (Abbr.)	Option (or Decision Driver)	Scope of Influence	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Assessment Question #	Type of Decision Driver
18	Acceptable Utility Plans	Can the utility provide a set of plans that meet the requirements of the project and the TxDOT accommodation rules?	Utility plans are acceptable	Yes, the utility CAN provide a set of plans that meet the requirements of the project and the TxDOT accommodation rules.	Utility-Levelity-Level		3.18	3.18	2.8	Hypothetical
19			Utility plans are unacceptable	No, the utility CANNOT provide a set of plans that meet the requirements of the project and the TxDOT accommodation rules.					2.9	Hypothetical
20			Don't know yet	Don't know yet.						
21	Acceptable Utility Specs	Can the utility provide a set of specifications that are acceptable to TxDOT in terms of assignment of responsibility, liability, and risk?	Utility specs are acceptable	Yes, the utility CAN provide a set of specifications that are acceptable to TxDOT in terms of assignment of responsibility, liability, and risk.	Utility-Levelity-Level		3.19	3.19	2.10	Hypothetical
22			Utility specs are unacceptable	No, the utility CANNOT provide a set of specifications that are acceptable to TxDOT in terms of assignment of responsibility, liability, and risk.					2.11	Hypothetical
23			Don't know yet	Don't know yet.						

Appendix E: Descriptions and Attributes of CTUC Decision Drivers (Cont'd)

#	Question Abbr.	Question	Option (Abbr.)	Option (or Decision Driver)	Scope of Influence	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Assessment Question #	Type of Decision Driver
24	Shared Underground	If some utilities in the project share the same underground physical facilities (e.g. utility vaults, trenches at different depths, multi-duct conduits, or utility corridors), will CTUC increase utility adjustment coordination and provide benefits to all involved utilities?	CTUC benefits all parties	Yes, CTUC WILL increase utility adjustment coordination and provide benefits to all involved utilities.	Special		3.9	3.9	2.12	Hypothetical
25			CTUC won't benefit all	No, CTUC WILL NOT increase utility adjustment coordination and provide benefits to all involved utilities.						
26			Not applicable	Not applicable.						
27			Don't know yet	Don't know yet.						

Appendix E: Descriptions and Attributes of CTUC Decision Drivers (Cont'd)

#	Question Abbr.	Question	Option (Abbr.)	Option (or Decision Driver)	Scope of Influence	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Assessment Question #	Type of Decision Driver
28	Shared Poles	If some utilities in the project share the same poles, what is the tendency of using the CTUC approach?	All want to use CTUC	Both the pole owner and tenant utilities are willing to join CTUC.	Special		3.11	3.11	2.13	Hypothetical
29			Pole owner: no CTUC	The pole owner IS NOT willing to join CTUC, but the others ARE.					2.14	Hypothetical
30			Pole tenants: no CTUC	The pole owner IS willing to join CTUC but the pole tenants ARE NOT.					2.15	Hypothetical
31			Tenant schedules conflict	All utilities ARE NOT willing to comply with the CTUC schedule.					2.16	Hypothetical
32			Not applicable	Not applicable.						
33			Don't know yet	Don't know yet.						
34	(R)Eligibility	Is the eligibility ratio of the adjustment 100% or NEARLY 100%?	Adj. are 100% reimbursable	Yes, the eligibility ratio of the adjustment IS 100% or NEARLY 100%.	Reimbursable	4.0	4.0	4.1	3.1	Descriptive
35			Adj. are non-reimbursable	No, the eligibility ratio of the adjustment IS NOT 100% or NEARLY 100%.						
36			Don't know yet	Don't know yet.						

Appendix E: Descriptions and Attributes of CTUC Decision Drivers (Cont'd)

#	Question Abbr.	Question	Option (Abbr.)	Option (or Decision Driver)	Scope of Influence	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Assessment Question #	Type of Decision Driver
37	(R)Cost Comparison	If the adjustment is reimbursable, how will the utility's cost of adjustment be affected (CTUC vs. Conventional)?	CTUC > 15% cheaper	CTUC adjustment costs will be more than 15% CHEAPER than the Conventional approach for the project.	Reimbursable		4.5	4.2	3.2	Comparative
38			CTUC 5-15% cheaper	CTUC adjustment costs will be 5%-15% CHEAPER than the Conventional approach for the project.					3.3	Comparative
39			CTUC is the same as Conv.	CTUC adjustment costs will be approximately the same as the Conventional approach for the project.						
40			CTUC 5-15% expensive	CTUC adjustment costs will be 5%-15% MORE EXPENSIVE than the Conventional approach for the project.					3.4	Comparative
41			CTUC > 15% expensive	CTUC adjustment costs will be more than 15% MORE EXPENSIVE than the Conventional approach for the project.					3.5	Comparative
42			Don't know yet	Don't know yet.						

Appendix E: Descriptions and Attributes of CTUC Decision Drivers (Cont'd)

#	Question Abbr.	Question	Option (Abbr.)	Option (or Decision Driver)	Scope of Influence	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Assessment Question #	Type of Decision Driver
43	(R)Front End Loading	If the adjustment is reimbursable with CTUC, will increased utility adjustment costs likely occur due to the TxDOT contractor's FRONT-END LOADING (UNBALANCED BIDDING)?	Increased costs with CTUC	Yes, increased utility adjustment costs WILL likely occur due to the TxDOT contractor's FRONT-END LOADING with CTUC.	Reimbursable	4.1	4.1		3.6	Hypothetical
44			No increased costs w/ CTUC	No, increased utility adjustment costs WILL NOT likely occur due to the TxDOT contractor's FRONT-END LOADING with CTUC.						
45			Don't know yet	Don't know yet.						
46	(R)Change Order Markup	If the adjustment is reimbursable with CTUC, will there be increased contractor CHANGE ORDER frequencies or markups?	Increased costs with CTUC	Yes, increased contractor CHANGE ORDER frequencies and markups WILL likely occur with CTUC.	Reimbursable	4.2	4.2		3.7	Hypothetical
47			No increased costs w/ CTUC	No, increased contractor CHANGE ORDER frequencies and markups WILL NOT likely occur with CTUC.						
48			Don't know yet	Don't know yet.						

Appendix E: Descriptions and Attributes of CTUC Decision Drivers (Cont'd)

#	Question Abbr.	Question	Option (Abbr.)	Option (or Decision Driver)	Scope of Influence	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Assessment Question #	Type of Decision Driver
49	(R)Added Contr. Tier	If the adjustment is reimbursable with CTUC, will increased costs result from the ADDED CONTRACTUAL TIER of subcontractors?	Increased costs with CTUC	Yes, increased costs due to the ADDED CONTRACTUAL TIER of subcontractors WILL result from CTUC.	Reimbursable		4.3		3.8	Hypothetical
50			No increased costs w/ CTUC	No, increased costs due to the ADDED CONTRACTUAL TIER of subcontractors WILL NOT result from CTUC.						
51			Don't know yet	Don't know yet.						
52	(R)Utility Delay Costs	If the adjustment is reimbursable, will possible UTILITY DELAY COSTS be reduced due to the adjustment schedule controlled by the CTUC contractor?	Reduced costs with CTUC	Yes, possible UTILITY DELAY COSTS could be reduced due to the adjustment schedule controlled by the CTUC contractor.	Reimbursable		4.4	4.3	3.9	Hypothetical
53			No reduced costs w/ CTUC	No, possible UTILITY DELAY COSTS could NOT be reduced due to the adjustment schedule controlled by the CTUC contractor.						
54			Don't know yet	Don't know yet.						

Appendix E: Descriptions and Attributes of CTUC Decision Drivers (Cont'd)

#	Question Abbr.	Question	Option (Abbr.)	Option (or Decision Driver)	Scope of Influence	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Assessment Question #	Type of Decision Driver
55	(NR)Utility Funding	If the adjustment is non-reimbursable, can the utility pay for adjustments in advance?	Cannot pay in advance	No, the utility IS NOT able or willing to pay for adjustments in advance.	Non-Reimbursable	5.2	5.2	5.2	4.1	Hypothetical
56			Can pay in advance	Yes, the utility IS able and willing to pay for adjustments in advance.						
57			Don't know yet	Don't know yet.						
58	(NR)SIB	If the adjustment is non-reimbursable and if the utility is NOT ABLE to make 100% of the funding available in escrow before construction, can it QUALIFY for State Infrastructure Bank funding?	Not qualify for SIB	No, the utility CANNOT QUALIFY for State Infrastructure Bank funding for the project.	Non-Reimbursable	5.3	5.3	5.3	4.2	Hypothetical
59			Qualify for SIB	Yes, the utility CAN QUALIFY for State Infrastructure Bank funding for the project.						
60			Don't know yet	Don't know yet.						

Appendix E: Descriptions and Attributes of CTUC Decision Drivers (Cont'd)

#	Question Abbr.	Question	Option (Abbr.)	Option (or Decision Driver)	Scope of Influence	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Assessment Question #	Type of Decision Driver
61	(NR)Cost Comparison	If the adjustment is non-reimbursable, how will the utility's cost of adjustment be affected (CTUC vs. Conventional)?	CTUC > 15% cheaper	CTUC adjustment costs will be more than 15% CHEAPER than the Conventional approach for the project.	Non-Reimbursable		5.9	5.9	4.3	Comparative
62			CTUC 5-15% cheaper	CTUC adjustment costs will be 5%-15% CHEAPER than the Conventional approach for the project.					4.4	Comparative
63			CTUC is the same as Conv.	CTUC adjustment costs will be approximately the same as the Conventional approach for the project.						
64			CTUC 5-15% expensive	CTUC adjustment costs will be 5%-15% MORE EXPENSIVE than the Conventional approach for the project.					4.5	Comparative
65			CTUC >15% expensive	CTUC adjustment costs will be more than 15% MORE EXPENSIVE than the Conventional approach for the project.					4.6	Comparative
66			Don't know yet	Don't know yet.						

Appendix E: Descriptions and Attributes of CTUC Decision Drivers (Cont'd)

#	Question Abbr.	Question	Option (Abbr.)	Option (or Decision Driver)	Scope of Influence	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Assessment Question #	Type of Decision Driver
67	(NR)Front End Loading	If the adjustment is non-reimbursable with CTUC, will increased utility adjustment costs likely occur due to the TxDOT contractor's FRONT-END LOADING (UNBALANCED BIDDING)?	Increased costs with CTUC	Yes, increased utility adjustment costs WILL likely occur due to the TxDOT contractor's FRONT-END LOADING with CTUC.	Non-Reimbursable	5.4	5.4	5.4	4.7	Hypothetical
68			No increased costs w/ CTUC	No, increased utility adjustment costs WILL NOT likely occur due to the TxDOT contractor's FRONT-END LOADING with CTUC.						
69			Don't know yet	Don't know yet.						
70	(NR)ChangeOrderMarkup	If the adjustment is non-reimbursable with CTUC, will there be increased contractor CHANGE ORDER frequencies or markups?	Increased costs with CTUC	Yes, increased contractor CHANGE ORDER frequencies and markups WILL likely occur with CTUC.	Non-Reimbursable	5.5	5.5	5.5	4.8	Hypothetical
71			No increased costs w/ CTUC	No, increased contractor CHANGE ORDER frequencies and markups WILL NOT likely occur with CTUC.						
72			Don't know yet	Don't know yet.						

