

**DEVELOPMENT OF A DECISION  
MODEL FOR SELECTION OF  
APPROPRIATE TIMELY DELIVERY  
TECHNIQUES FOR HIGHWAY  
PROJECTS**

**Final Report**

**SPR 646**



# **DEVELOPMENT OF A DECISION MODEL FOR SELECTION OF APPROPRIATE TIMELY DELIVERY TECHNIQUES FOR HIGHWAY PROJECTS**

## **Final Report**

**SPR 646**

by

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Federal Highway Administration  
400 Seventh Street, SW  
Washington, DC 20590-0003

**April 2009**



1. Report No. FHWA-OR-RD-09-16	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Development of a Decision Model for Selection of Appropriate Timely Delivery Techniques for Highway Projects		5. Report Date April 2009	
		6. Performing Organization Code	
7. Author(s) David N. Sillars, PhD, PE; Matt Hallowell, PhD; Jean Pol Armijos		8. Performing Organization Report No.	
9. Performing Organization Name and Address Oregon State University School of Civil and Construction Engineering 220 Owen Hall Corvallis, OR 97331		10. Work Unit No. (TRAIS)	
		11. Contract or Grant No. SPR 646	
12. Sponsoring Agency Name and Address Oregon Department of Transportation Research Unit and Federal Highway Administration 200 Hawthorne Ave. SE, Suite B-240 400 Seventh Street, SW Salem, OR 97301-5192 Washington, DC 20590-0003		13. Type of Report and Period Covered Final Report	
		14. Sponsoring Agency Code	
15. Supplementary Notes			
16. Abstract  <p>The primary "umbrella" method used by the Oregon Department of Transportation (ODOT) to ensure on-time performance in standard construction contracting is liquidated damages. The assessment value is usually a matter of some judgment. In practice, however, liquidated damages are not seen as an effective incentive, and they are rarely assessed. Other contracting and management methods which focus on encouraging timely performance have been identified, but they are used sporadically. Implementation of a system that creates better awareness of alternative schedule-delivery methods and that provides a consistent model for choosing among these methods would improve ODOT's schedule performance.</p> <p>This research project investigated the development of a tool to assist in selection of methods for ensuring timely project delivery, given a specific project profile. A selection model was developed that is stable and scalable. The investigators worked with a group of project delivery experts at ODOT to solicit and codify expert opinion. This data provided parameters that were used in a newly-developed algorithm for creating a model that prioritizes among project delivery choices. The model allows for user input of specific project parameters, which then creates a project-specific prioritization of techniques. The model proposes an implementation scheme that is managed centrally, providing for consistency, yet operated regionally, providing for project-based customization.</p>			
17. Key Words Construction management, alternative contracting, project delivery, schedule acceleration		18. Distribution Statement Copies available from NTIS, and online at <a href="http://www.oregon.gov/ODOT/TD/TP_RES/">http://www.oregon.gov/ODOT/TD/TP_RES/</a>	
19. Security Classification (of this report) Unclassified	20. Security Classification (of this page) Unclassified	21. No. of Pages 110 + appendices	22. Price

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### APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol	Symbol	When You Know	Multiply By	To Find	Symbol
<b><u>LENGTH</u></b>					<b><u>LENGTH</u></b>				
in	inches	25.4	millimeters	mm	mm	millimeters	0.039	inches	in
ft	feet	0.305	meters	M	m	meters	3.28	feet	ft
yd	yards	0.914	meters	M	m	meters	1.09	yards	yd
mi	miles	1.61	kilometers	km	km	kilometers	0.621	miles	mi
<b><u>AREA</u></b>					<b><u>AREA</u></b>				
in <sup>2</sup>	square inches	645.2	millimeters squared	mm <sup>2</sup>	mm <sup>2</sup>	millimeters squared	0.0016	square inches	in <sup>2</sup>
ft <sup>2</sup>	square feet	0.093	meters squared	M <sup>2</sup>	m <sup>2</sup>	meters squared	10.764	square feet	ft <sup>2</sup>
yd <sup>2</sup>	square yards	0.836	meters squared	M <sup>2</sup>	m <sup>2</sup>	meters squared	1.196	square yards	yd <sup>2</sup>
ac	acres	0.405	hectares	ha	ha	hectares	2.47	acres	ac
mi <sup>2</sup>	square miles	2.59	kilometers squared	km <sup>2</sup>	km <sup>2</sup>	kilometers squared	0.386	square miles	mi <sup>2</sup>
<b><u>VOLUME</u></b>					<b><u>VOLUME</u></b>				
fl oz	fluid ounces	29.57	milliliters	ml	ml	milliliters	0.034	fluid ounces	fl oz
gal	gallons	3.785	liters	L	L	liters	0.264	gallons	gal
ft <sup>3</sup>	cubic feet	0.028	meters cubed	M <sup>3</sup>	m <sup>3</sup>	meters cubed	35.315	cubic feet	ft <sup>3</sup>
yd <sup>3</sup>	cubic yards	0.765	meters cubed	M <sup>3</sup>	m <sup>3</sup>	meters cubed	1.308	cubic yards	yd <sup>3</sup>
NOTE: Volumes greater than 1000 L shall be shown in m <sup>3</sup> .									
<b><u>MASS</u></b>					<b><u>MASS</u></b>				
oz	ounces	28.35	grams	G	g	grams	0.035	ounces	oz
lb	pounds	0.454	kilograms	kg	kg	kilograms	2.205	pounds	lb
T	short tons (2000 lb)	0.907	megagrams	Mg	Mg	megagrams	1.102	short tons (2000 lb)	T
<b><u>TEMPERATURE (exact)</u></b>					<b><u>TEMPERATURE (exact)</u></b>				
°F	Fahrenheit	(F-32)/1.8	Celsius	°C	°C	Celsius	1.8C+32	Fahrenheit	°F

*SI is the symbol for the International System of Measurement
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## **ACKNOWLEDGEMENTS**

The author would like to thank the members of the ODOT Research Unit, and Technical Advisory Committee:

Jeff Graham, Oregon Division Operations Engineer, FHWA  
Mark Joerger, Senior Transportation Researcher, ODOT Research Unit  
Tom Lauer, Manager, ODOT Statewide Office of Project Delivery  
David J. Lutz, Project Delivery Unit Manager, ODOT Office of Project Delivery  
John J. Riedl, P.E., Senior Cost Engineer, ODOT Technical Services  
Kathryn A. Ryan, Branch Manager, ODOT Support Services

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# DEVELOPMENT OF A DECISION MODEL FOR SELECTION OF APPROPRIATE TIMELY DELIVERY TECHNIQUES FOR HIGHWAY PROJECTS

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## 1.0 INTRODUCTION

On-time highway construction project performance is an important goal at the Oregon Department of Transportation (ODOT). Pressure from two key constituents—the Legislature and trucking interests—creates an even stronger emphasis on this goal. First, the Oregon Legislative Assembly monitors the statistical on-time performance of ODOT’s construction projects. On-time performance is politically important and may affect legislative funding. Second, trucking associations have expressed concern over traffic delays, especially on the I-5 corridor. Their concerns are especially important in view of the current and planned bridge reconstruction program. ODOT has responded with the Freight Mobility initiative—focusing on ways that goods and people may be more easily moved and less inconvenienced during periods of construction.

Currently, statistics indicate that less than 50% of ODOT projects are completed within their originally contracted time of performance; this project completion experience indicates a mediocre schedule success rate. Further, project delay may cause uncertainty about exactly when traffic delays may occur on a given stretch of highway, making it difficult to make the public aware of these delays far in advance.

The primary “umbrella” method used to ensure on-time performance in standard ODOT contracting is liquidated damages. If a project exceeds its adjusted completion time, a specified dollar amount is assessed—theoretically at an amount sufficient to compensate ODOT for the cost of the delay. Often this amount is difficult to determine, so the assessment value is usually a matter of some judgment. In practice, however, liquidated damages are not seen as an effective incentive for on-time completion and thus are rarely assessed.

Other contracting and management methods that focus on encouraging on-time performance are used occasionally. One such method, Incentive/Disincentive Contracting, was the subject of recent ODOT time-related research (*Sillars and Armijos Leray 2006*). The goal of that project was to discover parameters and methods which would increase the effectiveness of that type of contracting. A better understanding of the various methods to improve on-time project delivery and a process for choosing among these methods could provide ODOT with the necessary tools to improve its schedule performance.

### 1.1 PURPOSE OF RESEARCH

The purpose of this study was to identify alternative methods to liquidated damages for encouraging on-time project delivery and to develop a means of selection among those methods, using a selection model that is stable and scalable.

According to Thomas et al. (1995), liquidated damages are the monetary penalty specified, usually in dollars per day, for each day beyond the contract time that substantial completion has not been reached. Liquidated damages may be specified only for the date of substantial

completion or for milestone dates. From the perspective of ODOT, such a penalty is a method of risk transfer via contract. That is, the liquidated damages are a method whereby ODOT transfers some damages caused by schedule delay to the contractor. While this method typically covers only a portion of ODOT's cost of schedule delay, the damages serve as a disincentive for the contractor. One should note that liquidated damages are not a form of project acceleration but rather a method of risk management. Project acceleration occurs when a project is expedited during construction to exceed the schedule goals set during planning. Liquidated damages are defined before contracts are signed and sometimes before a date for substantial completion is defined.

Liquidated damages have several limitations: they are assessed after a delay has occurred; they are only a disincentive, in that they focus on preventing delay instead of encouraging acceleration; and it is difficult to prove fault of delay on complex projects – hence they are rarely assessed. Therefore, this study concentrated on alternative methods of schedule risk management.

The objectives of this research were to:

- Update the current ODOT inventory of time-based performance methods and establish a common set of methods so that they may be compared among themselves;
- Create a model, potentially using multi-criteria selection techniques, that may be further developed by ODOT into a working contract method selection tool;
- Determine a set of generic project characteristics to use in the evaluation process;
- Establish an initial relationship between project characteristics and contracting methods that will aid in contract method selection; and
- Populate the conceptual selection model with both contracting methods and project characteristics, to use as a basis for model evaluation.

## **1.2 METHODOLOGY**

This research project was divided into the following tasks, which are shown schematically in Figure 1.1:

- Conduct a literature review of time-related contracting methods;
- Select appropriate procedures for further development;
- Identify models used by other DOTs for selection among time-based methods;
- Develop an ODOT model for selection among time-based methods;
- Identify common project characteristics to use as criteria for method selection;
- Rank project characteristics vis-à-vis appropriateness to method; and
- Populate and evaluate the conceptual model.