Appendix E: Descriptions and Attributes of CTUC Decision Drivers (Cont'd)

#	Question Abbr.	Question	Option (Abbr.)	Option (or Decision Driver)	Scope of Influence	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Assessment Question #	Type of Decision Driver
73	(NR)Added Contr. Tier	If the adjustment is non-reimbursable with CTUC, will increased costs result from the ADDED CONTRACTUAL TIER of subcontractors?	Increased costs with CTUC	Yes, increased costs due to the ADDED CONTRACTUAL TIER of subcontractors WILL result from CTUC.	Non-Reimbursable		5.6	5.6	4.9	Hypothetical
74			No increased costs w/ CTUC	No, increased costs due to the ADDED CONTRACTUAL TIER of subcontractors WILL NOT result from CTUC.						
75			Don't know yet	Don't know yet.						
76	(NR)Utility Delay Costs	If the adjustment is non-reimbursable, will possible UTILITY DELAY COSTS be reduced due to the adjustment schedule controlled by the CTUC contractor?	Reduced costs with CTUC	Yes, possible UTILITY DELAY COSTS could be reduced due to the adjustment schedule controlled by the CTUC contractor.	Non-Reimbursable		5.7	5.7	4.10	Hypothetical
77			No reduced costs w/ CTUC	No, possible UTILITY DELAY COSTS could NOT be reduced due to the adjustment schedule controlled by the CTUC contractor.						
78			Don't know yet	Don't know yet.						

Appendix E: Descriptions and Attributes of CTUC Decision Drivers (Cont'd)

#	Question Abbr.	Question	Option (Abbr.)	Option (or Decision Driver)	Scope of Influence	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Assessment Question #	Type of Decision Driver
79	(NR)Indirect Costs	If the adjustment is non-reimbursable, will increased INDIRECT COSTS to utilities from TxDOT charges for Engineering and Contingency fees result from CTUC?	Increased costs with CTUC	Yes, increased INDIRECT COSTS to utilities from TxDOT charges for Engineering and Contingency fees WILL result from CTUC.	Non-Reimbursable		5.8	5.8	4.11	Hypothetical
80			No increased costs w/ CTUC	No, increased INDIRECT COSTS to utilities from TxDOT charges for Engineering and Contingency fees WILL NOT result from CTUC.						
81			Don't know yet	Don't know yet.						
82	Util.Work Beyond ROW	Does the utility adjustment work include extensions BEYOND the TxDOT ROW or outside the construction project limits?	Work is beyond ROW	Yes, the utility adjustment work includes extensions BEYOND the TxDOT ROW or outside the construction project limits.	Utility-Level	3.1	3.12	3.12	5.1	Descriptive
83			Work is within ROW	No, the utility adjustment work DOES NOT include extensions BEYOND the TxDOT ROW or outside the construction project limits.						
84			Don't know yet	Don't know yet.						

Appendix E: Descriptions and Attributes of CTUC Decision Drivers (Cont'd)

#	Question Abbr.	Question	Option (Abbr.)	Option (or Decision Driver)	Scope of Influence	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Assessment Question #	Type of Decision Driver
85	Traffic Control	Will the CTUC contractor (who will do both utility adjustment and highway construction) be significantly more EFFECTIVE at controlling traffic for the project (vs. Conventional)?	Better control with CTUC	Yes, the CTUC contractor WILL be significantly more EFFECTIVE at controlling traffic for the project (vs. Conventional).	Utility-Level		3.16	3.16	5.2	Comparative
86			No better control w/ CTUC	No, the CTUC contractor WILL NOT be significantly more EFFECTIVE at controlling traffic for the project (vs. Conventional).						
87			Don't know yet	Don't know yet.						
88	Safety Control	Will the CTUC approach have better safety control (e.g. better use of barricades, traffic control, etc.)?	Better safety ctrl. w/ CTUC	Yes, the CTUC approach will have better safety control.	Utility-Level		3.17	3.17	5.3	Comparative
89			Better safety ctrl. w/ Conv.	No, the Conventional approach will have better safety control.					5.4	Comparative
90			CTUC is the same as Conv.	No, they are about the same.						
91			Don't know yet	Don't know yet.						

Appendix E: Descriptions and Attributes of CTUC Decision Drivers (Cont'd)

#	Question Abbr.	Question	Option (Abbr.)	Option (or Decision Driver)	Scope of Influence	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Assessment Question #	Type of Decision Driver
92	Clearing / Grubbing	Is the utility-adjustment-related site clearing and grubbing SUBSTANTIAL on the project?	Substantial on the util. adj.	Yes, the utility-adjustment-related site clearing and grubbing is SUBSTANTIAL on the project.	Utility-Level		3.13	3.13	5.5	Descriptive
93	Clearing / Grubbing	Is the utility-adjustment-related site clearing and grubbing SUBSTANTIAL on the project?	Not substantial on the adj.	No, the utility-adjustment-related site clearing and grubbing IS NOT SUBSTANTIAL on the project.	Utility-Level		3.13	3.13		
94	Clearing / Grubbing	Is the utility-adjustment-related site clearing and grubbing SUBSTANTIAL on the project?	Don't know yet	Don't know yet.	Utility-Level		3.13	3.13		
95	HAZMAT	Does HAZMAT-related work (e.g. asbestos, leaking underground storage tanks, contaminated soils, contaminated groundwater, or unknown substances) apply ONLY to the utility adjustment work?	Only apply to this adj.	Yes, HAZMAT-related work ONLY applies to the utility adjustment work.	Utility-Level	3.8	3.15	3.15	5.6	Descriptive
96	HAZMAT	Does HAZMAT-related work (e.g. asbestos, leaking underground storage tanks, contaminated soils, contaminated groundwater, or unknown substances) apply ONLY to the utility adjustment work?	Not only apply to this adj.	No, HAZMAT-related work DOES NOT ONLY apply to the utility adjustment work.	Utility-Level	3.8	3.15	3.15		
97	HAZMAT	Does HAZMAT-related work (e.g. asbestos, leaking underground storage tanks, contaminated soils, contaminated groundwater, or unknown substances) apply ONLY to the utility adjustment work?	Not applicable	Not applicable.	Utility-Level	3.8	3.15	3.15		
98	HAZMAT	Does HAZMAT-related work (e.g. asbestos, leaking underground storage tanks, contaminated soils, contaminated groundwater, or unknown substances) apply ONLY to the utility adjustment work?	Don't know yet	Don't know yet.	Utility-Level	3.8	3.15	3.15		

Appendix E: Descriptions and Attributes of CTUC Decision Drivers (Cont'd)

#	Question Abbr.	Question	Option (Abbr.)	Option (or Decision Driver)	Scope of Influence	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Assessment Question #	Type of Decision Driver
99	Design Spec Source	What is the utility's attitude toward design specifications for the project?	Use TxDOT's specs	The utility is willing to ADOPT TxDOT design specifications for the project.	Utility-Level		3.20	3.20	5.7	Hypothetical
100			Develop composite specs	A new COMPOSITE set of specifications (comprised of the utility and TxDOT provisions) is needed for the project.					5.8	Hypothetical
101			Use utility's specs	The utility will USE utility design specifications for the project.						
102			Don't know yet	Don't know yet.						
103	Utility Crew Limitations	Can only the UTILITY's CREW perform the utility adjustment?	Only utility crew can do	Yes, only the UTILITY's crew can perform the utility adjustment.	Utility-Level	3.9	3.8	3.8	5.9	Descriptive
104			TxDOT contractor can do	No, the UTILITY's crew is not the only one who can perform the utility adjustment.						
105			Don't know yet	Don't know yet.						

Appendix E: Descriptions and Attributes of CTUC Decision Drivers (Cont'd)

#	Question Abbr.	Question	Option (Abbr.)	Option (or Decision Driver)	Scope of Influence	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Assessment Question #	Type of Decision Driver
106	Utility Crew Availability	Will the utility's crews be FREED UP for other projects as a result of CTUC?	CTUC frees up utility crews	Yes, with CTUC the utility's crews will be FREED UP for other projects.	Utility-Level		3.21	3.21	5.10	Hypothetical
107			No influence with CTUC	No, with CTUC the utility's crews will NOT be FREED UP for other projects.						
108			Don't know yet	Don't know yet.						
109	Contractor Capability	Is it possible that the pool of likely TxDOT contractors will be WILLING to HIRE a subcontractor from a list of pre-qualified contractors provided by the utility?	Can hire pre-qualify subs	Yes, the pool of likely TxDOT contractors IS WILLING to HIRE a subcontractor from a list of pre-qualified contractors provided by the utility.	Utility-Level	3.7	3.7	3.7	5.11	Hypothetical
110			Can do everything	No, the pool of likely TxDOT contractors IS NOT WILLING to HIRE a subcontractor from a list of pre-qualified contractors provided by the utility.						
111			Don't know yet	Don't know yet.						

Appendix E: Descriptions and Attributes of CTUC Decision Drivers (Cont'd)

#	Question Abbr.	Question	Option (Abbr.)	Option (or Decision Driver)	Scope of Influence	Question # (CTUC Phase 1 Analysis)	Question # (Phase 2 TxDOT Analysis)	Question # (Phase 2 Utility Analysis)	Assessment Question #	Type of Decision Driver
112	Utility Facility Upgrade	Does the utility adjustment include an extensive amount of utility facility upgrades in relation to the transportation work?	Extensive utility upgrade	Yes, the utility adjustment includes an extensive amount of utility facility upgrades in relation to the transportation work.	Utility-Level		3.22	3.22	5.12	Descriptive
113			No extensive upgrades	No, the utility adjustment DOES NOT include an extensive amount of utility facility upgrades in relation to the transportation work.						
114			Don't know yet	Don't know yet.						
115	Added Environ. Scope	Does the utility adjustment work include any detrimental changes to the project's environmental clearance?	Detrimental environ. change	Yes, the utility adjustment work includes a detrimental change to the project's environmental clearance.	Utility-Level	3.10	3.23	3.23	5.13	Descriptive
116			No detrimental change	No, the utility adjustment work DOES NOT include a detrimental change to the project's environmental clearance.						
117			Don't know yet	Don't know yet.						

Appendix F: Assessment Results of CTUC Decision Drivers (District-Level)

Note: **CTUC Preference Assessment**

N = total number of the experts in a district
P% = the percentage of experts who selected "Pro-CTUC" or "sometimes Pro-CTUC and sometimes Neutral" for a given decision driver
N% = the percentage of experts who selected "Neutral" for a given decision driver
A% = the percentage of experts who selected "Anti-CTUC" or "sometimes Anti-CTUC and sometimes Neutral" for a given decision driver

Impact Level Assessment

AS: the percentage of experts from one party who thought that the given decision driver has "Anti-CTUC" and "Show-Stopper" impact
AH: the percentage of experts from one party who thought that the given decision driver has "Anti-CTUC" and "High" impact
AM: the percentage of experts from one party who thought that the given decision driver has "Anti-CTUC" and "Medium" impact
AL: the percentage of experts from one party who thought that the given decision driver has "Anti-CTUC" and "Low" impact
N: the percentage of experts from one party who thought that the given decision driver has "Neutral" impact
PL: the percentage of experts from one party who thought that the given decision driver has "Pro-CTUC" and "Low" impact
PM: the percentage of experts from one party who thought that the given decision driver has "Pro-CTUC" and "Medium" impact
PH: the percentage of experts from one party who thought that the given decision driver has "Pro-CTUC" and "High" impact
DK: the percentage of experts from one party who did not know the impact of the given decision driver

Gray Code

Gray:	if most experts of a group thought that a given decision driver should have "Pro-CTUC" impact on the CTUC decision
Light Gray:	if most experts of a group thought that a given decision driver should have "Neutral" impact on the CTUC decision
Dark Gray:	if most experts of a group thought that a given decision driver should have "Anti-CTUC" impact on the CTUC decision

Appendix F: Assessment Results of CTUC Decision Drivers: District-Level (Cont'd)

Decision Driver	TxDOT (CTUC Preference)											
	San Antonio(n=15)			Houston(n=7)			Dallas(n=6)			All(n=28)		
	P%	N%	A%	P%	N%	A%	P%	N%	A%	P%	N%	A%
2.1 Traffic is heavy	100.0	0.0	0.0	100.0	0.0	0.0	83.3	16.7	0.0	96.4	3.6	0.0
2.2 Fewer lane closures in CTUC	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0
2.3 Physical interferences exist	86.7	13.3	0.0	100.0	0.0	0.0	100.0	0.0	0.0	92.9	7.1	0.0
2.4 Adj. only happen in constr.	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0
2.5 Severe schedule pressures	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0
2.6 Ill-def.adj.scope at 60%PS&E	6.7	0.0	93.3	0.0	14.3	85.7	16.7	16.7	66.7	7.1	7.1	85.7
2.7 No schedule pressures	13.3	20.0	66.7	0.0	0.0	100.0	0.0	0.0	100.0	7.1	10.7	82.1
2.8 Utility plans are acceptable	100.0	0.0	0.0	100.0	0.0	0.0	83.3	16.7	0.0	96.4	3.6	0.0
2.9 Utility plans are unacceptable	6.7	0.0	93.3	0.0	0.0	100.0	0.0	0.0	100.0	3.6	0.0	96.4
2.10 Utility specs are acceptable	100.0	0.0	0.0	100.0	0.0	0.0	83.3	16.7	0.0	96.4	3.6	0.0
2.11 Utility specs are unacceptable	6.7	0.0	93.3	0.0	0.0	100.0	0.0	0.0	100.0	3.6	0.0	96.4
2.12 Shared underground fac.: all CTUC	93.3	6.7	0.0	100.0	0.0	0.0	100.0	0.0	0.0	96.4	3.6	0.0
2.13 For pole utilities: all join CTUC	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0
2.14 Pole owner opt out of CTUC	13.3	26.7	60.0	14.3	0.0	85.7	16.7	33.3	50.0	14.3	21.4	64.3
2.15 Pole tenant opt out of CTUC	0.0	*100.0*	0.0	14.3	14.3	71.4	0.0	33.3	66.7	3.6	*64.3*	32.1
2.16 Pole tenant sch. conflict w/ CTUC	0.0	6.7	93.3	0.0	0.0	100.0	0.0	0.0	100.0	0.0	3.6	96.4
3.1 Adj. are 100% reimbursable	80.0	20.0	0.0	100.0	0.0	0.0	83.3	16.7	0.0	85.7	14.3	0.0
3.2 CTUC > 15% Cheaper	100.0	0.0	0.0	100.0	0.0	0.0	83.3	16.7	0.0	96.4	3.6	0.0
3.3 CTUC 5%-15% Cheaper	100.0	0.0	0.0	100.0	0.0	0.0	83.3	16.7	0.0	96.4	3.6	0.0
3.4 CTUC 5%-15% Expensive	13.3	13.3	73.3	0.0	14.3	85.7	0.0	16.7	83.3	7.1	14.3	78.6
3.5 CTUC >15% Expensive	6.7	6.7	86.7	0.0	0.0	100.0	0.0	0.0	100.0	3.6	3.6	92.9
3.6 Front-end loading: incr. cost w/ CTUC	6.7	13.3	80.0	0.0	0.0	100.0	0.0	0.0	100.0	3.6	7.1	89.3
3.7 Change order: incr. cost w/ CTUC	6.7	6.7	86.7	0.0	0.0	100.0	0.0	0.0	100.0	3.6	3.6	92.9
3.8 Added contr. tier: incr. cost w/ CTUC	6.7	6.7	86.7	0.0	0.0	100.0	0.0	0.0	100.0	3.6	3.6	92.9
3.9 Reduced delay costs due to CTUC	100.0	0.0	0.0	100.0	0.0	0.0	83.3	16.7	0.0	96.4	3.6	0.0
4.1 Utility cannot pay in advance	6.7	0.0	93.3	0.0	0.0	100.0	0.0	0.0	100.0	3.6	0.0	96.4
4.2 Utility not qualify for SIB	6.7	6.7	86.7	0.0	0.0	100.0	0.0	0.0	100.0	3.6	3.6	92.9
4.3 CTUC >15% Cheaper	93.3	6.7	0.0	100.0	0.0	0.0	83.3	16.7	0.0	92.9	7.1	0.0
4.4 CTUC 5%-15% Cheaper	93.3	6.7	0.0	100.0	0.0	0.0	83.3	16.7	0.0	92.9	7.1	0.0
4.5 CTUC 5%-15% Expensive	13.3	13.3	73.3	0.0	0.0	100.0	0.0	0.0	100.0	7.1	7.1	85.7
4.6 CTUC >15% Expensive	6.7	13.3	80.0	0.0	0.0	100.0	0.0	0.0	100.0	3.6	7.1	89.3
4.7 Front-end loading: incr. cost w/ CTUC	0.0	6.7	93.3	0.0	0.0	100.0	0.0	0.0	100.0	0.0	3.6	96.4
4.8 Change order: incr. cost w/ CTUC	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0

Appendix F: Assessment Results of CTUC Decision Drivers: District-Level (Cont'd)

Decision Driver	TxDOT (CTUC Preference)											
	San Antonio(n=15)			Houston(n=7)			Dallas(n=6)			All(n=28)		
	P%	N%	A%	P%	N%	A%	P%	N%	A%	P%	N%	A%
4.9 Added contr. tier: incr. cost w/ CTUC	6.7	13.3	80.0	0.0	0.0	100.0	0.0	0.0	100.0	3.6	7.1	89.3
4.10 Reduced delay costs due to CTUC	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0
4.11 Indirect costs b/c of CTUC	6.7	0.0	93.3	0.0	0.0	100.0	0.0	0.0	100.0	3.6	0.0	96.4
5.1 Util work beyond ROW	0.0	0.0	100.0	0.0	14.3	85.7	16.7	0.0	83.3	3.6	3.6	92.9
5.2 Traffic ctrl. better in CTUC	93.3	6.7	0.0	100.0	0.0	0.0	83.3	16.7	0.0	92.9	7.1	0.0
5.3 Better safety ctrl. w/ CTUC	93.3	6.7	0.0	100.0	0.0	0.0	100.0	0.0	0.0	96.4	3.6	0.0
5.4 Better safety ctrl. w/ Conv.	6.7	6.7	86.7	0.0	0.0	100.0	0.0	0.0	100.0	3.6	3.6	92.9
5.5 Substantial clearing & grubbing on util.	86.7	13.3	0.0	100.0	0.0	0.0	100.0	0.0	0.0	92.9	7.1	0.0
5.6 HAZMAT: only apply to this adj.	6.7	0.0	93.3	0.0	0.0	100.0	16.7	16.7	66.7	7.1	3.6	89.3
5.7 Use TxDOT's specs	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0
5.8 Develop composite specs	13.3	13.3	73.3	0.0	0.0	100.0	0.0	33.3	66.7	7.1	14.3	78.6
5.9 Only utility crew can do	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
5.10 CTUC frees up utility crews	86.7	13.3	0.0	100.0	0.0	0.0	83.3	16.7	0.0	89.3	10.7	0.0
5.11 Contr. can hire pre-qualify subs												
5.12 Extensive utility upgrade	20.0	20.0	60.0	14.3	*57.1*	28.6	66.7	16.7	16.7	28.6	28.6	42.9
5.13 Detrimental environment change	20.0	13.3	66.7	0.0	28.6	71.4	0.0	*50.0*	50.0	10.7	25.0	64.3

Appendix F: Assessment Results of CTUC Decision Drivers: District-Level (Cont'd)

Decision Driver	Utility (CTUC Preference)																							
	San Antonio						Houston						Dallas						All					
	W/WW(n=2)			Non-W/WW(n=7)			W/WW(n=2)			Non-W/WW(n=4)			W/WW(n=2)			Non-W/WW(n=7)			W/WW(n=6)			Non-W/WW(n=18)		
	P%	N%	A%	P%	N%	A%	P%	N%	A%	P%	N%	A%	P%	N%	A%	P%	N%	A%	P%	N%	A%	P%	N%	A%
2.1 Traffic is heavy	100.0	0.0	0.0	85.7	14.3	0.0	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	85.7	14.3	0.0	100.0	0.0	0.0	83.3	16.7	0.0
2.2 Fewer lane closures in CTUC	100.0	0.0	0.0	85.7	14.3	0.0	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	88.9	11.1	0.0
2.3 Physical interferences exist	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	25.0	*50.0*	25.0	100.0	0.0	0.0	28.6	28.6	42.9	100.0	0.0	0.0	55.6	22.2	22.2
2.4 Adj. only happen in constr.	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	85.7	14.3	0.0	100.0	0.0	0.0	88.9	11.1	0.0
2.5 Severe schedule pressures	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	94.4	5.6	0.0
2.6 Ill-def.adj.scope at 60%PS&E	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	25.0	75.0	0.0	*50.0*	50.0	0.0	0.0	100.0	0.0	16.7	83.3	0.0	5.6	94.4
2.7 No schedule pressures	0.0	*50.0*	50.0	0.0	28.6	71.4	100.0	0.0	0.0	0.0	*75.0*	25.0	0.0	*50.0*	50.0	0.0	28.6	71.4	33.3	*33.3*	33.3	0.0	38.9	61.1
2.8 Utility plans are acceptable	100.0	0.0	0.0	85.7	14.3	0.0	100.0	0.0	0.0	75.0	25.0	0.0	50.0	*50.0*	0.0	85.7	14.3	0.0	83.3	16.7	0.0	83.3	16.7	0.0
2.9 Utility plans are unacceptable	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	25.0	75.0	50.0	0.0	50.0	0.0	0.0	100.0	16.7	0.0	83.3	0.0	5.6	94.4
2.10 Utility specs are acceptable	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	85.7	14.3	0.0	100.0	0.0	0.0	88.9	11.1	0.0
2.11 Utility specs are unacceptable	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	25.0	75.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	5.6	94.4
2.12 Shared underground fac.: all CTUC	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	94.4	5.6	0.0
2.13 For pole utilities: all join CTUC				100.0	0.0	0.0				25.0	25.0	50.0				25.0	0.0	75.0				53.8	7.7	38.5
2.14 Pole owner opt out of CTUC				0.0	0.0	100.0				0.0	*50.0*	50.0				0.0	*50.0*	50.0				0.0	30.8	69.2
2.15 Pole tenant opt out of CTUC				0.0	40.0	60.0				0.0	25.0	75.0				0.0	25.0	75.0				0.0	30.8	69.2
2.16 Pole tenant sch. conflict w/ CTUC				0.0	0.0	100.0				0.0	25.0	75.0				0.0	0.0	100.0				0.0	7.7	92.3
3.1 Adj. are 100% reimbursable	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	85.7	14.3	0.0	100.0	0.0	0.0	88.9	11.1	0.0
3.2 CTUC > 15% Cheaper	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	94.4	5.6	0.0
3.3 CTUC 5%-15% Cheaper	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	94.4	5.6	0.0
3.4 CTUC 5%-15% Expensive	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	25.0	75.0	0.0	*50.0*	50.0	0.0	0.0	100.0	0.0	16.7	83.3	0.0	5.6	94.4
3.5 CTUC >15% Expensive	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	25.0	75.0	0.0	*50.0*	50.0	0.0	0.0	100.0	0.0	16.7	83.3	0.0	5.6	94.4
3.6 Front-end loading: incr. cost w/ CTUC																								
3.7 Change order: incr. cost w/ CTUC																								
3.8 Added contr. tier: incr. cost w/ CTUC																								
3.9 Reduced delay costs due to CTUC	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	94.4	5.6	0.0
4.1 Utility cannot pay in advance	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	25.0	75.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	5.6	94.4
4.2 Utility not qualify for SIB	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	25.0	75.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	5.6	94.4
4.3 CTUC >15% Cheaper	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	94.4	5.6	0.0
4.4 CTUC 5%-15% Cheaper	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	94.4	5.6	0.0
4.5 CTUC 5%-15% Expensive	0.0	0.0	100.0	0.0	14.3	85.7	0.0	0.0	100.0	0.0	25.0	75.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	11.1	88.9
4.6 CTUC >15% Expensive	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	25.0	75.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	5.6	94.4
4.7 Front-end loading: incr. cost w/ CTUC	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
4.8 Change order: incr. cost w/ CTUC	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	25.0	75.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	5.6	94.4