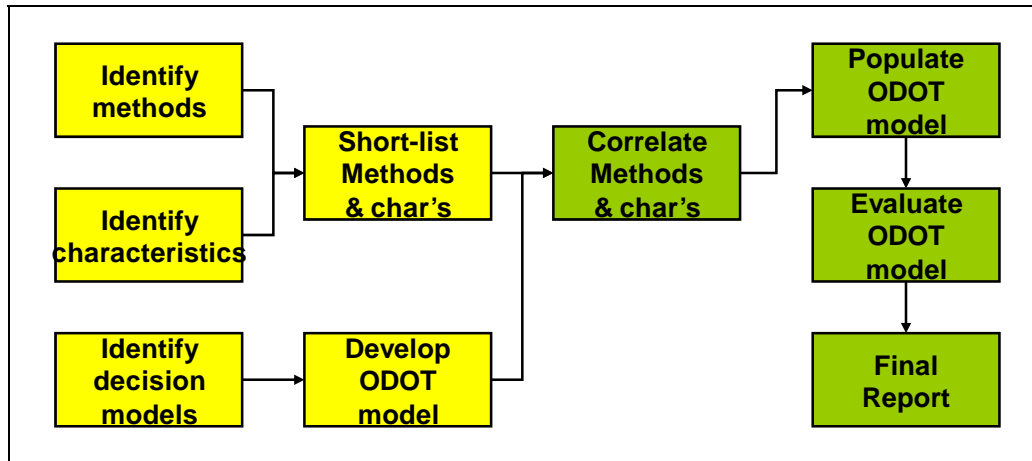


Figure 1.1: Research flow

These tasks are further discussed below. As the project proceeded, the first three tasks provided insight and some modification of the remaining tasks, under the direction of an ODOT Technical Advisory Committee. This report presents the results of the completion of these tasks:

**Review and document national and ODOT time-based methods:** identify methods commonly used to encourage on-time performance or expedited delivery. Working with ODOT personnel, review available listings of time-based methods used on ODOT projects. Categorize the information and develop a structured listed of methods with common parameters which allow comparison among the various methods. (Chapter 2)

**Select appropriate procedures for further development:** based on the information derived from the previous tasks and input from ODOT, select appropriate methods for additional definition and inclusion in a conceptual methods selection model. (Chapters 2 & 3)

**Identify model(s) used by other DOTs for selection among time-based methods:** identify one or more existing models to be used as a basis for selecting among available time-based project methods, given multiple project characteristics (multi-criteria decision-making). (Chapter 2)

**Develop an ODOT model for selection among time-based project methods:** based upon evaluation of the identified model(s), develop an appropriate model for project contract performance method selection that may be further developed operationally by ODOT. (Chapter 3)

**Identify common project characteristics to use as criteria for method selection:** identify existing ODOT project systems that document project characteristics, and select those characteristics that are appropriate for use in selecting among time-based project contracting methods. (Chapters 2 & 3)

**Rank project characteristics vis-à-vis appropriateness to method:** based on methods and project characteristics identified, utilize ODOT personnel to establish a relationship between

characteristics and methods that will aid in selecting appropriate performance methods for a specific project. (Chapter 4)

**Populate and evaluate conceptual model:** using scoring data developed in the ranking process, utilize the conceptual methods selection model to simulate various project scenarios and evaluate the results to verify the utility of the model. (Chapters 4 & 5)



## **2.0 LITERATURE REVIEW**

### **2.1 OVERVIEW**

The literature discussed in this section is intended to provide a review of current modeling techniques for selection among methods for helping ensure project timeliness, given a specific project's characteristics. This literature review covers the investigation of three topics:

- Methods used for assuring timeliness of project delivery;
- Characteristics of projects that are factors in project timeliness; and
- Models for selecting project contracting methods.

These steps are shown graphically as the three left-hand boxes in the research flow chart in Figure 1.1.

### **2.2 DECISION MODELS IN USE**

In a recent study by the National Cooperative Highway Research Program (NCHRP) (*Anderson and Damnjanovic 2007*), it was found that of the agencies canvassed in the study, 88% indicated that they did not have a systematic means for selecting a contracting method to encourage timely construction. Of those with systematic selection processes, the report discussed systems which were found to be particularly noteworthy, developed by five states – Minnesota, Utah, Ohio, California, and Pennsylvania.

The five state transportation agency systems identified in the NCHRP report had several characteristics in common. They all focused on contractual delivery or procurement systems, and they all utilized project profiles or project characteristics as the means of distinguishing among the choice of contracting methods. When selecting whether a characteristic applies to a project, the evaluation method was simply a “yes” or “no” response. For example, a typical consideration may be whether the project would cause “significant traffic disruption.”

Of the five state transportation agency decision systems described in the report, only one – Utah – had developed a software-based system (*Utah LTAP 2005*); it was unclear whether this system had been implemented, however. The Utah Local Technical Assistance Program (LTAP) decision tool utilized a system that allowed user input of project characteristics, as shown in Figure 2.1.



Figure 2.1: Utah LTAP innovative contracting choices

This decision model is available on the Utah State University Innovative Contracting website at <http://www.ic.usu.edu/>. The software-based selection tool is entitled the “Innovative Contracting Project Planner.” The Utah planner provides guidance toward the use of the alternatives shown in Figure 2.1 and provides recommendations on innovative contracting methods, given project-specific input provided by the user.

The program is based on a decision tree model (see Figure 2.2). The choice of which branch to take depends on a pre-determined judgment of which method is most likely to be successful under various conditions.

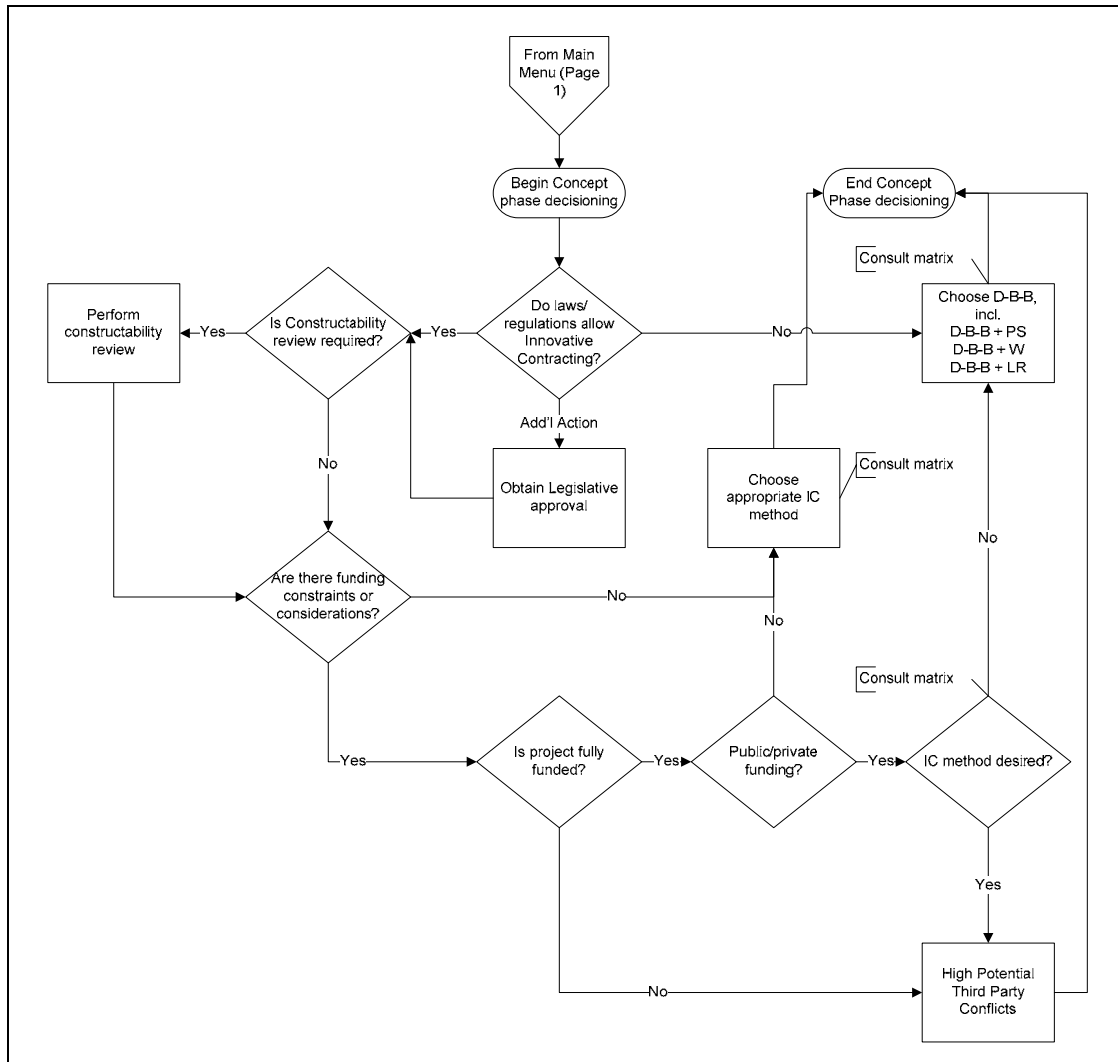


Figure 2.2: Utah LTAP decision flow chart

The user is asked to describe the project, and the branches are automatically selected; the process is invisible to the user. The user is given a recommended set of alternatives and a final table that provides estimates of success under the various alternatives.

The user is then asked to use judgment to make the final selection of delivery method, based on a table of likely success, as indicated in Figure 2.3.

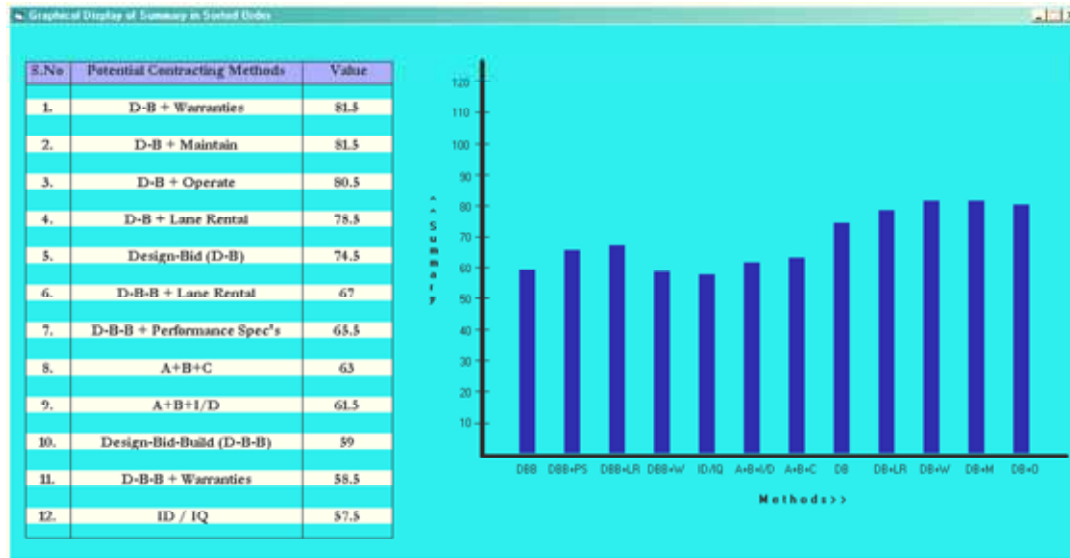


Figure 2.3: Utah LTAP model output

## 2.3 THEORETICAL DECISION MODELS

### 2.3.1 Introduction

One of the most challenging aspects in any engineering or management field is to make an optimal decision by choosing among multiple alternatives when addressing a particular situation. For centuries, the human race has relied upon experts to use judgment and intuition to choose among alternatives for a given set of criteria. During the last century, however, many objective methods have been developed to rank alternatives in complicated scenarios. These methods are commonly referred to as Multiple Criteria Decision Analyses (MCDA).