Appendix F: Assessment Results of CTUC Decision Drivers: District-Level (Cont'd)

Decision Driver	Utility (CTUC Preference)																							
	San Antonio						Houston						Dallas						All					
	W/WW(n=2)			Non-W/WW(n=7)			W/WW(n=2)			Non-W/WW(n=4)			W/WW(n=2)			Non-W/WW(n=7)			W/WW(n=6)			Non-W/WW(n=18)		
	P%	N%	A%	P%	N%	A%	P%	N%	A%	P%	N%	A%	P%	N%	A%	P%	N%	A%	P%	N%	A%	P%	N%	A%
4.9 Added contr. tier: incr. cost w/ CTUC	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
4.10 Reduced delay costs due to CTUC	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0
4.11 Indirect costs b/c of CTUC	0.0	0.0	100.0	0.0	14.3	85.7	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	5.6	94.4
5.1 Util work beyond ROW	0.0	*50.0*	50.0	0.0	28.6	71.4	0.0	*100.0*	0.0	0.0	25.0	75.0	0.0	*100.0*	0.0	0.0	14.3	85.7	0.0	*83.3*	16.7	0.0	22.2	77.8
5.2 Traffic ctrl. better in CTUC	100.0	0.0	0.0	85.7	14.3	0.0	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	88.9	11.1	0.0
5.3 Better safety ctrl. w/ CTUC	100.0	0.0	0.0	85.7	14.3	0.0	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	88.9	11.1	0.0
5.4 Better safety ctrl. w/ Conv.	0.0	0.0	100.0	0.0	14.3	85.7	0.0	0.0	100.0	0.0	25.0	75.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	11.1	88.9
5.5 Substantial clearing & grubbing on util.	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	94.4	5.6	0.0
5.6 HAZMAT: only apply to this adj.	100.0	0.0	0.0	57.1	28.6	14.3	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	85.7	0.0	14.3	100.0	0.0	0.0	72.2	16.7	11.1
5.7 Use TxDOT's specs	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	94.4	5.6	0.0
5.8 Develop composite specs	0.0	0.0	100.0	0.0	14.3	85.7	0.0	*100.0*	0.0	0.0	25.0	75.0	0.0	*50.0*	50.0	0.0	14.3	85.7	0.0	*50.0*	50.0	0.0	16.7	83.3
5.9 Only utility crew can do	0.0	0.0	100.0	0.0	14.3	85.7	0.0	0.0	100.0	0.0	25.0	75.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	11.1	88.9
5.10 CTUC frees up utility crews	100.0	0.0	0.0	85.7	14.3	0.0	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	85.7	14.3	0.0	100.0	0.0	0.0	83.3	16.7	0.0
5.11 Contr. can hire pre-qualify subs	100.0	0.0	0.0	85.7	14.3	0.0	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	71.4	0.0	28.6	100.0	0.0	0.0	77.8	11.1	11.1
5.12 Extensive utility upgrade	0.0	*100.0*	0.0	28.6	*42.9*	28.6	0.0	0.0	100.0	0.0	*50.0*	50.0	0.0	*50.0*	50.0	0.0	42.9	57.1	0.0	*50.0*	50.0	11.1	*44.4*	44.4
5.13 Detrimental environment change	50.0	*50.0*	0.0	14.3	*42.9*	42.9	0.0	*100.0*	0.0	50.0	25.0	25.0	0.0	*100.0*	0.0	28.6	14.3	57.1	16.7	*83.3*	0.0	27.8	27.8	44.4

Appendix F: Assessment Results of CTUC Decision Drivers: District-Level (Cont'd)

Decision Driver	TxDOT (Impact Level)																																			
	San Antonio(n=15)									Houston(n=7)									Dallas(n=6)									All(n=28)								
	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK
2.1 Traffic is heavy	0	0	0	0	13	0	47	33	7	0	0	0	0	0	0	14	71	14	0	0	0	0	17	0	33	50	0	0	0	0	0	11	0	36	46	7
2.2 Fewer lane closures in CTUC	0	0	0	0	13	7	13	67	0	0	0	0	0	0	0	29	57	14	0	0	0	0	0	33	50	17	0	0	0	0	0	7	11	25	54	4
2.3 Physical interferences exist	0	0	0	0	33	7	27	33	0	0	0	0	0	0	14	29	14	43	0	0	0	0	0	0	33	67	0	0	0	0	0	18	7	29	36	11
2.4 Adj. only happen in constr.	0	0	0	0	0	7	0	93	0	0	0	0	0	0	14	29	29	29	0	0	0	0	0	0	17	83	0	0	0	0	0	0	7	11	75	7
2.5 Severe schedule pressures	0	0	0	0	0	0	27	73	0	0	0	0	0	0	0	0	86	14	0	0	0	0	0	0	17	83	0	0	0	0	0	0	0	18	79	4
2.6 Ill-def.adj.scope at 60%PS&E	7	53	20	13	0	0	7	0	0	29	14	29	0	0	0	0	0	29	0	50	17	0	17	0	0	17	0	11	43	21	7	4	0	4	4	7
2.7 No schedule pressures	0	0	0	33	60	0	7	0	0	29	0	0	43	14	0	0	0	14	0	0	17	50	33	0	0	0	0	7	0	4	39	43	0	4	0	4
2.8 Utility plans are acceptable	0	0	0	0	20	7	20	53	0	0	0	0	0	0	14	43	14	29	0	0	0	0	17	17	17	50	0	0	0	0	0	14	11	25	43	7
2.9 Utility plans are unacceptable	27	53	7	7	0	0	0	0	7	29	29	14	0	0	0	0	0	29	0	67	33	0	0	0	0	0	0	21	50	14	4	0	0	0	0	11
2.10 Utility specs are acceptable	0	0	0	0	13	7	20	60	0	0	0	0	0	0	14	14	29	43	0	0	0	0	33	0	33	33	0	0	0	0	0	14	7	21	46	11
2.11 Utility specs are unacceptable	27	53	0	7	7	0	0	7	0	29	14	14	0	0	0	0	0	43	0	33	50	17	0	0	0	0	0	21	39	14	7	4	0	0	4	11
2.12 Shared underground fac.: all CTUC	0	0	0	0	13	7	27	53	0	0	0	0	0	0	14	14	57	14	0	0	0	0	0	0	33	67	0	0	0	0	0	7	7	25	57	4
2.13 For pole utilities: all join CTUC	0	0	0	0	20	0	40	40	0	0	0	0	0	14	14	14	14	43	0	0	0	0	17	0	33	50	0	0	0	0	0	18	4	32	36	11
2.14 Pole owner opt out of CTUC	20	20	0	7	40	0	7	7	0	43	29	0	0	0	0	0	14	14	0	50	0	0	33	0	0	17	0	21	29	0	4	29	0	4	11	4
2.15 Pole tenant opt out of CTUC	0	0	0	0	0	0	0	0	100	14	29	14	0	0	0	0	14	29	0	67	0	0	33	0	0	0	0	4	21	4	0	7	0	0	4	61
2.16 Pole tenant sch. conflict w/ CTUC	40	20	13	13	13	0	0	0	0	43	43	0	0	0	0	0	0	14	0	33	33	0	0	0	0	0	33	32	29	14	7	7	0	0	0	11
3.1 Adj. are 100% reimbursable	0	0	0	0	27	20	0	53	0	0	0	0	0	14	14	29	29	14	0	0	0	0	33	17	17	33	0	0	0	0	0	25	18	11	43	4
3.2 CTUC > 15% Cheaper	0	0	0	0	7	27	13	53	0	0	0	0	0	14	0	43	29	14	0	0	0	0	17	0	33	50	0	0	0	0	0	11	14	25	46	4
3.3 CTUC 5%-15% Cheaper	0	0	0	0	7	40	47	7	0	0	0	0	0	14	29	29	14	14	0	0	0	0	17	0	50	33	0	0	0	0	0	11	29	43	14	4
3.4 CTUC 5%-15% Expensive	7	0	47	7	27	0	0	13	0	14	0	43	14	14	0	0	0	14	17	17	17	33	17	0	0	0	0	11	4	39	14	21	0	0	7	4
3.5 CTUC >15% Expensive	13	40	20	0	20	0	0	7	0	14	29	14	14	14	0	0	0	14	33	0	17	50	0	0	0	0	0	18	29	18	14	14	0	0	4	4
3.6 Front-end loading: incr. cost w/ CTUC	7	33	7	20	27	0	0	0	7	14	14	29	0	14	0	0	0	29	17	33	17	17	17	0	0	0	0	11	29	14	14	21	0	0	0	11
3.7 Change order: incr. cost w/ CTUC	13	27	20	20	13	0	0	0	7	14	14	0	14	0	0	0	0	57	0	50	17	17	17	0	0	0	0	11	29	14	18	11	0	0	0	18
3.8 Added contr. tier: incr. cost w/ CTUC	13	13	20	20	20	0	0	0	13	14	14	29	14	0	0	0	0	29	0	33	33	17	17	0	0	0	0	11	18	25	18	14	0	0	0	14
3.9 Reduced delay costs due to CTUC	0	0	0	0	7	7	13	73	0	0	0	0	0	14	0	29	43	14	0	0	0	0	17	0	0	83	0	0	0	0	0	11	4	14	68	4
4.1 Utility cannot pay in advance	73	7	7	0	7	0	0	0	7	29	43	0	14	0	0	0	0	14	50	50	0	0	0	0	0	0	0	57	25	4	4	4	0	0	0	7
4.2 Utility not qualify for SIB	33	33	7	0	13	0	0	0	13	57	29	0	14	0	0	0	0	0	33	17	33	0	0	0	0	0	17	39	29	11	4	7	0	0	0	11
4.3 CTUC >15% Cheaper	0	0	0	0	13	13	33	40	0	0	0	0	0	0	0	29	57	14	0	0	0	0	17	0	33	50	0	0	0	0	0	11	7	32	46	4
4.4 CTUC 5%-15% Cheaper	0	0	0	0	13	20	40	27	0	0	0	0	0	14	29	29	14	14	0	0	0	0	17	0	50	33	0	0	0	0	0	14	18	39	25	4