Bogetoft and Pruzan (1991) define MCDA as “a structured approach to selecting among multiple, noncommensurate and conflicting alternatives.” Simply put, these analysis methods involve ranking a finite set of alternatives in terms of a finite set of decision criteria. While many MCDA methods can be complicated in their procedures, the process of choosing among many alternatives to achieve an optimal result is not uncommon. In fact, we all perform MCDA on a daily basis using intuition and judgment. Take, for example, deciding what type of headwear to wear on a particular morning. The decision is likely to be dependent on several characteristics unique to that day such as weather, activities, degree of formality required and temperature. Likewise, there may be several alternatives to choose from such as a baseball cap, fedora, rain hood or no headwear. In this situation an individual would use judgment and intuition to choose among the alternatives.

Formal MCDA methods use structured processes for ranking alternatives based on their interaction with the various characteristics. These formal MCDA methods are implemented in lieu of personal judgment when a problem has significant potential impacts, the number of

alternatives or characteristics are too numerous or when the differences between alternatives are subtle (*Triantaphyllou 2000*).

There are two classes of MCDA methods: continuous and discrete. Discrete MCDA methods operate with a countable number of independent, well-defined alternatives and criteria. Continuous methods typically require mathematical programming with multiple objective functions (*Kuhn and Tucker 1951*). Although not as elegant or theoretically satisfying from a mathematical standpoint, discrete methods have far more potential for practical application. This study, therefore, focused on discrete mathematical modeling techniques, highlighting MCDA methods that have a countable number of decision alternatives and criteria.

The basic activities required for any MCDA method, discrete or otherwise, are as follows (*Triantaphyllou 2000*):

1. “Determine the relevant criteria (goals) and alternatives.
2. “Attach numerical measures to the relative importance of the criteria and to the impacts of the alternatives to these criteria.
3. “Process the numerical values to determine a ranking of each alternative.”

The reader should note that nearly all MCDA techniques are common in their approach to steps 1 and 2 but are unique in their approach to step 3.

### **2.3.2 MCDA Notation**

As noted in Triantaphyllou and Baig (2005), the typical MCDA problem consists of a number, say  $m$ , alternatives to be evaluated in a number, say  $n$ , of decision criteria. Alternatives are denoted as  $A_i$  (for  $i = 1, 2, 3, \dots, m$ ) and the criteria as  $C_j$  (for  $j = 1, 2, 3, \dots, n$ ). Finally, each criterion is associated with a weight of importance, denoted  $w_j$  (for  $j = 1, 2, 3, \dots, n$ ). It is assumed that the decision maker knows the relative weights and the values for each alternative in terms of each criterion ( $a_{ij}$ ). Customarily, weights are normalized so that they add up to one. The higher the weight, the more important the criterion is assumed to be in relation to the others. The above notation will be used to describe various MCDA methods throughout this report. The notation is summarized in the decision matrix shown in Table 2.1.

**Table 2.1: MCDA generic decision matrix structure**

	Criteria				
	$C_1$	$C_2$	$C_3$	$\dots$	$C_n$
Alts.	$(w_1)$	$w_2$	$w_3$	$\dots$	$w_n$
$A_1$	$a_{11}$	$a_{12}$	$a_{13}$	$\dots$	$a_{1n}$
$A_2$	$a_{21}$	$a_{22}$	$a_{23}$	$\dots$	$a_{2n}$
$\vdots$	$\cdot$	$\cdot$	$\cdot$	$\dots$	$\cdot$
$\cdot$	$\cdot$	$\cdot$	$\cdot$	$\dots$	$\cdot$
$A_m$	$a_{m1}$	$a_{m2}$	$a_{m3}$	$\dots$	$a_{mn}$

### 2.3.3 MCDA Models Overview

MCDA models range extensively in their complexity and applicability to real-world scenarios. For the purpose of this research, only the cardinal discrete MCDA methods are described and analyzed. Cardinal methods are defined by Chen and Hwang (1991) as those that allow the user to input any numerical values for performance of alternatives. That is, cardinal methods are not limited to binary values, integers or ranks. Seven methods will be reviewed in this report, none of which involve subjective (or “fuzzy”) user inputs. The models are as follows:

- Weighted Sum Method (WSM)
- Weighted Product Method (WPM)
- Analytic Hierarchy Process (AHP)
- Multiplicative Analytic Hierarchy Process (Multiplicative AHP)
- Revised Analytical Hierarchy Process (RAHP)
- Elimination and Choice Translating Reality (ELECTRE)
- Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

Included in the overview of each method is a brief description of the background, the fundamental concepts, required user inputs, benefits, limitations and step-by-step instructions. A simple example will be provided throughout the instructions to reinforce the description and for comparison with other methods. Each example will use the same user inputs, which are included in Appendix A.

One should note that the examples provided have been adapted from Triantaphyllou (2000). This book provides excellent guidance and perhaps the best overview and most in-depth description of MCDA available today. The reader is encouraged to refer to this publication for additional information not covered in this report.

#### 2.3.3.1 Weighted Sum Method (WSM)

##### 2.3.3.1.1 Background and theory

The weighted sum method is the simplest and most intuitively satisfying of all MCDA methods. Fishburn (1967) is credited with the earliest publication that

recognizes the WSM but, due to its simplicity and congruence with the concept that drives ‘weighted averages,’ it is unclear where the WSM was originally implemented. Like weighted averages, the WSM operates under the additive utility assumption (*Triantaphyllou 2000*). Under this assumption, the value or “score” of an alternative is equal to the sum of the performance of an alternative under each criterion ( $a_{ij}$ ) multiplied by the relative weight assigned to that criterion ( $w_j$ ). The alternative with the optimal score (e.g., highest or lowest) represents the optimal choice. The WSM is defined by Equation 2-1:

$$A^* = \max \sum_{j=1}^n a_{ij} w_j \quad (2-1)$$

where:  $n$  is the number of decision criteria;  $a_{ij}$  is the value of the  $i^{\text{th}}$  alternative in terms of the  $j^{\text{th}}$  criterion; and  $w_j$  is the weight assigned to the  $j^{\text{th}}$  criterion.

#### 2.3.3.1.2 Required user inputs

The following inputs are required of the user:

- Performance of each alternative under each criterion ( $a_{ij}$ )
- Relative weights for each criterion ( $w_j$ )

#### 2.3.3.1.3 Step-by-step procedure

The WSM can be summarized through three relatively simple steps. These steps are outlined as follows using the data from Appendix A as an example.

#### 1. Single dimensional user inputs are entered in matrix format (see 0).

$$\mathbf{A} = \begin{bmatrix} 25 & 20 & 15 & 30 \\ 10 & 30 & 20 & 30 \\ 30 & 25 & 30 & 10 \end{bmatrix}$$

$$\mathbf{W} = \begin{bmatrix} 0.20 & 0 & 0 & 0 \\ 0 & 0.15 & 0 & 0 \\ 0 & 0 & 0.40 & 0 \\ 0 & 0 & 0 & 0.25 \end{bmatrix}$$

#### 2. Each alternative is scored by entering values and weights into Equation 2-1.

$$A^* = \max \sum_{j=1}^n a_{ij} w_j, \text{ for } i = 1, 2, 3, \dots, m$$

$$A_1 = 25 * 0.20 + 20 * 0.15 + 15 * 0.40 + 30 * 0.25 = 21.50$$

Similarly,

$$A_2 = 22.00$$

$$A_3 = 24.50$$

### 3. The optimal solution is chosen.

Choose the best alternative (i.e., the alternative with the highest WSM score):

$$A_3 > A_2 > A_1$$

Therefore, choose alternative 3.

#### 2.3.3.1.4 *Benefits*

The major benefits of this method are simplicity, user-friendliness and intuitive satisfaction. Therefore, the WSM is easy to explain to potential stakeholders making it less of a “black-box approach.” This may prove especially useful when interacting with less sophisticated, diverse, or highly concerned stakeholders.

#### 2.3.3.1.5 *Limitations and criticism*

The most significant limitation of this method is that it only applies to single-dimensional problems (i.e., all criteria are measured in the same units). This limitation is significant, because most problems that require MCDA methods have multi-dimensional criteria such as days, dollars, measures of quality, safety, etc. To circumvent this problem Garber and Hoel (2002) suggest replacing actual values for each alternative with ranks. While ranking creates non-dimensional data, influence of significant differences between alternatives are lost in transformation. Using ranks with the WSM is not recommended because there are more suitable multi-dimensional MCDA techniques.

### 2.3.3.2 **Weighted Product Method (WPM)**

#### 2.3.3.2.1 *Background and theory*

The WPM was introduced by Miller and Starr (1969) as an improvement to the WSM. In fact, most literature such as Bogetoft and Pruzan (1991) recognize the WPM as simply a revised version of the weighted sum method. The two methods require the same user inputs but differ in operations and output. The major advantage of the WPM is that it is a dimensionless analysis (i.e., criteria do not have to be measured in the same units). In the WPM alternatives are compared one pair at a time. Each alternative is compared to the others by multiplying the ratios for each comparison. Additionally, each ratio is raised to the power of the



weight for the corresponding criterion. This method is more clearly defined in Equation 2-2.

$$R(A_k / A_l) = \prod_{j=1}^n (aK_j / aL_j)^{w_j} \quad (2-2)$$

where: n is the number of decision criteria; aK<sub>j</sub> is the value of the alternative K in terms of the j<sup>th</sup> criterion; aL<sub>j</sub> is the value of the alternative L in terms of the j<sup>th</sup> criterion; and w<sub>j</sub> is the weight assigned to the j<sup>th</sup> criterion.

#### 2.3.3.2.2 Required user inputs

The following inputs are required of the user:

- Performance of each alternative under each criterion (a<sub>ij</sub>)
- Relative weights for each criterion (w<sub>j</sub>)

#### 2.3.3.2.3 Step-by-step procedure

The WPM procedure may be described through a series of three simple steps. Again, the data from Appendix A will be used as an example.

#### 1. User inputs are entered in matrix format (see 0).

$$\mathbf{A} = \begin{bmatrix} 25 & 20 & 15 & 30 \\ 10 & 30 & 20 & 30 \\ 30 & 25 & 30 & 10 \end{bmatrix}$$

$$\mathbf{W} = \begin{bmatrix} 0.20 & 0 & 0 & 0 \\ 0 & 0.15 & 0 & 0 \\ 0 & 0 & 0.40 & 0 \\ 0 & 0 & 0 & 0.25 \end{bmatrix}$$

#### 2. Each alternative is scored by entering values and weights into Equation 2-2.

$$R(A_1/A_2) = (25/10)^{0.20} \times (20/30)^{0.15} \times (15/20)^{0.40} \times (30/30)^{0.25} = 1.007 \geq 1$$

Similarly,

$$\begin{aligned} R(A_1/A_3) &= 0.923 < 1 \\ R(A_2/A_3) &= 0.930 < 1 \end{aligned}$$

#### 3. The optimal solution is chosen.

$$A3 > A1 > A2$$

Therefore, choose alternative 3.

#### 2.3.3.2.4 *Benefits*

Like the WSM, the weighted product model is simple and intuitively satisfying. During the creation of pairwise comparison ratios this method becomes dimensionless. Therefore the method is more robust because it can be used in multi-dimension data. In addition, a comparison of MCDA methods indicated that the WPM was one of only two methods that were immune to ranking disputes in benefit to cost and benefit minus cost approaches (*Triantaphyllou and Baig 2005*).

#### 2.3.3.2.5 *Limitations and criticism*

Despite the simplicity and benefits of the WPM, it received harsh criticism by many authors. Critics contend that when the weights are used as a power factor, heterogeneous criteria tend to cancel each other and result in a false ranking (*Mogharreban 2006*). Kepner and Tregoe (*1965*) add that, “the WPM exhibits compensatory behavior and therefore should not be used with ‘musts’ (requisite criteria) ...because it eliminates attributes with poor attributes.” Given the limitations, a decision maker should be cognizant of the potential pitfalls and avoid implementing the WPM with requisite or heterogeneous criteria.

### 2.3.3.3 *Analytic Hierarchy Process (AHP)*

#### 2.3.3.3.1 *Background and theory*

The Analytic Hierarchy Process was developed in the early 1980's by Saaty (*1980*) and immediately gained popularity. Many researchers have expressed interest in the AHP because of the simple matrix technique, pairwise comparison and the readily available software tool: Expert Choice™ (*Kujawski 2003*). The AHP procedure is relatively simple to follow. The procedure is identical to the WSM method except that each value ( $a_{ij}$ ) is normalized by dividing by the sum of the observed values for each criterion ( $\sum a_j$ ).

The driving equation has been previously defined in Equation 2-1.

#### 2.3.3.3.2 *Required user inputs*

The following inputs are required of the user:

- Performance of each alternative under each criterion ( $a_{ij}$ )
- Relative weights for each criterion ( $w_j$ )

#### 2.3.3.3.3 Step-by-step procedure

The AHP may be described through a series of simple steps. Again, the data from Appendix A will be used as an example. One should note that there are many variations on the basic AHP method. The following steps can be gleaned from the text and examples provided in Triantaphyllou (2000):

1. User inputs are entered in matrix format (see 0).

$$\mathbf{A} = \begin{bmatrix} 25 & 20 & 15 & 30 \\ 10 & 30 & 20 & 30 \\ 30 & 25 & 30 & 10 \end{bmatrix}$$

$$\mathbf{W} = \begin{bmatrix} 0.20 & 0 & 0 & 0 \\ 0 & 0.15 & 0 & 0 \\ 0 & 0 & 0.40 & 0 \\ 0 & 0 & 0 & 0.25 \end{bmatrix}$$

2. A transformed matrix is created by replacing each score ( $a_{ij}$ ) with a normalized, relative score [ $a_{ij} / \sum(a_j)$ ]. Simply, the transformed score is calculated by dividing each score by the sum of values for that particular criterion. The transformed matrix,  $\mathbf{X}$ , is as follows.

$$\mathbf{X} = \begin{bmatrix} 25/65 & 20/75 & 15/65 & 30/70 \\ 10/65 & 30/75 & 20/65 & 30/70 \\ 30/65 & 25/75 & 30/65 & 10/70 \end{bmatrix}$$

3. Each alternative is scored by entering values and weights into Equation 2-1.

$$A^* = \max_i \sum_{j=1}^n a_{ij} \cdot w_j$$

$$A_1 = (25/65) \times 0.20 + (20/75) \times 0.15 + (15/65) \times 0.40 + (30/70) \times 0.25 = 0.316$$

Similarly,

$$A_2 = 0.321$$

$$A_3 = 0.363$$

4. **The alternative with the highest AHP score represents the optimal solution. Choose the best alternative (i.e., the alternative with the highest AHP score).**

$$A_3 > A_2 > A_1$$

Therefore, choose alternative 3.

#### 2.3.3.3.4 *Benefits*

Since its inception in the early 1980's the AHP has been cited in over 1,000 journal articles, making it the most widely implemented MCDA method (Saaty 1994). The wide acceptance by the scientific community makes the method easy to defend. The method is so prolific because it provides a dimensionless analysis without the issues associated with the WPM (i.e., using weights as a power factor). Additionally, the method is simple, easy to implement and describe, and there are many available computer programs.

#### 2.3.3.3.5 *Limitations and criticism*

Despite the method's overwhelming popularity, it is not without its critics. Belton and Gear (1983) challenged the original method introduced by (Saaty 1980) because they observed a ranking inconsistency when the relative values for each criterion add up to one. That is, when the sum of the scores ( $a_{ij}$ ) for any criteria ( $C_j$ ) add up to one, a ranking abnormality occurs. Triantaphyllou (2000) provides an excellent example of this phenomenon.

In what was described as a "heated discussion" at the international symposia for analytic hierarchy processes (ISAHP), Saaty finally conceded that inconsistencies could occur in the original method and agreed that the revised AHP was a superior method (Triantaphyllou and Baig 2005). This method is discussed in detail in the following section.

### 2.3.3.4 *Revised Analytical Hierarchy Process (Revised AHP)*

#### 2.3.3.4.1 *Background and theory*

As previously indicated, the fundamental AHP has been criticized for ranking inconsistencies. Belton and Gear (1983) suggested a revision, aptly named the Revised AHP. The revision requires the insertion of an **identical** copy of an existing alternative. Also, instead of having the relative values add up to one, the AHP revision involves dividing each value by the maximum value of the relative alternatives [ $a_{ij}/\max(a_j)$ ]. The combination of these two procedures eliminates the ranking inconsistencies of the basic AHP.

After this transformation, the score is calculated using the earlier Equation 2-1.

#### 2.3.3.4.2 Required user inputs

The following inputs are required of the user:

- Performance of each alternative under each criterion ( $a_{ij}$ )
- Relative weights for each criterion ( $w_j$ )

#### 2.3.3.4.3 Step-by-step procedure

The AHP may be described through a series of simple steps. Again, the data from Appendix A will be used as an example.

**1. User inputs are entered in matrix format (see 0).**

$$\mathbf{A} = \begin{bmatrix} 25 & 20 & 15 & 30 \\ 10 & 30 & 20 & 30 \\ 30 & 25 & 30 & 10 \end{bmatrix}$$

$$\mathbf{W} = \begin{bmatrix} 0.20 & 0 & 0 & 0 \\ 0 & 0.15 & 0 & 0 \\ 0 & 0 & 0.40 & 0 \\ 0 & 0 & 0 & 0.25 \end{bmatrix}$$

**2. An identical copy of an existing alternative is added to the data matrix.**  
For this example an identical alternative,  $A_4$  will be added where  $A_4 \equiv A_2$ .

$$A_{\text{new}} = \begin{bmatrix} 25 & 20 & 15 & 30 \\ 10 & 30 & 20 & 30 \\ 30 & 25 & 30 & 10 \\ 10 & 30 & 20 & 30 \end{bmatrix}$$

**3. Each entry is divided by the sum of all alternatives in each column ( $a_{ij} / \sum a_j$ ). This matrix is referred to as Matrix B.**

$$\mathbf{B} = \begin{bmatrix} 25/75 & 20/105 & 15/85 & 30/100 \\ 10/75 & 30/105 & 20/85 & 30/100 \\ 30/75 & 25/105 & 30/85 & 10/100 \\ 10/75 & 30/105 & 20/85 & 30/100 \end{bmatrix}$$

**4. Each alternative is scored by entering values and weights into Equation 2-1.**

$$A_1 = (25/75) \times 0.20 + (20/105) \times 0.15 + (15/85) \times 0.40 + (30/100) \times 0.25 = 0.241$$

Similarly,

$$A_2 = 0.239$$

$$A_3 = 0.282$$

$$A_4 = 0.239$$

##### **5. Select the optimal solution.**

Choose the best alternative (i.e. the alternative with the highest AHP score).

$$A_3 > A_1 > A_2 \equiv A_4$$

Therefore, choose alternative 3.

##### *2.3.3.4.4 Benefits*

The Revised AHP is credited with all of the benefits associated with the basic AHP without the criticisms. This is achieved through the insertion of an identical alternative. In review, the chief benefits of the AHP methods are as follows:

- Dimensionless
- Simple and easy to implement
- Available computer programs

##### *2.3.3.4.5 Limitations and criticism*

A review of a significant body of literature showed it was clear that there are few limitations associated with the Revised AHP method. Saaty (1994) provides the most criticism stating that, "...identical alternatives should not be considered in the decision process." It is not surprising that these statements were made, given that the revision highlights the shortcomings of Saaty's original method. That being said, there are no other major criticisms of this method.

#### **2.3.3.5 Multiplicative Analytic Hierarchy Process (Multiplicative AHP)**

##### *2.3.3.5.1 Background and theory*

The Multiplicative AHP is yet another variation of the basic Analytic Hierarchy Process. The procedure merges the ideas of the original AHP with the methodology of the WPM. Barzilai and Lootsma (1994) introduced this method and it was subsequently analyzed, explored and accepted as a legitimate method (Triantaphyllou 2000). In a later paper, Triantaphyllou and Baig (2005) explored the relationship between the WPM and the Multiplicative AHP and determined that both methods are perfectly consistent with one another. That is, given the same set of conflicting criteria, both approaches will generate an identical result.

This method is defined in Equation 2-3:

$$R(A_k / A_i) = \prod_{j=1}^n (a_{kj} / a_{ij})^{w_j} \quad (2-3)$$

where: n is the number of decision criteria;  $a_{ij}$  is the value of the  $i^{\text{th}}$  alternative in terms of the  $j^{\text{th}}$  criterion and  $w_j$  is the weight assigned to the  $j^{\text{th}}$  criterion.