Appendix F: Assessment Results of CTUC Decision Drivers: District-Level (Cont'd)

Decision Driver	TxDOT (Impact Level)																																			
	San Antonio(n=15)									Houston(n=7)									Dallas(n=6)									All(n=28)								
	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK
4.5 CTUC 5%-15% Expensive	7	13	40	7	20	0	0	13	0	14	0	43	14	14	0	0	0	14	17	67	0	17	0	0	0	0	0	11	21	32	11	14	0	0	7	4
4.6 CTUC >15% Expensive	20	33	20	0	20	0	0	0	7	14	43	14	0	14	0	0	0	14	33	50	17	0	0	0	0	0	0	21	39	18	0	14	0	0	0	7
4.7 Front-end loading: incr. cost w/ CTUC	27	13	27	7	13	0	0	0	13	14	29	14	0	0	0	0	0	43	33	33	33	0	0	0	0	0	0	25	21	25	4	7	0	0	0	18
4.8 Change order: incr. cost w/ CTUC	20	40	20	7	7	0	0	0	7	14	14	14	14	0	0	0	0	43	0	67	17	0	0	0	0	0	17	14	39	18	7	4	0	0	0	18
4.9 Added contr. tier: incr. cost w/ CTUC	13	13	13	20	20	0	0	7	13	14	0	29	29	0	0	0	0	29	17	50	33	0	0	0	0	0	0	14	18	21	18	11	0	0	4	14
4.10 Reduced delay costs due to CTUC	0	0	0	0	0	0	27	67	7	0	0	0	0	14	0	0	71	14	0	0	0	0	0	17	17	67	0	0	0	0	0	4	4	18	68	7
4.11 Indirect costs b/c of CTUC	7	20	33	13	7	0	0	0	20	14	0	14	29	0	0	0	0	43	17	33	33	0	0	0	0	0	17	11	18	29	14	4	0	0	0	25
5.1 Util work beyond ROW	80	20	0	0	0	0	0	0	0	57	14	14	0	14	0	0	0	0	50	17	17	0	0	0	0	17	0	68	18	7	0	4	0	0	4	0
5.2 Traffic ctrl. better in CTUC	0	0	0	0	13	0	40	47	0	0	0	0	0	0	14	43	43	0	0	0	0	0	17	0	33	33	17	0	0	0	0	11	4	39	43	4
5.3 Better safety ctrl. w/ CTUC	0	0	0	0	20	0	27	53	0	0	0	0	0	0	14	14	57	14	0	0	0	0	17	0	33	50	0	0	0	0	0	14	4	25	54	4
5.4 Better safety ctrl. w/ Conv.	7	27	20	7	33	0	0	0	7	29	29	14	14	0	0	0	0	14	0	17	67	17	0	0	0	0	0	11	25	29	11	18	0	0	0	7
5.5 Substantial clearing & grubbing on util.	0	0	0	0	13	7	40	33	7	0	0	0	0	0	14	29	29	29	0	0	0	0	17	0	17	67	0	0	0	0	0	11	7	32	39	11
5.6 HAZMAT: only apply to this adj.	73	20	0	0	0	0	7	0	0	57	29	14	0	0	0	0	0	0	0	33	33	0	17	0	0	17	0	54	25	11	0	4	0	4	4	0
5.7 Use TxDOT's specs	0	0	0	0	13	0	40	33	13	0	0	0	0	14	43	14	29	0	0	0	0	0	17	17	17	50	0	0	0	0	0	14	14	29	36	7
5.8 Develop composite specs	13	13	20	7	27	0	0	13	7	0	0	29	29	14	0	0	0	29	0	0	50	17	33	0	0	0	0	7	7	29	14	25	0	0	7	11
5.9 Only utility crew can do	87	13	0	0	0	0	0	0	0	86	14	0	0	0	0	0	0	0	67	17	0	17	0	0	0	0	0	82	14	0	4	0	0	0	0	0
5.10 CTUC frees up utility crews	0	0	0	0	27	27	13	27	7	0	0	0	0	0	29	14	29	29	0	0	0	0	17	0	33	50	0	0	0	0	0	18	21	18	32	11
5.11 Contr. can hire pre-qualify subs																																				
5.12 Extensive utility upgrade	27	27	0	0	27	0	0	13	7	14	0	0	0	43	14	0	0	29	17	0	0	0	17	0	0	67	0	21	14	0	0	29	4	0	21	11
5.13 Detrimental environment change	40	20	0	0	0	0	0	20	20	57	14	0	0	29	0	0	0	0	50	0	0	0	33	0	0	0	17	46	14	0	0	14	0	0	11	14

Appendix F: Assessment Results of CTUC Decision Drivers: District-Level (Cont'd)

Decision Driver	Utility (Impact Level)																																			
	San Antonio																		Houston																	
	W/WW(n=2)									Non-W/WW(n=7)									W/WW(n=2)									Non-W/WW(n=4)								
	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK
2.1 Traffic is heavy	0	0	0	0	0	0	0	0	100	0	0	0	0	29	14	14	43	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	25	50	0	25
2.2 Fewer lane closures in CTUC	0	0	0	0	0	0	0	0	100	0	0	0	0	29	14	14	43	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	25	0	50	25
2.3 Physical interferences exist	0	0	0	0	0	0	0	0	100	0	0	0	0	14	14	29	43	0	0	0	0	0	0	0	0	0	100	0	25	0	0	25	0	0	25	25
2.4 Adj. only happen in constr.	0	0	0	0	0	0	0	0	100	0	0	0	0	14	0	0	86	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	75	25
2.5 Severe schedule pressures	0	0	0	0	0	0	0	0	100	0	0	0	0	14	0	0	86	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	25	50	25
2.6 Ill-def.adj.scope at 60%PS&E	0	0	0	0	50	0	0	0	50	29	57	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	100	25	50	0	0	0	0	0	0	25
2.7 No schedule pressures	0	0	0	0	100	0	0	0	0	0	0	0	29	71	0	0	0	0	0	0	0	0	0	0	0	0	100	0	25	0	0	50	0	0	0	25
2.8 Utility plans are acceptable	0	0	0	0	0	0	0	50	50	0	0	0	0	43	14	14	29	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	25	50	25
2.9 Utility plans are unacceptable	50	0	0	50	0	0	0	0	0	43	43	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	25	0	25	25	0	0	0	0	25
2.10 Utility specs are acceptable	0	0	0	0	0	0	0	50	50	0	0	0	0	14	0	29	57	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	75	25
2.11 Utility specs are unacceptable	0	0	0	50	50	0	0	0	0	57	14	14	14	0	0	0	0	0	0	0	0	0	0	0	0	0	100	25	25	0	25	0	0	0	0	25
2.12 Shared underground fac.: all CTUC	0	0	0	0	0	0	0	0	100	0	0	0	0	14	14	14	29	29	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	75	25
2.13 For pole utilities: all join CTUC										0	0	0	0	0	20	0	40	40										0	50	0	0	0	0	0	25	25
2.14 Pole owner opt out of CTUC										40	20	0	0	0	0	0	0	40										0	25	0	25	50	0	0	0	0
2.15 Pole tenant opt out of CTUC										40	20	0	0	20	0	0	0	20										0	25	0	25	25	0	0	0	25
2.16 Pole tenant sch. conflict w/ CTUC										40	20	0	0	0	0	0	0	40										25	25	0	0	25	0	0	0	25
3.1 Adj. are 100% reimbursable	0	0	0	0	0	0	0	0	100	0	0	0	0	14	14	14	43	14	0	0	0	0	0	0	0	0	100	0	0	0	0	75	0	25	0	0
3.2 CTUC > 15% Cheaper	0	0	0	0	0	0	0	0	100	0	0	0	0	43	14	0	29	14	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	75	25
3.3 CTUC 5%-15% Cheaper	0	0	0	0	50	0	0	0	50	0	0	0	0	43	14	14	14	14	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	25	25	50
3.4 CTUC 5%-15% Expensive	0	0	0	0	50	0	0	0	50	14	14	14	0	43	0	0	0	14	0	0	0	0	0	0	0	0	100	25	50	0	0	0	0	0	0	25
3.5 CTUC >15% Expensive	0	0	50	0	0	0	0	0	50	14	14	29	0	29	0	0	0	14	0	0	0	0	0	0	0	0	100	25	50	0	0	0	0	0	0	25
3.6 Front-end loading: incr. cost w/ CTUC																																				
3.7 Change order: incr. cost w/ CTUC																																				
3.8 Added contr. tier: incr. cost w/ CTUC																																				
3.9 Reduced delay costs due to CTUC	0	0	0	0	0	0	0	0	100	0	0	0	0	0	14	14	57	14	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	75	25
4.1 Utility cannot pay in advance	50	0	0	0	0	0	0	0	50	14	71	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	100	75	0	0	0	0	0	0	0	25
4.2 Utility not qualify for SIB	0	50	0	0	0	0	0	0	50	29	43	14	0	0	0	0	0	14	0	0	0	0	0	0	0	0	100	50	25	0	0	0	0	0	0	25
4.3 CTUC >15% Cheaper	0	0	0	0	50	0	0	0	50	0	0	0	0	29	0	0	57	14	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	50	25	25
4.4 CTUC 5%-15% Cheaper	0	0	0	0	50	0	0	0	50	0	0	0	0	29	0	14	43	14	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	50	25	25

Appendix F: Assessment Results of CTUC Decision Drivers: District-Level (Cont'd)

Decision Driver	Utility (Impact Level)																																			
	San Antonio																		Houston																	
	W/WW(n=2)									Non-W/WW(n=7)									W/WW(n=2)									Non-W/WW(n=4)								
	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK
4.5 CTUC 5%-15% Expensive	0	0	0	50	0	0	0	0	50	29	14	0	14	29	0	0	0	14	0	0	0	0	0	0	0	0	100	25	50	0	0	0	0	0	0	25
4.6 CTUC >15% Expensive	0	0	50	0	0	0	0	0	50	43	29	0	0	14	0	0	0	14	0	0	0	0	0	0	0	0	100	25	50	0	0	0	0	0	0	25
4.7 Front-end loading: incr. cost w/ CTUC	0	50	0	0	0	0	0	0	50	14	43	29	0	0	0	0	0	14	0	0	0	0	0	0	0	0	100	100	0	0	0	0	0	0	0	0
4.8 Change order: incr. cost w/ CTUC	0	0	0	0	0	0	0	0	100	29	57	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	100	75	0	0	0	25	0	0	0	0
4.9 Added contr. tier: incr. cost w/ CTUC	0	0	0	0	0	0	0	0	100	29	29	29	0	0	0	0	0	14	0	0	0	0	0	0	0	0	100	50	50	0	0	0	0	0	0	0
4.10 Reduced delay costs due to CTUC	0	0	0	0	50	0	0	0	50	0	0	0	0	0	14	14	57	14	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	25	75	0
4.11 Indirect costs b/c of CTUC	0	0	0	50	0	0	0	0	50	29	29	0	14	14	0	0	0	14	0	0	0	0	0	0	0	0	100	75	25	0	0	0	0	0	0	0
5.1 Util work beyond ROW	50	0	0	0	50	0	0	0	0	71	0	0	0	29	0	0	0	0	0	0	0	0	0	0	0	0	100	25	25	0	0	25	0	0	0	25
5.2 Traffic ctrl. better in CTUC	0	0	0	0	50	0	0	0	50	0	0	0	0	29	14	0	43	14	0	0	0	0	0	0	0	0	100	0	0	0	0	0	25	25	25	25
5.3 Better safety ctrl. w/ CTUC	0	0	0	0	50	0	0	0	50	0	0	0	0	43	14	0	29	14	0	0	0	0	0	0	0	0	100	0	0	0	0	0	25	25	25	25
5.4 Better safety ctrl. w/ Conv.	0	0	0	0	0	0	0	0	100	0	14	29	14	29	0	0	0	14	0	0	0	0	0	0	0	0	100	25	0	25	0	25	0	0	0	25
5.5 Substantial clearing & grubbing on util.	0	0	0	0	0	0	0	0	100	0	0	0	0	0	14	14	57	14	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	25	50	25
5.6 HAZMAT: only apply to this adj.	0	0	0	0	0	0	0	100	0	14	0	0	0	29	0	0	57	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	75	25
5.7 Use TxDOT's specs	0	0	0	0	0	0	0	0	100	0	0	0	0	29	29	0	14	29	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	50	50
5.8 Develop composite specs	0	0	0	0	0	0	0	0	100	43	14	0	0	43	0	0	0	0	0	0	0	0	100	0	0	0	0	25	0	25	0	0	0	0	0	50
5.9 Only utility crew can do	100	0	0	0	0	0	0	0	0	14	71	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	100	75	0	0	0	0	0	0	0	25
5.10 CTUC frees up utility crews	0	0	0	0	0	0	0	0	100	0	0	0	0	29	29	14	14	14	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	25	50	25
5.11 Contr. can hire pre-qualify subs	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	29	57	14	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	25	50	25
5.12 Extensive utility upgrade	0	0	0	0	50	0	0	0	50	14	0	14	0	43	0	0	29	0	0	0	0	0	0	0	0	0	100	0	0	0	0	75	0	0	0	25
5.13 Detrimental environment change	0	0	0	0	0	0	0	0	100	29	0	14	0	43	0	0	14	0	0	0	0	0	100	0	0	0	0	0	0	0	0	25	0	25	25	25

Appendix F: Assessment Results of CTUC Decision Drivers: District-Level (Cont'd)

Decision Driver	Utility (Impact Level)																																			
	Dallas																		All Utilities																	
	W/WW(n=2)									Non-W/WW(n=7)									W/WW(n=6)									Non-W/WW(n=18)								
	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK
2.1 Traffic is heavy	0	0	0	0	0	0	50	50	0	0	0	0	0	14	29	43	0	14	0	0	0	0	0	0	17	17	67	0	0	0	0	17	22	33	17	11
2.2 Fewer lane closures in CTUC	0	0	0	0	0	50	0	50	0	0	0	0	0	0	43	0	43	14	0	0	0	0	0	17	0	17	67	0	0	0	0	11	28	6	44	11
2.3 Physical interferences exist	0	0	0	0	0	50	50	0	0	0	43	0	0	29	0	14	14	0	0	0	0	0	0	17	17	0	67	0	22	0	0	22	6	17	28	6
2.4 Adj. only happen in constr.	0	0	0	0	0	0	50	50	0	0	0	0	0	14	0	14	57	14	0	0	0	0	0	0	17	17	67	0	0	0	0	11	0	6	72	11
2.5 Severe schedule pressures	0	0	0	0	0	0	0	100	0	0	0	0	0	14	0	43	29	14	0	0	0	0	0	0	0	33	67	0	0	0	0	11	0	22	56	11
2.6 Ill-def.adj.scope at 60%PS&E	0	0	0	0	100	0	0	0	0	43	43	0	0	0	0	0	0	14	0	0	0	0	50	0	0	0	50	33	50	0	0	6	0	0	0	11
2.7 No schedule pressures	0	50	0	0	50	0	0	0	0	14	29	14	0	43	0	0	0	0	0	17	0	0	50	0	0	0	33	6	17	6	11	56	0	0	0	6
2.8 Utility plans are acceptable	0	0	0	0	50	50	0	0	0	0	0	0	0	43	0	14	43	0	0	0	0	0	17	17	0	17	50	0	0	0	0	33	6	17	39	6
2.9 Utility plans are unacceptable	0	0	50	0	0	50	0	0	0	29	29	14	14	14	0	0	0	0	17	0	17	17	0	17	0	0	33	33	28	17	11	6	0	0	0	6
2.10 Utility specs are acceptable	0	0	0	0	0	100	0	0	0	0	0	0	0	43	0	0	57	0	0	0	0	0	0	33	0	17	50	0	0	0	0	22	0	11	61	6
2.11 Utility specs are unacceptable	0	0	50	50	0	0	0	0	0	29	43	0	14	14	0	0	0	0	0	0	17	33	17	0	0	0	33	39	28	6	17	6	0	0	0	6
2.12 Shared underground fac.: all CTUC	0	0	0	0	0	0	50	50	0	0	0	0	0	0	14	29	57	0	0	0	0	0	0	0	17	17	67	0	0	0	0	6	11	17	50	17
2.13 For pole utilities: all join CTUC										0	75	0	0	0	0	0	25	0										0	38	0	0	0	8	0	31	23
2.14 Pole owner opt out of CTUC										0	0	25	25	50	0	0	0	0										15	15	8	15	31	0	0	0	15
2.15 Pole tenant opt out of CTUC										25	25	0	25	25	0	0	0	0										23	23	0	15	23	0	0	0	15
2.16 Pole tenant sch. conflict w/ CTUC										50	25	0	0	25	0	0	0	0										38	23	0	0	15	0	0	0	23
3.1 Adj. are 100% reimbursable	0	0	0	0	0	0	0	100	0	0	0	0	0	57	14	14	14	0	0	0	0	0	0	0	0	33	67	0	0	0	0	44	11	17	22	6
3.2 CTUC > 15% Cheaper	0	0	0	0	0	0	50	50	0	0	0	0	0	14	0	14	71	0	0	0	0	0	0	0	17	17	67	0	0	0	0	22	6	6	56	11
3.3 CTUC 5%-15% Cheaper	0	0	0	0	0	50	50	0	0	0	0	0	0	14	14	14	43	14	0	0	0	0	17	17	17	0	50	0	0	0	0	22	11	17	28	22
3.4 CTUC 5%-15% Expensive	0	0	50	0	50	0	0	0	0	43	29	0	0	29	0	0	0	0	0	0	17	0	33	0	0	0	50	28	28	6	0	28	0	0	0	11
3.5 CTUC >15% Expensive	0	0	50	0	50	0	0	0	0	43	29	0	0	29	0	0	0	0	0	0	33	0	17	0	0	0	50	28	28	11	0	22	0	0	0	11
3.6 Front-end loading: incr. cost w/ CTUC																																				
3.7 Change order: incr. cost w/ CTUC																																				
3.8 Added contr. tier: incr. cost w/ CTUC																																				
3.9 Reduced delay costs due to CTUC	0	0	0	0	0	0	0	100	0	0	0	0	0	14	0	14	71	0	0	0	0	0	0	0	0	33	67	0	0	0	0	6	6	11	67	11
4.1 Utility cannot pay in advance	0	0	100	0	0	0	0	0	0	71	14	0	0	0	0	0	0	14	17	0	33	0	0	0	0	0	50	50	33	0	0	0	0	0	0	17
4.2 Utility not qualify for SIB	0	0	100	0	0	0	0	0	0	43	29	0	0	0	0	0	0	29	0	17	33	0	0	0	0	0	50	39	33	6	0	0	0	0	0	22
4.3 CTUC >15% Cheaper	0	0	0	0	0	0	50	50	0	0	0	0	0	0	0	43	57	0	0	0	0	0	17	0	17	17	50	0	0	0	0	11	0	28	50	11
4.4 CTUC 5%-15% Cheaper	0	0	0	0	0	50	50	0	0	0	0	0	0	0	0	29	57	14	0	0	0	0	17	17	17	0	50	0	0	0	0	11	0	28	44	17

Appendix F: Assessment Results of CTUC Decision Drivers: District-Level (Cont'd)