#### 2.3.3.5.2 Required user inputs

The following inputs are required of the user:

- Performance of each alternative under each criterion ( $a_{ij}$ )
- Relative weights for each criterion ( $w_j$ )

#### 2.3.3.5.3 Step-by-step procedure

The Multiplicative AHP may be described through a series of simple steps. Again, the data from Appendix A will be used as an example:

##### 1. User inputs are entered in matrix format (see Appendix A).

$$\mathbf{A} = \begin{bmatrix} 25 & 20 & 15 & 30 \\ 10 & 30 & 20 & 30 \\ 30 & 25 & 30 & 10 \end{bmatrix}$$

$$\mathbf{W} = \begin{bmatrix} 0.20 & 0 & 0 & 0 \\ 0 & 0.15 & 0 & 0 \\ 0 & 0 & 0.40 & 0 \\ 0 & 0 & 0 & 0.25 \end{bmatrix}$$

##### 2. A transformed matrix is created by replacing each score ( $a_{ij}$ ) with a normalized, relative score [ $a_{ij} / \sum(a_j)$ ]. Simply, the transformed score is calculated by dividing each score by the sum of values for that particular criterion. The transformed matrix, $\mathbf{X}$ , is as follows.

$$\mathbf{X} = \begin{bmatrix} 25/65 & 20/75 & 15/65 & 30/70 \\ 10/65 & 30/75 & 20/65 & 30/70 \\ 30/65 & 25/75 & 30/65 & 10/70 \end{bmatrix}$$

##### 3. Each alternative is scored by entering values and weights into Equation 2-3.

$$A_1/A_2 = [(25/65)/(10/65)]^{0.20} \times [(20/65)/(30/65)]^{0.15} \times [(15/65)/(20/65)]^{0.40} \times [(30/70)/(30/70)]^{0.25} = 1.007$$

Similarly,

$$A_1/A_3 = 0.930$$

$$A_2/A_3 = 0.923$$

**4. The alternative with the highest score represents the optimal solution.**

$$A_3 > A_1 > A_2$$

Therefore, choose alternative 3.

*2.3.3.5.4 Benefits*

The chief advantage that the Multiplicative AHP has over the basic AHP predecessor is the fact that the analysis is non-dimensional. However, the revised AHP method achieves this without the ranking inconsistency associated with the basic AHP. This method is a logical attempt at improving the basic AHP in the same way the WPM is an attempt to improve the WSM (Vaidya and Kumar 2006). Additionally, this method is immune to the ranking inconsistency of the associated with the AHP.

*2.3.3.5.5 Limitations and criticism*

As previously indicated this method is mathematically consistent with the WPM approach. Therefore, this method is not preferred to the simpler WPM method (Triantaphyllou and Baig 2005). However, this method is susceptible to the same criticism as the WPM. That is, the Multiplicative AHP uses weights as a power factor. Therefore, heterogeneous criteria tend to cancel each other and result in a false ranking (Mogharreban 2006). Also, as indicated previously, the WPM is always preferred to the Multiplicative AHP, because the same result is obtained without the more complicated programming associated with the Multiplicative AHP.

**2.3.3.6 Elimination and Choice Translating Reality (ELECTRE)**

*2.3.3.6.1 Background and theory*

The Elimination Choice Translating Reality method is named from a loose translation of the French original introduced in Benayoun et al. (1966). Unlike the previous methods, ELECTRE takes an approach called “outranking.” Outranking is achieved by using separate pairwise comparisons among alternatives under each criterion. Alternatives are said to be dominated, or outranked, if there is another alternative which outranks them in one or more criteria and equals it in the remaining criteria (Triantaphyllou 2000).

Ultimately, the ELECTRE procedure produces a binary outranking matrix. One should note that the ELECTRE outranking process does not produce true binary values (i.e., 1's and 0's) that one would expect. Instead, the output matrix includes



1's, 0's and fractional values between 1 and 0. These fractional values describe the degree to which one alternative outranks another. Though it is customary to refer to the ELECTRE output as 'binary,' one should note that the output is not binary in the true sense of the term. This method and the interpretation of results are best described through an example that includes a short description of each step. An example of a widely accepted variant, ELECTRE III is provided in the following section based on guidance provided by Buchanan and Sheppard (2000). This variation of the ELECTRE method avoids the use of "fuzzy" variables (i.e., subjective user inputs chosen by the decision maker).

#### 2.3.3.6.2 Required user inputs

The following inputs are required of the user:

- Performance of each alternative under each criterion ( $a_{ij}$ )
- Relative weights for each criterion ( $w_j$ )

#### 2.3.3.6.3 Step-by-step procedure

The ELECTRE method can be performed through the following steps.

##### 1. User inputs are entered in matrix format (see Appendix A).

$$\mathbf{A} = \begin{bmatrix} 25 & 20 & 15 & 30 \\ 10 & 30 & 20 & 30 \\ 30 & 25 & 30 & 10 \end{bmatrix}$$

$$\mathbf{W} = \begin{bmatrix} 0.20 & 0 & 0 & 0 \\ 0 & 0.15 & 0 & 0 \\ 0 & 0 & 0.40 & 0 \\ 0 & 0 & 0 & 0.25 \end{bmatrix}$$

##### 2. Normalize the decision matrix, A, Q and P, by entering each value into Equation 2-4:

$$x_{ij} = a_{ij} / \sqrt{\sum_{k=1}^m (a_{kj})^2} \quad (2-4)$$

where:  $x_{ij}$  is the normalized value of the  $i^{\text{th}}$  alternative in terms of the  $j^{\text{th}}$  criterion and  $m$  is the number of decision criteria; other terms are as defined in Equation 2-1.

For example,

$$x_{11} = 25 / \text{SQRT}(25^2 + 10^2 + 30^2) = 0.62$$

Following, we get a normalized matrix A, referred to as  $A_{\text{norm}}$

$$A_{\text{norm}} = \begin{bmatrix} 0.62 & 0.46 & 0.38 & 0.69 \\ 0.25 & 0.68 & 0.51 & 0.69 \\ 0.74 & 0.57 & 0.77 & 0.23 \end{bmatrix}$$

3. **A weighted matrix is created by multiplying the normalized matrices by the weighted matrix (W). We will call this matrix  $A_{\text{norm,w}}$ .**

$$A_{\text{norm,w}} = \begin{bmatrix} 0.124 & 0.068 & 0.152 & 0.173 \\ 0.050 & 0.103 & 0.204 & 0.173 \\ 0.148 & 0.085 & 0.308 & 0.058 \end{bmatrix}$$

4. **Concordance and Discordance sets are created by comparing each alternative to another for each criterion. Take, for example, the comparison of  $A_1$  to  $A_3$ .**

Compare concordance of each alternative, one criterion at a time as follows:

$$\begin{aligned} C1(A_1/A_3) &= 0, & \text{since } 0.124 < 0.148 \\ C2(A_1/A_3) &= 0, & \text{since } 0.068 < 0.085 \\ C3(A_1/A_3) &= 0, & \text{since } 0.152 < 0.308 \\ C4(A_1/A_3) &= 1, & \text{since } 0.173 \geq 0.058 \end{aligned}$$

Therefore,

$$C(A_1/A_3) = (0+0+0+1)/(1+1+1+1) = 0.25$$

Similarly, a concordance matrix is created as follows:

$$\text{Concordance} = \begin{bmatrix} 1.00 & 0.50 & 0.25 \\ 0.75 & 1.00 & 0.50 \\ 0.75 & 0.75 & 1.00 \end{bmatrix}$$

In a similar process the discordance of each alternative is compared one alternative at a time, as follows:

$$\begin{aligned} C1(A_1/A_2) &= 0, & \text{since } 0.124 \geq 0.050 \\ C2(A_1/A_2) &= 1, & \text{since } 0.068 < 0.103 \\ C3(A_1/A_2) &= 1, & \text{since } 0.152 < 0.204 \\ C4(A_1/A_2) &= 0, & \text{since } 0.173 < 0.173 \end{aligned}$$

Therefore,  $C(A_1/A_3) = (0+1+1+0)/(1+1+1+1) = 0.50$

$$\text{Discordance} = \begin{bmatrix} 0.00 & 0.50 & 0.75 \\ 0.25 & 0.00 & 0.50 \\ 0.25 & 0.50 & 0.00 \end{bmatrix}$$

- 5. The ELECTRE score is created by simultaneously considering the Concordance matrix with the Discordance matrix. This is performed by summing the rows (for each alternative) of the concordance matrix and subtracting the sum of the corresponding row of the Discordance matrix.**

$$A_1 = 1.75 - 1.25 = 0.50$$

Similarly,

$$A_2 = 1.50$$

$$A_3 = 1.75$$

- 6. The alternative with the highest score represents the optimal solution.**

The highest value represents the optimal solution.

$$A_3 > A_2 > A_1$$

Therefore, choose alternative 3.

#### 2.3.3.6.4 *Benefits*

Results have indicated that the ELECTRE method provides relatively sensible and straightforward rankings (*Buchanan and Sheppard 2000*). The outranking procedure, unlike those previously discussed, allows for cost-benefit analyses. In fact, this method was successfully applied in the rankings of projects for the Paris Metro stations (*Roy et al. 1986*). That is, the user may define the ideal solution as the largest or the smallest value depending on the characteristics of a particular criterion (*Triantaphyllou 2000*). The ELECTRE method is also attractive to some decision makers because the procedure is more complicated than other procedures and requires an in depth understanding of programming language. For the less sophisticated decision maker there are various ELECTRE programs that can be purchased. A simple Google™ search returns six sites attempting to sell computer programs specifically designed to perform the ELECTRE method.

#### 2.3.3.6.5 *Limitations and criticism*

If we assume that the simplest MCDA method is always preferred when all else is equal, the ELECTRE method may be criticized for the substantial programming required. Because the ELECTRE process utilizes outranking it should not be used when there are many ties between alternatives, especially when using ELECTRE

III, which does not incorporate fuzzy inputs (e.g., preference or indifference thresholds). Other methods, such as TOPSIS are more suitable when there are many ties (*Olson 2004*).

### **2.3.3.7 Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)**

#### **2.3.3.7.1 Background and theory**

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method was developed as an alternative outranking method by Yoon and Hwang (1980). The basic concept behind TOPSIS is that the ideal solution should have the shortest distance to the ideal positive solution and the farthest distance from the ideal negative solution (*Triantaphyllou 2000*). The procedure assumes that the user can define the ideal positive and ideal negative solution for every criterion and that these values are achieved by one or more alternatives. The procedure utilizes the Euclidian distance defined in Equation 2-4. This method is best illustrated through an example.