Decision Driver	Utility (Impact Level)																																			
	Dallas																		All Utilities																	
	W/WW(n=2)									Non-W/WW(n=7)									W/WW(n=6)									Non-W/WW(n=18)								
	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK	AS	AH	AM	AL	N	PL	PM	PH	DK
4.5 CTUC 5%-15% Expensive	0	0	50	50	0	0	0	0	0	71	29	0	0	0	0	0	0	0	0	0	17	33	0	0	0	0	50	44	28	0	6	11	0	0	0	11
4.6 CTUC >15% Expensive	50	0	50	0	0	0	0	0	0	71	29	0	0	0	0	0	0	0	17	0	33	0	0	0	0	0	50	50	33	0	0	6	0	0	0	11
4.7 Front-end loading: incr. cost w/ CTUC	50	50	0	0	0	0	0	0	0	86	14	0	0	0	0	0	0	0	17	33	0	0	0	0	0	0	50	61	22	11	0	0	0	0	0	6
4.8 Change order: incr. cost w/ CTUC	50	50	0	0	0	0	0	0	0	86	14	0	0	0	0	0	0	0	17	17	0	0	0	0	0	0	67	61	28	0	0	6	0	0	0	6
4.9 Added contr. tier: incr. cost w/ CTUC	50	0	50	0	0	0	0	0	0	71	29	0	0	0	0	0	0	0	17	0	17	0	0	0	0	0	67	50	33	11	0	0	0	0	0	6
4.10 Reduced delay costs due to CTUC	0	0	0	0	50	0	0	50	0	0	0	0	0	0	0	14	86	0	0	0	0	0	33	0	0	17	50	0	0	0	0	0	6	17	72	6
4.11 Indirect costs b/c of CTUC	50	0	50	0	0	0	0	0	0	71	29	0	0	0	0	0	0	0	17	0	17	17	0	0	0	0	50	56	28	0	6	6	0	0	0	6
5.1 Util work beyond ROW	0	0	0	0	100	0	0	0	0	29	43	0	14	14	0	0	0	0	17	0	0	0	50	0	0	0	33	44	22	0	6	22	0	0	0	6
5.2 Traffic ctrl. better in CTUC	0	0	0	0	0	0	50	50	0	0	0	0	0	0	57	14	29	0	0	0	0	0	17	0	17	17	50	0	0	0	0	11	33	11	33	11
5.3 Better safety ctrl. w/ CTUC	0	0	0	0	0	50	0	50	0	0	0	0	0	0	43	29	29	0	0	0	0	0	17	17	0	17	50	0	0	0	0	17	28	17	28	11
5.4 Better safety ctrl. w/ Conv.	0	50	0	50	0	0	0	0	0	14	43	14	0	29	0	0	0	0	0	17	0	17	0	0	0	0	67	11	22	22	6	28	0	0	0	11
5.5 Substantial clearing & grubbing on util.	0	0	0	0	0	0	50	50	0	0	0	0	0	0	14	29	43	14	0	0	0	0	0	0	17	17	67	0	0	0	0	0	11	22	50	17
5.6 HAZMAT: only apply to this adj.	0	0	0	0	0	0	50	50	0	14	0	0	0	0	0	14	57	14	0	0	0	0	0	0	17	50	33	11	0	0	0	11	0	6	61	11
5.7 Use TxDOT's specs	0	0	0	0	0	100	0	0	0	0	0	0	0	14	0	0	57	29	0	0	0	0	0	33	0	0	67	0	0	0	0	17	11	0	39	33
5.8 Develop composite specs	0	0	0	50	50	0	0	0	0	29	14	14	0	29	0	0	0	14	0	0	0	17	50	0	0	0	33	33	11	11	0	28	0	0	0	17
5.9 Only utility crew can do	100	0	0	0	0	0	0	0	0	71	14	0	0	14	0	0	0	0	67	0	0	0	0	0	0	0	33	50	33	0	0	11	0	0	0	6
5.10 CTUC frees up utility crews	0	0	0	0	0	0	50	50	0	0	0	0	0	14	14	14	43	14	0	0	0	0	0	0	17	17	67	0	0	0	0	17	17	17	33	17
5.11 Contr. can hire pre-qualify subs	0	0	0	0	0	0	0	100	0	14	14	0	0	14	14	14	29	0	0	0	0	0	0	0	0	33	67	6	6	0	0	6	6	22	44	11
5.12 Extensive utility upgrade	0	0	0	50	50	0	0	0	0	29	0	0	14	57	0	0	0	0	0	0	0	17	33	0	0	0	50	17	0	6	6	56	0	0	11	6
5.13 Detrimental environment change	0	0	0	0	0	0	0	0	100	14	14	0	14	14	0	14	14	14	0	0	0	0	33	0	0	0	67	17	6	6	6	28	0	11	17	11

Appendix G: CTUC DST Analysis Reports for a Sample Project

Sample Project Information

Section 1: Project Information

1. TxDOT District: San Antonio
2. TxDOT Area Office: Bexar 410
3. Highway Project Name: IH 410 Test
4. Highway CCSJ: 1234-56-789
5. Highway ROW CSJ: 9876-54-321

Section 2: Assessor Information

1. Assessor Name: Test Test
2. Date Completed: 8/28/2006 12:0:0 PM
3. Job Title: Test Engineer
4. Phone Number: 512-471-8417
5. Email Address: txdot@test.com

Section 3: Decision Support Tool Settings

1. Password Protection Enabled? No
2. Knowledge Base Source: Experts are from TxDOT, SAT, HOU, DAL Districts
3. Total Number of Experts: 28
4. Years of Work Experience: 387

Section 4: Project Configuration of All Utility Adjustments

CTUC Phase 2 Analysis Neded?	Utility Type	Reimbursability	Utility Adjustment Name
Yes	Waste and/or Wastewater	Reimbursable	Water Line (Range/Station A-B)
Yes	Communication	Non-Reimbursable	West Comm. Cable (412-416)
No	Transmission Power Line	Don't know	High-V Power Line (Sta. 410)

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Decision Support Tool for the Combined Transportation and Utility Construction Strategy

Short Explanation of CTUC Phase 2 TxDOT Analysis

Utility Adjustment Name: Water Line (Range/Station A-B)

Section 1: Project and Utility Adjustment Information

1. TxDOT District: San Antonio
2. TxDOT Area Office: Bexar 410
3. Highway Project Name: IH 410 Test
4. Highway CCSJ: 1234-56-789
5. Highway ROW CSJ: 9876-54-321
6. Utility Type: Water and/or Wastewater
7. Is the Eligibility Ratio of This Utility Adjustment 100% or Nearly 100%? Yes

Section 2: Assessor Information

1. Assessor Name: Test Test
2. Date Completed: 8/28/2006 1:0:0 PM
3. Job Title: Test Engineer
4. Phone Number: 512-471-8417
5. Email Address: txdot@test.com

Section 3: Detailed Analysis Data

List of Pro-CTUC Decision Drivers

Decision Driver	Project Circumstance	Impact
#2.4 Schedule Pressures	The project HAS severe schedule pressures, and CTUC can lead to EARLIER project completion.	2.81

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Decision Driver	Project Circumstance	Impact
#2.5 Utility Adjustment Timing	The adjustment can be performed ONLY DURING the construction phase.	2.73
#4.2 (R)Utility Delay Costs	Possible UTILITY DELAY COSTS could be reduced due to the adjustment schedule controlled by the CTUC contractor.	2.44
#3.4 Shared Underground	CTUC WILL increase utility adjustment coordination and provide benefits to all involved utilities.	2.37
#2.2 Lane Closures	CTUC WILL require substantially FEWER lane closures than the Conventional approach during the project execution.	2.30
#2.1 Traffic Condition	The traffic condition at the project location IS HEAVY.	2.27
#3.10 Safety Control	The CTUC approach will have better safety control.	2.22
#3.9 Traffic Control	The CTUC contractor WILL be significantly more EFFECTIVE at controlling traffic for the project (vs. Conventional).	2.19
#3.7 Clearing / Grubbing	The utility-adjustment-related site clearing and grubbing is SUBSTANTIAL on the project.	2.12
#3.12 Acceptable Utility Specs	The utility CAN provide a set of specifications that are acceptable to TxDOT in terms of assignment of responsibility, liability, and risk.	2.12
#4.1 (R)Cost Comparison	CTUC adjustment costs will be more than 15% CHEAPER than the Conventional approach for the project.	2.11
#3.11 Acceptable Utility Plans	The utility CAN provide a set of plans that meet the requirements of the project and the TxDOT accommodation rules.	2.04
#3.13 Design Spec Source	The utility is willing to ADOPT TxDOT design specifications for the project.	1.92
#2.3 Physical Interferences	Physical interferences EXIST between 2 or more adjusted utilities on the project.	1.92
#4.0 (R)Eligibility	The eligibility ratio of the adjustment IS 100% or NEARLY 100%.	1.74

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Decision Support Tool for the Combined Transportation and Utility Construction Strategy

Decision Driver	Project Circumstance	Impact
#3.14 Utility Crew Availability	With CTUC the utility's crews will be FREED UP for other projects.	1.72

Note: (R) = Reimbursable; (NR) = Non-Reimbursable; "Impact" = the impact of the circumstance on the CTUC decision (High=3; Medium=2; Low=1).

List of Anti-CTUC Decision Drivers

Decision Driver	Project Circumstance	Resolvable?	Impact
#3.3 Utility Crew Limitations	Only the UTILITY's crew can perform the utility adjustment.	Yes	-3.75
#3.6 Util Work Beyond ROW	The utility adjustment work includes extensions BEYOND the TxDOT ROW or outside the construction project limits.	Yes	-3.29
#3.8 HAZMAT	HAZMAT-related work ONLY applies to the utility adjustment work.	Yes	-2.93
#3.16 Added Environ. Scope	The utility adjustment work includes a detrimental change to the project's environmental clearance.	No	-2.29
#4.3 (R)Front End Loading	Increased utility adjustment costs WILL likely occur due to the TxDOT contractor's FRONT-END LOADING with CTUC.	Yes	-1.92
#3.15 Utility Facility Upgrade	The utility adjustment includes an extensive amount of utility facility upgrades in relation to the transportation work.	Yes	-0.68

Note: (R) = Reimbursable; (NR) = Non-Reimbursable; "Impact" = the impact of the circumstance on the CTUC decision (Show-Stopper=-4; High=-3; Medium=-2; Low=-1).

List of Neutral Decision Drivers

Decision Driver	Project Circumstance
#4.4 (R)Change Order Markup	Increased contractor CHANGE ORDER frequencies and markups WILL NOT likely occur with CTUC.

Note: (R) = Reimbursable; (NR) = Non-Reimbursable.

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Decision Support Tool for the Combined Transportation and Utility Construction Strategy

List of "Don't Know" Decision Drivers

Decision Driver	Project Circumstance	Pro/N/Anti?	Impact
#4.5 (R)Added Contr. Tier	Increased costs due to the ADDED CONTRACTUAL TIER of subcontractors WILL result from CTUC.	Anti-CTUC	-1.92
#3.2 Contractor Capability	The pool of likely TxDOT contractors IS WILLING to HIRE a subcontractor from a list of pre-qualified contractors provided by the utility.	Pro-CTUC	0.16

Note: (R)=Reimbursable; (NR)=Non-Reimbursable; "Impact" = the impact of the circumstance on the CTUC decision.

Pro-CTUC: High = 3; Medium = 2; Low = 1; Neutral = 0; Anti-CTUC: Show-Stopper = -4; High = -3; Medium = -2; Low = -1;

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Complete Results of CTUC Phase 2 TxDOT Analysis

Section 1: Project Information

1. TxDOT District:	San Antonio
2. TxDOT Area Office:	Bexar 410
3. Highway Project Name:	IH 410 Test
4. Highway CCSJ:	1234-56-789
5. Highway ROW CSJ:	9876-54-321

Section 2: Assessor Information

1. Assessor Name:	Test Test
2. Date Completed:	8/28/2006 12:0:0 PM
3. Job Title:	Test Engineer
4. Phone Number:	512-471-8417
5. Email Address:	txdot@test.com

Section 3: Decision Support Tool Settings

1. Password Protection Enabled?	No
2. Knowledge Base Source:	Experts are from TxDOT SAT, HOU, DAL Districts.
3. Total Number of Experts:	28
4. Years of Work Experience:	387

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Section 4: Project Configuration of All Utility Adjustments

CTUC Phase 2 Analysis Needed?	Utility Type	Reimbursability	Utility Adjustment Name
Yes	Water and/or Wastewater	Reimbursable	Water Line (Range/Station A-B)
Yes	Communication	Non-Reimbursable	West Comm. Cable (412-416)
No	Transmission Power Line	Don't know	High-V Power Line (Sta. 410)

Section 5: Detailed Analysis Data of Each Utility Adjustment

Utility Adjustment Name: Water Line (Range/Station A-B)

1. Utility type: Water and/or Wastewater
2. Subject utility number: U10001
3. Is this utility a LPA? Yes
4. Is the eligibility ratio of this utility adjustment project 100% or NEARLY 100%? Yes
5. Description: Additional information can be entered here.
For example, utility positions, contact persons, etc.
6. Please comment on this adjustment scope: You can enter further information here.