The TOPSIS method is succinctly defined by the following steps (*Olson 2004*):

1. “Obtain performance data for  $n$  alternatives over  $k$  criteria. Raw measurements are usually standardized, converting raw measures  $x_{ij}$  into standardized measures  $s_{ij}$  .
2. “Develop a set of importance weights, for each of the criteria. The basis for these weights can be anything, but, usually, is ad hoc reflective of relative importance. Scale is not an issue if standardizing was accomplished in Step 1.
3. “Identify the ideal alternative (extreme performance on each criterion)  $s^+$ .
4. “Identify the nadir alternative (reverse extreme performance on each criterion)  $s_j^-$ .
5. “Develop a distance measure over each criterion to both ideal ( $D^+$ ) and nadir ( $D_j^-$ ).
6. “For each alternative, determine a ratio  $R$  equal to the distance to the nadir divided by the sum of the distance to the nadir and the distance to the ideal,  $R = D_j^- / (D_j^- + D^+)$ .
7. “Rank order alternatives by maximizing the ratio in Step 6.”

#### **2.3.3.7.2 Required user inputs**

The following inputs are required of the user:

- Performance of each alternative under each criterion ( $a_{ij}$ )
- Relative weights for each criterion ( $w_j$ )

### 2.3.3.7.3 Step-by-step procedure

1. User inputs are entered in matrix format (see 0).

$$\mathbf{A} = \begin{bmatrix} 25 & 20 & 15 & 30 \\ 10 & 30 & 20 & 30 \\ 30 & 25 & 30 & 10 \end{bmatrix}$$

$$\mathbf{W} = \begin{bmatrix} 0.20 & 0 & 0 & 0 \\ 0 & 0.15 & 0 & 0 \\ 0 & 0 & 0.40 & 0 \\ 0 & 0 & 0 & 0.25 \end{bmatrix}$$

2. Normalize the decision matrix A by entering each value into Equation 2-4 (see the ELECTRE method):

For example,

$$x_{11} = 25 / \text{SQRT}(25^2 + 10^2 + 30^2) = 0.62$$

Following, we get a normalized matrix A, referred to as  $A_{\text{norm}}$

$$A_{\text{norm}} = \begin{bmatrix} 0.62 & 0.46 & 0.38 & 0.69 \\ 0.25 & 0.68 & 0.51 & 0.69 \\ 0.74 & 0.57 & 0.77 & 0.23 \end{bmatrix}$$

3. A weighted matrix is created by multiplying the normalized matrix ( $A_{\text{norm}}$ ) by the weighted matrix (W). We will call this matrix D.

$$\mathbf{D} = \begin{bmatrix} 0.124 & 0.068 & 0.154 & 0.173 \\ 0.050 & 0.103 & 0.204 & 0.173 \\ 0.148 & 0.085 & 0.307 & 0.058 \end{bmatrix}$$

4. The ideal positive and ideal negative values are identified

$$\mathbf{I}_p = \begin{bmatrix} 0.148 & 0 & 0 & 0 \\ 0 & 0.103 & 0 & 0 \\ 0 & 0 & 0.307 & 0 \\ 0 & 0 & 0 & 0.173 \end{bmatrix}$$

$$I_n = \begin{bmatrix} 0.050 & 0 & 0 & 0 \\ 0 & 0.068 & 0 & 0 \\ 0 & 0 & 0.152 & 0 \\ 0 & 0 & 0 & 0.058 \end{bmatrix}$$

5. Calculate the distance of each alternative from the ideal positive solution. These values are organized in matrix E and are calculated using Equation 2-5.

$$S_i^+ = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^*)^2} \quad (2-5)$$

where:

$S_i^+$  is the Euclidian distance of a value from the ideal positive solution; and  $v_j^*$  is the ideal positive solution for a particular criterion.

$$E = \begin{bmatrix} 0.024 & 0.034 & 0.154 & 0 \\ 0.098 & 0 & 0.102 & 0 \\ 0 & 0.017 & 0 & 0.115 \end{bmatrix}$$

6. Calculate the distance of each alternative from the ideal negative solution. These values are organized in matrix F and are calculated using Equation 2-6.

$$S_i^- = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^-)^2}, \text{ for } i=1,2,3,\dots,m \quad (2-6)$$

where:

$S_i^-$  is the Euclidian distance of a value from the ideal negative solution; and  $V_j^-$  is the ideal negative solution for a particular criterion.

$$F = \begin{bmatrix} 0.074 & 0 & 0 & 0.115 \\ 0 & 0.034 & 0.052 & 0.115 \\ 0.098 & 0.017 & 0.156 & 0 \end{bmatrix}$$

7. Calculate the TOPSIS matrix through Equation 2-7 as follows. The results are displayed in matrix G.

$$C_i = S_i^- / (S_i^+ + S_i^-) \quad (2-7)$$

For example,

$$G_{11} = 0.074/(0.024+0.074) = 0.756$$

Through similar processes, we obtain matrix G as follows:

$$G = \begin{bmatrix} 0.755 & 0 & 0 & 1 \\ 0 & 1 & 0.333 & 1 \\ 1 & 0.5 & 1 & 0 \end{bmatrix}$$

#### 8. Choose the highest score by summing the rows of matrix G.

For example,

$$A_1 = 0.755+0.339+0+1 = 1.75$$

Similarly,

$$A_2 = 2.33$$

$$A_3 = 2.50$$

$$A_3 > A_2 > A_1$$

Therefore, choose alternative 3 because it demonstrates the largest distance from the ideal negative solution.

#### 2.3.3.7.4 Benefits

Although the TOPSIS method is relatively complicated from a programming standpoint, the method does not have the shortcomings associated with other methods (*Triantaphyllou and Baig 2005*; *Kujawski 2003*). That is, the TOPSIS method does not have the ranking inconsistencies of multiplicative methods, it is dimensionless, and it describes the final output as a Euclidean Distance which is intuitively satisfying. This method was originally created as an improvement to ELECTRE and it is the opinion of the authors that TOPSIS is, in fact, better. Deng et al. (2000), Triantaphyllou (2000) and Olson (2004) agree with this assertion.

#### 2.3.3.7.5 Limitations and criticism

Major legitimate criticisms of this method all involve the methodology of weighting criteria. (Note: these criticisms apply to all methods reviewed in this paper, not only TOPSIS.) For example, Deng et al. (2000) argues that no single method of obtaining weights is sufficient to guarantee an accurate weight. Other than this criticism (which applies to all MCDA methods), there are no major

criticisms found in the significant body of literature that has been reviewed for this study.

### 2.3.4 Choosing the Most Appropriate MCDA Method

The purpose of the preceding overview of methods was to evaluate the methods and to highlight their benefits and limitations. It is clear that a strategic selection of an MCDA method is largely dependent on the characteristics of the problem at hand and available data. Unfortunately, there is not an MCDA method that has been identified as superior in every case. That is to say, there is no “silver bullet.” Therefore, one must strategically match an MCDA to the specific characteristics of the problem at hand.

To aid in the selection of an MCDA method, Table 2.2 presents the limitations of each method as identified in the literature review. Please note that “relatively complicated” refers to the degree to which the method is intuitively satisfying and easy to explain. Similarly, “lack of application in literature” refers to the relative amount of literature that justifies the implementation of a particular method.

**Table 2.2: MCDA limitations**

	LIMITATION			
	One-Dimensional	Identified Ranking Inconsistencies	Relatively Complicated (i.e. “black boxy”)	Lack of Application in Literature (i.e. not “tried and true”)
<b>WSM</b>	x	x		
<b>WPM</b>		x		
<b>AHP</b>		x		
<b>Multiplicative AHP</b>				x
<b>Revised AHP</b>				
<b>ELECTRE</b>			x	x
<b>TOPSIS</b>			x	

One may view the selection of an MCDA method as a “Catch 22” in that the selection of an MCDA method is a multi-criteria problem in itself. However, selecting an MCDA method is slightly different. Instead of measuring the strength of various methods under certain criteria, methods either have characteristics or do not. For example, methods either incorporate multi-dimensional data or they do not. Therefore, the selection of an MCDA method is best completed through a simple flow chart, as shown in Figure 2.4.

As indicated, the selection of an MCDA method depends on the characteristics of the problem at hand. Take, for example, the selection of an alternative to liquidated damages in highway construction, given particular project characteristics. In this particular situation the data and decision-maker requirements have the following characteristics:

- Multi-dimensional data
- Many similarities among alternatives for a particular criteria
- The method must be easy to interpret and explain



- The method should be supported and validated by literature and implemented on many peer-reviewed research projects
- The method should not have identified ranking inconsistencies of any kind.

The following flow chart, Figure 2.4, represents a formal selection process of an MCDA method for the characteristics listed above. In this figure bold lines represent the decision path for these characteristics. One will note that much of the information contained in Figure 2.5 corresponds with Table 2.2. It is clear, when faced with complex decisions, that the desirable method under most circumstances is the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS).