7. To what degree does the utility have PAST CTUC EXPERIENCE? Extensive
8. What is the likelihood that the utility will PARTICIPATE in CTUC for this adjustment? High
9. Will this utility likely allow the TxDOT contractor to ONLY install utility INFRASTRUCTURE (e.g. manholes, poles, conduit, etc.)?
Answer: Yes
10. Which elements of this adjustment can the pool of likely TxDOT contractors perform?
Can do: Everything

11. Which elements can they not perform?
Can't do: Nothing

12. Please specify any physical interferences that EXIST between 2 or more adjusted utilities on the project:
Answer:

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13. Please elaborate any schedule pressures of this highway project:

Answer:

14. Type of adjustment work: Water

Question #2.4:

Does the project HAVE severe schedule pressures?

1. Answer Category: **Pro-CTUC**
2. Answer: Yes, the project HAS severe schedule pressures, and CTUC can lead to EARLIER project completion.

3. Experts' Opinions:

Avg. Impact Level	Anti-CTUC					Pro-CTUC			Don't Know
	ShowStopper	High	Medium	Low	Neutral	Low	Medium	High	
2.81	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	17.86%	78.57%	3.57%

4. Resolvability: What % of experts think the situation is resovable? 0.00%

Responsible Party: TxDOT: 0.00% Utility: 0.00% Others: 0.00%

5. Do You Agree with Experts' Opinion? Yes

Question #2.5:

Can the adjustment be performed ONLY during the CONSTRUCTION PHASE (e.g. permit issues or utility adjustment work is contingent upon some level of construction work completion)?

1. Answer Category: **Pro-CTUC**
2. Answer: Yes, the adjustment can be performed ONLY DURING the construction phase.

3. Experts' Opinions:

Avg. Impact Level	Anti-CTUC					Pro-CTUC			Don't Know
	ShowStopper	High	Medium	Low	Neutral	Low	Medium	High	
2.73	0.00%	0.00%	0.00%	0.00%	0.00%	7.14%	10.71%	75.00%	7.14%

4. Resolvability: What % of experts think the situation is resovable? 0.00%

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Responsible Party: TxDOT: 0.00% Utility: 0.00% Others: 0.00%

5. Do You Agree with Experts' Opinion? Yes

Question #2.2: Will CTUC require substantially FEWER lane closures than the Conventional approach during the project execution?

1. Answer Category: **Pro-CTUC**
2. Answer: Yes, CTUC WILL require substantially FEWER lane closures than the Conventional approach during the project execution.
3. Experts' Opinions:

Avg. Impact Level	Anti-CTUC					Pro-CTUC			Don't Know
	ShowStopper	High	Medium	Low	Neutral	Low	Medium	High	
2.30	0.00%	0.00%	0.00%	0.00%	7.14%	10.71%	25.00%	53.57%	3.57%

4. Resolvability: What % of experts think the situation is resovable? 0.00%

Responsible Party: TxDOT: 0.00% Utility: 0.00% Others: 0.00%

5. Do You Agree with Experts' Opinion? Yes

Question #2.1: Do you expect HEAVY traffic conditions at the project location (e.g. in metropolitan or urban areas)?

1. Answer Category: **Pro-CTUC**
2. Answer: Yes, the traffic condition at the project location IS HEAVY.
3. Experts' Opinions:

Avg. Impact Level	Anti-CTUC					Pro-CTUC			Don't Know
	ShowStopper	High	Medium	Low	Neutral	Low	Medium	High	
2.27	0.00%	0.00%	0.00%	0.00%	10.71%	0.00%	35.71%	46.43%	7.14%

4. Resolvability: What % of experts think the situation is resovable? 0.00%

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Responsible Party: TxDOT: 0.00% Utility: 0.00% Others: 0.00%

5. Do You Agree with Experts' Opinion? Yes

Question #2.3: Do physical interferences EXIST between 2 or more adjusted utilities on the project?

1. Answer Category: **Pro-CTUC**
2. Answer: Yes, physical interferences EXIST between 2 or more adjusted utilities on the project.

3. Experts' Opinions:

Avg. Impact Level	Anti-CTUC					Pro-CTUC			Don't Know
	ShowStopper	High	Medium	Low	Neutral	Low	Medium	High	
1.92	0.00%	0.00%	0.00%	0.00%	17.86%	7.14%	28.57%	35.71%	10.71%

4. Resolvability: What % of experts think the situation is resovable? 0.00%

Responsible Party: TxDOT: 0.00% Utility: 0.00% Others: 0.00%

5. Do You Agree with Experts' Opinion? Yes

Question #4.0: Is the eligibility ratio of the adjustment 100% or NEARLY 100%?

1. Answer Category: **Pro-CTUC**
2. Answer: Yes, the eligibility ratio of the adjustment IS 100% or NEARLY 100%.

3. Experts' Opinions:

Avg. Impact Level	Anti-CTUC					Pro-CTUC			Don't Know
	ShowStopper	High	Medium	Low	Neutral	Low	Medium	High	
1.74	0.00%	0.00%	0.00%	0.00%	25.00%	17.86%	10.71%	42.86%	3.57%

4. Resolvability: What % of experts think the situation is resovable? 0.00%

Responsible Party: TxDOT: 0.00% Utility: 0.00% Others: 0.00%

5. Do You Agree with Experts' Opinion? Yes

Question #3.3:

Is it possible that the pool of likely TxDOT contractors will be WILLING to HIRE a subcontractor from a list of pre-qualified contractors provided by the utility?

1. Answer Category: **Pro-CTUC**
2. Answer: Yes, the pool of likely TxDOT contractors IS WILLING to HIRE a subcontractor from a list of pre-qualified contractors provided by the utility.
3. Experts' Opinions:

Avg. Impact Level	Anti-CTUC					Pro-CTUC			Don't Know
	ShowStopper	High	Medium	Low	Neutral	Low	Medium	High	
0.16	2.68%	2.68%	0.00%	0.89%	50.89%	3.57%	4.46%	6.25%	28.57%

4. Resolvability: What % of experts think the situation is resovable? 0.00%

Responsible Party: TxDOT: 0.00% Utility: 0.00% Others: 0.00%

5. Do You Agree with Experts' Opinion? Yes

Question #3.2:

Does the utility adjustment work include extensions BEYOND the TxDOT ROW or outside the construction project limits?

1. Answer Category: **Anti-CTUC**
2. Answer: Yes, the utility adjustment work includes extensions BEYOND the TxDOT ROW or outside the construction project limits.
3. Experts' Opinions:

Avg. Impact Level	Anti-CTUC					Pro-CTUC			Don't Know
	ShowStopper	High	Medium	Low	Neutral	Low	Medium	High	
-3.29	67.86%	17.86%	7.14%	0.00%	3.57%	0.00%	0.00%	3.57%	0.00%

4. Resolvability: What % of experts think the situation is resovable? 96.43%

Responsible Party: TxDOT: 46.43% Utility: 35.71% Others: 17.86%

5. Do You Agree with Experts' Opinion? Yes

Question #3.4: Does HAZMAT-related work (e.g. asbestos, leaking underground storage tanks, contaminated soils, contaminated groundwater, or unknown substances) apply ONLY to the utility adjustment work?

1. Answer Category: **Anti-CTUC**
2. Answer: Yes, HAZMAT-related work ONLY applies to the utility adjustment work.

3. Experts' Opinions:

Avg. Impact	Anti-CTUC					Pro-CTUC			Don't
Level	ShowStopper	High	Medium	Low	Neutral	Low	Medium	High	Know
-2.93	53.57%	25.00%	10.71%	0.00%	3.57%	0.00%	3.57%	3.57%	0.00%

4. Resolvability: What % of experts think the situation is resovable? 64.29%

Responsible Party: TxDOT: 50.00% Utility: 33.33% Others: 16.67%

5. Do You Agree with Experts' Opinion? Yes

Question #4.2: If the adjustment is reimbursable with CTUC, will there be increased contractor CHANGE ORDER frequencies or markups?

1. Answer Category: **Anti-CTUC**
2. Answer: Yes, increased contractor CHANGE ORDER frequencies and markups WILL likely occur with CTUC.

3. Experts' Opinions:

Avg. Impact	Anti-CTUC					Pro-CTUC			Don't
Level	ShowStopper	High	Medium	Low	Neutral	Low	Medium	High	Know
-2.13	10.71%	28.57%	14.29%	17.86%	10.71%	0.00%	0.00%	0.00%	17.86%

4. Resolvability: What % of experts think the situation is resovable? 53.57%

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Responsible Party: TxDOT: 39.29% Utility: 39.29% Others: 21.43%

5. Do You Agree with Experts' Opinion? Yes

Question #4.1: If the adjustment is reimbursable with CTUC, will increased utility adjustment costs likely occur due to the TxDOT contractor's FRONT-END LOADING (UNBALANCED BIDDING)?

1. Answer Category: **Anti-CTUC**
2. Answer: Yes, increased utility adjustment costs WILL likely occur due to the TxDOT contractor's FRONT-END LOADING with CTUC.
3. Experts' Opinions:

Avg. Impact Level	Anti-CTUC					Pro-CTUC			Don't Know
	ShowStopper	High	Medium	Low	Neutral	Low	Medium	High	
-1.92	10.71%	28.57%	14.29%	14.29%	21.43%	0.00%	0.00%	0.00%	10.71%

4. Resolvability: What % of experts think the situation is resovable? 50.00%

Responsible Party: TxDOT: 50.00% Utility: 27.27% Others: 22.73%

5. Do You Agree with Experts' Opinion? Yes

Question #3.5: Can only the UTILITY's CREW perform the utility adjustment?

1. Answer Category: **Neutral**
2. Answer: No, the UTILITY's crew is not the only one who can perform the utility adjustment.

3. Experts' Opinions: N/A.

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Question #3.6: Does the utility adjustment work include any detrimental changes to the project's environmental clearance?

1. Answer Category: **Don't Know**
2. Answer: Yes, the utility adjustment work includes a detrimental change to the project's environmental clearance.

3. Experts' Opinions:

Avg. Impact Level	Anti-CTUC					Pro-CTUC			Don't Know
	ShowStopper	High	Medium	Low	Neutral	Low	Medium	High	
-2.29	46.43%	14.29%	0.00%	0.00%	14.29%	0.00%	0.00%	10.71%	14.29%

4. Resolvability: What % of experts think the situation is resovable? 0.00%
Responsible Party: TxDOT: 0.00% Utility: 0.00% Others: 0.00%

5. Do You Agree with Experts' Opinion? Yes