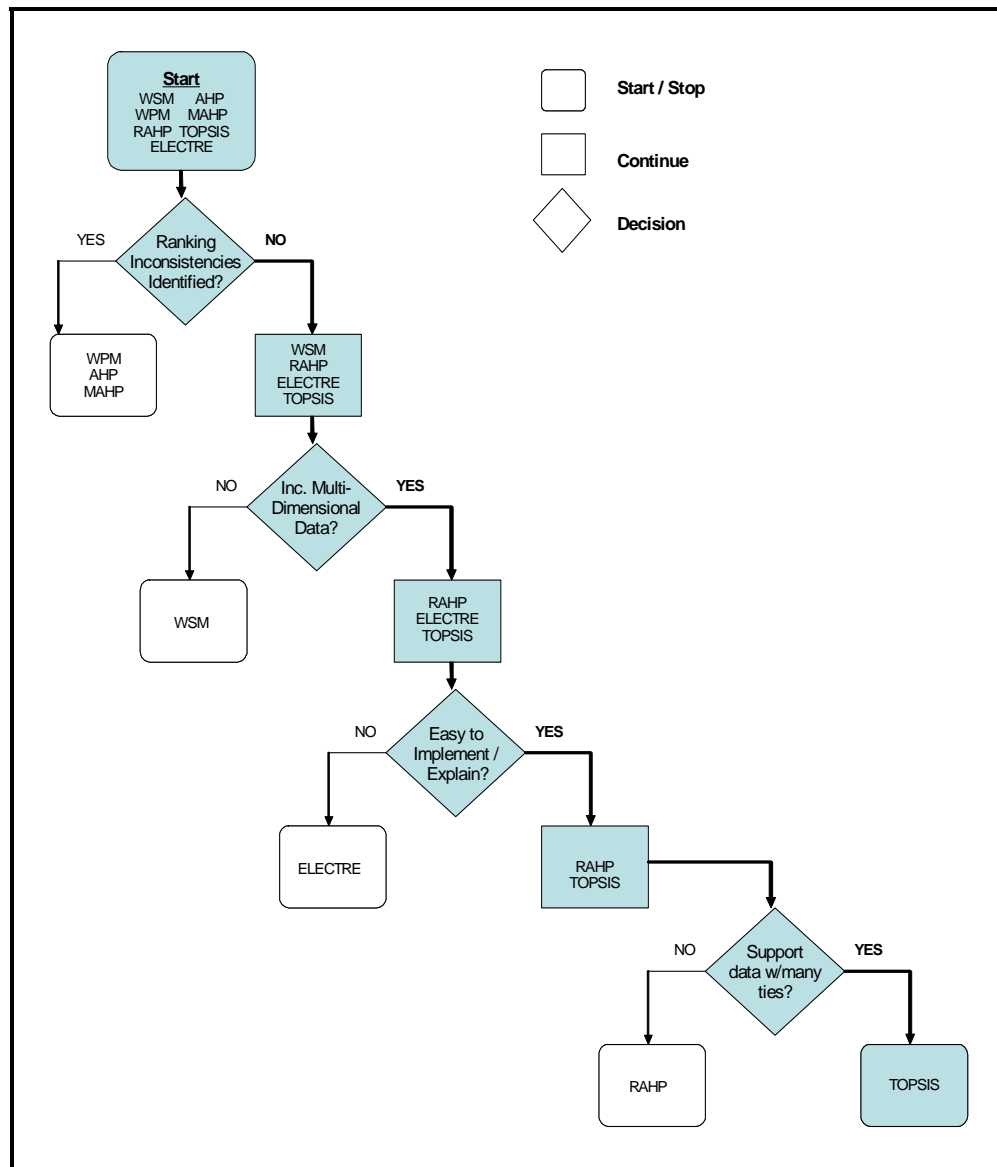


Figure 2.4: MCDA flowchart

### 2.3.5 Conclusion

Multi-Criteria Decision Analyses are effective methods for choosing among multiple alternatives, given a set of multiple, non-commensurate alternatives. These methods all commonly use distinct sets of input – a set (or array) of assessments of effectiveness of a set of methodologies toward achieving one of a set of criteria (goals) within the constraints of a project's characteristics. Evaluation of these inputs revealed an important basis of this study – that this study was focused on a single criterion, timeliness. The selection of appropriate methods to maximize timeliness depends not on mediating among goals, but on the valid establishment of the initial matrix that rates effectiveness of method against the goal.

MCDA techniques apply when simple intuition and judgment are insufficient. They are appropriate when the consequences for a poor alternative selection are high, when there are many alternatives or many criteria and when the differences between performances of the alternatives are subtle. Seven of the most well-known, validated methods were reviewed in this study. The literature review uncovered two undeniable facts: there are many distinct discrete methods for mathematically selecting among alternatives and that each of these methods have their strengths and weaknesses. Selecting the “best” method for a particular problem is a difficult task.

This report has reviewed the specific process associated with each method as well as the strengths, weaknesses and criticisms. Based on the characteristics of the study, the flow chart presented in Figure 2.1 suggested that the TOPSIS method had the most desirable balance of characteristics, given the constraints of this study. In other studies a different method may be clearly warranted. Simpler one-dimensional studies, for example, may only require the simple weighted sum method.

While much of the MCDA discussion revolves around mediating against diverse goals, and the history of MCDA has developed methods to resolve such mediation, the authors were relieved of this mediation by focusing on timeliness exclusively. This technique of focusing on one goal revealed that establishment of the initial array of effectiveness values had a significant effect on the resulting prioritization of methods. It was a goal of this project to propose a methodology and model for objective, repeatable and scalable prioritization of timeliness methods. To do so depended on consistent establishment of the initial methods/characteristics array (array “A” in Appendix A). The discussions of MCDA techniques did not establish defined methodologies for this process.

It is development of the raw input, then, that appeared to demand significant attention, and to that end, discovery of prior study into methods and project characteristics were useful to understand the problem. It is additionally noted, however, that this project focused on timeliness as the sole criterion for method selection, although ultimately it would be fully expected that any methods thus selected would need to be mediated against other goals.

## **2.4 METHODS**

### **2.4.1 Introduction**

The purpose of this section is to provide a literature review of the current alternative project delivery, project management, and contracting methods for timely delivery of construction projects. In the traditional design-bid-build method of project delivery the construction schedule risks are often (though ineffectively) addressed by incorporating liquidated damages clauses in the contract documents. This section focuses on finding and describing the different available alternatives to liquidated damages for managing schedule performance and risks in construction projects.

Liquidated damages represent a method of contractual risk transfer. Other innovative contractual methods that may reduce project duration include, but are not limited to: A+B contracts, Best Value procurement, A+C, Incentive/Disincentive (I/D) clauses, and lane rental. Additionally, there are methods of project delivery that are designed to expedite project schedules such as Design-Build, Construction Manager/General Contractor (CM-GC) and Build-Operate-Transfer. Lastly, there are project management tools that can be used to facilitate schedule adherence such as constructability review methods and prefabrication.

It must be observed that many different combinations between these methods may be applicable for the same project. This study did not cover these combinations; future research could be conducted about the possible combinations and selection of the most appropriate suite of methods.

The methods described below are organized into three categories: selection process methods, teaming methods and construction process methods. These methods will be briefly introduced, and the mechanisms by which they reduce schedule risk will be discussed.

### **2.4.2 Selection Process and Contracting Methods**

Besides liquidated damages, alternate contracting methods have proven to be fairly effective for timely completion of construction projects. Contracting methods such as A+B or Best Value affect the procurement and award of the contract. In addition; they may impact project duration, not only during the procurement phase but also during construction. For instance, when Incentive/Disincentive provisions are used, the contractor has motivation to accelerate the construction schedule.

A publication from a Transportation Research Board workshop series (2002) identifies eleven project delivery methods. The various alternatives from the TRB meetings are as follows:

Selection Process methods:

- A+B
- A + B + warranty credit
- A + B + traffic control bonus
- A + B + past performance

- A + B + warranty with performance payments
- A + B + incentive, disincentive

Contracting methods:

- Incentive/Disincentive (I/D)
- Lane Rental
- Performance incentives
- No-excuse bonus

Teaming methods:

- Design-build
- Build-operate-transfer (BOT)
- Construction Management/General Contractor (CM/GC)

This section will outline A+B contracting, Incentive/Disincentive, and lane rental—as identified in the above-referenced TRB report. In addition, A+C bidding and Best Value procurement will also be discussed. These five methods are the important alternatives to liquidated damages.

#### **2.4.2.1 A+B Contracting**

Typically, public agencies select the lowest bidder and require that the contractor maintain the stipulated end date for the project. Recently, the Federal Highway Administration (FHA) recommended that state DOTs and the USDOT adopt a method known as A+B contracting (*Herbsman et al. 1995*). Simply put, A+B contracting occurs when contractors are required to include both a cost (the “A” component) and time (the “B” component) in their bid for a project. This method is similar to the intermediate completion date bid process with a fixed start date and where the contractor has control of the completion date. Incentives and disincentives are often combined with this process.

All participating contractors are evaluated based on a Total Cost Bid (TCB) which includes the estimated construction cost (ECC) and estimated project duration (EPD).

The TCB is calculated through Equation 2-8:

$$TCB = ECC + (DRUC \times EPD) \quad (2-8)$$

The value of the daily road user cost (DRUC) is predetermined by the contracting agency and specified in the request for proposals. It is based on costs such as road user delay time, any detour costs, construction engineering costs, etc. (*FHWA Director Office of Engineering 1995*)

The “A” component of an A+B contract is the ECC, and the “B” component is the product of DRUC and EPD. The lowest TCB is typically awarded the contract. This

contracting method sets schedule at the same level of importance as budget and provides an intuitive method for combining both elements into one contract.

The formula is only used to determine the lowest bid for award and is not used to determine payment to the contractor. The contractor's estimate for the completion of critical work becomes the contract time. For projects that have high road user delay impacts, the A+B bidding method can be an effective method to significantly reduce these impacts.

After a five-year evaluation period under SEP-14, A+B bidding was declared operational on May 4, 1995 and is no longer considered to be experimental (*AASHTO Contract Administration Task Force 2001*).

According to Herbsman et al. (1995) and Shen et al. (1999), several advantages and disadvantages to the A+B method exist:

#### *2.4.2.1.1 Advantages*

- Time reduction is achieved through competition among contractors instead of strict budget estimates;
- Even when the winning bid did not include the lowest ECC, the public still benefits from A+B because of time reductions;
- The proliferation of A+B contracting requires contractors to seek methods of working more quickly and not just cheaply;
- A+B is less expensive and more effective than I/D clauses;
- It is the most economical method of all contractual alternatives;
- Due to its simplicity and success, A+B contracting has become popular with many state DOTs;
- Allows the contractor to select the best time to start a project based on weather, contractor resources and workload;
- Causes the project to take on a higher priority over other contractor work;
- Improves the pace at which a project is completed;
- Causes the contractor to estimate the job more efficiently, reducing impacts to traffic and businesses; and
- Tends to favor contractors that operate on a more efficient basis.

#### *2.4.2.1.2 Disadvantages*

- Potential problems may arise when contractors are too eager to win a project award and underestimate construction time or overestimate their capabilities;
- Quality of the work can suffer when it is not prioritized through contracting;
- Contractors may seek change orders to recover losses due to poor estimation, resulting in an adversarial relationship between the contractor and the DOT;
- More work needs to be done in creating standard guidelines for developing the DRUC;
- The exemption process can slightly increase the design costs for the project;

- The contractor has control over the completion time, and this may not be the shortest time for completion of the work;
- Unknowns to construction do have a negative impact on this process;
- The project first cost (bid proposal) may be slightly higher than the low dollar bid, and the lowest bid may not be the successful bid based upon time; and
- Owner still controls the start time but does not control the final completion time for the project (*Riedl 2005*).

Strong et al. (2007), confirmed in their paper the suggestions of prior research that the use of A + B contracts leads to shorter project duration. In their study they performed a national survey of state DOTs and concluded that A+B is the most effective means of contracting when compared with the traditional contracting approach, lane rental and design-build. According to Strong, A+B should not only be used for projects with high road user costs but should be considered for all projects regardless of project type or critical performance factors.

In light of the previously mentioned advantages and disadvantages it is clear that A+B contracting may serve as a reasonable alternative to liquidated damages. However, state highway agencies must be cognizant of the contractor capabilities and recognize potential estimation problems, especially when A+B contracting is originally introduced to a geographical region.

#### **2.4.2.2 Incentive/Disincentive (I/D)**

In 1989, the FHWA issued Technical Advisory T5080.10, “Incentive/Disincentive (I/D) for early completion,” the purpose of which was “to provide guidance for the development and administration of incentive/disincentive provisions for early completion on highway construction projects or designated phase(s)” (*FHWA 1989*). An incentive/disincentive provision was defined in the Advisory as “a contract provision which compensates the contractor a certain amount of money for each day identified critical work is completed ahead of schedule and assesses a deduction for each day the contractor overruns the I/D time.”

Incentive/Disincentive provisions have been used in two different alternative methods of delivery: I/D only and A+B+I/D. Each of these methods has been found to be successful in reducing construction time to some degree (*Herbsman 1995*).

The I/D only method has been under experimentation for a long time. It is often the low-price method with the inclusion of I/D clauses. It is a system in which a contractor is motivated to accelerate construction after the bid has been awarded. This method has been used on numerous occasions by state highway agencies (SHAs); however, many practitioners are not very pleased with past results (*Herbsman et al. 1995*). Some advantages and disadvantages identified by Herbsman et al. (1995) include the following:

#### 2.4.2.2.1 *Advantages*

- Tends to achieve construction time reduction in most of the projects that use this contracting approach.
- Gives SHAs the flexibility to adjust their financial exposure by utilizing a flat rate or percentage caps for I/D fees.
- Encourages compliance to required completion times for work.
- Provides the contractor with an economic incentive to offset added costs for swing shift and overtime.
- Does not necessarily force the contractor to use overtime, thereby encouraging more efficient bid pricing prior to start of construction.
- Improves the pace towards sooner project completion
- When compared with the A+B method, the I/D approach is believed to have a much less adversarial relationship between owner and contractor. This is apparently related to the fact that the contractor may receive some amount of incentive payments.

#### 2.4.2.2.2 *Disadvantages*

- The fees are usually based on the engineer's estimates, as established by the SHA. Transportation departments usually define contract time based on the performance of the average contractor. This practice creates a situation whereby a good competitive contractor can reduce contract time with little or no additional commitment of resources.
- This tool complicates the changes and claims processes – requires the contractor to accelerate work when weather impacts are encountered. The disincentive establishes an automatic “cost to the contractor” if the project is delayed.
- The contractor has control over the start time, which may not be the best time for the SHA to manage the work. Owner still controls the final completion date but does not control the start time for the project.

According to Strong et al. (2007), A+B contracting is frequently coupled with I/D clauses, although A+B awards can be made without I/D clauses, and I/D clauses can be used with any contract type. I/D amounts can be based on estimates of such items as traffic safety, risks, maintenance of traffic costs, or road user delay costs.

In their research for the Oregon Department of Transportation, Sillars and Armijos Leray (2006) consolidated diverse guidelines for implementing an Incentive/Disincentive contracting process to be used by state highway agencies (SHAs) and proposed a holistic methodology for developing I/D projects. The implementation process included the identification of goals and needs in accelerating project schedule, evaluation of those projects with I/D criteria, selection of type of contract, incentive type, implementation of a risk management process, determination of key parameters, preparation of specifications, contract administration and evaluation process (Sillars and Armijos Leray 2006).

### 2.4.2.3 Lane Rental

The Lane Rental method specifies the dollar per time unit rate that is charged for the contractor's use of a traffic lane through traffic closures. The lane rental rate is placed in the specifications and charged to the contractor for the use of those traffic lanes over time. Lane rentals are established on the basis of the time that contractors take over the use of one or several lanes.

Generally the rate is established by determining road user costs for the highway. The time element can be increments of days, hours, quarter hours or less if needed. Lane rental is similar to the "A + B with incentive" bid process with float time between lane closures and without the need for the extensive exemption process. The contractor reduces his schedule to best performance without schedule compression and with minimal impact to traffic (*Riedl 2005*).

Originally introduced in the United Kingdom, lane rental has only recently become popular with state DOT's (*BDTP 1989*). The original form of lane rental in the United Kingdom was the bonus/rental charge. In this method, the bidding contractor estimates the time needed for lane closure and includes this cost (based on lane rental fees) into the bid. The lowest bidder is determined by the lowest combination of the cost of work items plus the cost of lane rental. If the contractor overruns the time estimate, the rental fee will be deducted, or charged to the contractor, and if ahead of schedule, a bonus (incentive) is received for work completed early (*Herbsman et al. 1995; Herbsman and Glagola 1998*).

In order to avoid the payment of excessive lane closure fees, the contractor will strive to minimize construction work during the peak traffic hours. The productivity of the contractor during lane closure periods would be maximized in an effort to pay the lowest fees possible. *Herbsman et al. (1995)*, argue that the net effect of Lane Rental is a substantial reduction to the normal traffic flow. The lane-rental appears to favor the more efficient firms who are able to provide careful thought for work planning.

There are several advantages and disadvantages to the lane rental method as follows:

#### 2.4.2.3.1 Advantages

- Contractors better manage work and material deliveries, thus maximizing productivity and minimizing lane closure in an effort to pay the lowest fee possible (*Bondar 1988*).
- In the UK, the average reduction in construction duration was approximately 25 percent (*Srinivasan and Harris 1991*).
- This method allows the contractor to choose the best work patterns for construction, and the contractors are highly motivated to reduce construction time (*Herbsman et al. 1995*).
- This method causes the contractor to estimate the job more efficiently to reduce the rental costs. In executing the work, if the contractor can find



additional ways to reduce the time actually needed to complete the work, he then receives a bonus for the reduced time impacting the public (*Riedl 2005*).

- Lane rentals work very well where there is a need to reduce lane closure impacts in a low-price process and where there is activity float time that can be captured in the schedule.
- Lane rentals are relatively easy to place into a specification and use (*Riedl 2005*).

#### 2.4.2.3.2 *Disadvantages*

- There is a tendency for contractors to cut corners when faced with the possibility of unanticipated lane closures (*BDTP 1989*).
- This method could lead to poor quality and adversarial contractor - DOT relationships (*Herbsman et al. 1995*).
- The contractor has control over the time compression for work, and advancing of schedules is left to the contractor's work efficiencies and resources. The Owner still controls the final completion date but does not control the time compression for the project.
- Lane rentals can support schedule compressions but do not force the advancing of schedules.
- Where projects require compressed schedules and mandatory completion times, the use of lane rentals by itself cannot guarantee that the schedule will be met, and other tools will be needed to support the lane rental process.
- The contractor has control over the time compression for work, and advancing of schedules is left to the contractor's work efficiencies and resources. The Owner still controls the final completion date but does not control the time compression for the project (*Riedl 2005*).

Lane rental fees are a very reasonable method of schedule risk transfer. Instead of assigning liquidated damages, the lane rental procedure requires the contractor to pay the public a fee for actual losses sustained. This method essentially reduces loss associated with lane closures for the general public. The intention with lane rental is not to reduce the overall contract time, but instead to focus on the time that the public is impacted. In recent years lane rental has become increasingly popular with state DOTs.

#### 2.4.2.4 *A + C Bidding*

This method is a procurement process that includes special work experience as a component in the selection process of the contractor for a project. In addition to the bid amount, the contractor's expertise described in the contractor's proposal is used in a scoring process to determine the best value contractor. An incentive/disincentive may also be used with this process. The disincentive may be applied as a separate element in addition to liquidated damages.

This method can also be seen as a special case within another innovative method known as Best Value contracting. In fact, this bid process is intended to provide the "best value"

of cost and expertise for completion of a project. An exemption to the normal bid process is required for this style of bidding.

This selection method is used to allow the contractor to submit a proposal on a project based on the contractor's selection of best-qualified trade workers, subcontractors and best cost. When special skills and expertise become a cost element in the proposal process, the contractor must put an emphasis on providing the highest level of skill at the best price to perform the work in the most efficient manner possible. The contractor with the highest skilled set of tradesmen and subcontractors along with the best price is selected for the work. Even though this is not a method per se for schedule compression, the fact that the trades of the contractor are carefully selected implies that fewer mistakes will be made, the amount of rework will be reduced, and the schedule of the project will benefit from the experience and productivity of the labor.

After the contract is awarded, the Department of Transportation (DOT) realizes a second benefit in that the DOT already knows the strengths and weaknesses of the contractor and subcontractors for the work. This information allows the DOT to take additional steps to ensure that the necessary level of skill is provided prior to awarding the contract. This procurement method is used for most work categories. This tool is similar to the contractor prequalification on categories of work with an emphasis on the level of skill that a contractor is willing to commit to a project.

#### *2.4.2.4.1 Advantages:*

- Allows the contractor to select the best qualified workers at the best value for a project based on contractors' skills, resources and workload;
- Causes the project to take on a higher priority over other contractor work;
- Improves the quality of work in a project;
- Causes the contractor to estimate the job using the highest skills at the best price; and
- Tends to favor contractors who maintain a higher level of skilled staff and who operate on a more efficient basis at prices lower than the highest prices.

#### *2.4.2.4.2 Disadvantages:*

- The exemption process slightly increases the administrative time and costs for the project.
- The contractor has control over the quality of the work.
- Unknowns to construction do have a negative impact on this process.
- The project first cost (bid proposal) may be slightly higher than the low dollar bid, and the lowest bid may not be successful, based upon the skill level provided.

As described in the next section, A+B and A+C procurement can be viewed as variations of an all-inclusive method known as Best Value procurement. They have been outlined by themselves in this paper because of their extensive use and importance as alternative

methods. The over-arching category of Best Value procurement includes additional methods which may involve parameters not found in A+B and A+C procurements.

#### **2.4.2.5 Best Value**

Best Value is essentially a method of procurement that encompasses diverse criteria for pre-qualification, post-qualification, A+B bidding, multi-parameter bidding, bid alternates and extended warranties. Besides costs, the Best Value method for awarding contracts includes factors such as time, quality, past project performance and experience of the contractor.

Gransberg et al. (2007) have defined the Best Value parameters based on a study of the evaluation criteria, evaluation rating systems and award algorithms. These parameters define individual elements, which can be combined to create an appropriate best-value definition, evaluation and award (*GransBerg et al. 2007*). The following parameters were identified:

##### **Best Value Parameters**

- Cost: Bid Cost, Life-cycle cost
- Time: Schedule, Lane Rental, Traffic Control
- Qualifications/Performance: Prequalification, Past project performance, Key personnel experience, Subcontractor information, Project Management Plans
- Quality: Warranty, Warranty Credit, Quality Parameter measured with % in limits, Quality Parameter using performance indicator, Quality Management Plans
- Design Alternates: Design with Bid Alternate, Design-Build with Performance Specifications

Best Value procurement may include combinations of two or more of the above parameters. From their case studies, Gransberg et al. (2007) found that Cost and Qualifications criteria are the most heavily used parameters in all types of Best Value contracts.

Gransberg et al. (2007) claimed that as the project complexity increases, the complexity of the evaluation rating systems also increases to accommodate multiple competing objectives within a given project. They argued that each project will have a rating system that is best suited for its particular needs, and that an agency's attempt to standardize rating systems for all projects may not be a wise decision.

The final award is based on a Best Value Award Algorithm. This algorithm allows the agency to define the procedure for combining parameters, evaluation criteria and evaluation rating systems into a final award recommendation. From their literature review, Gransberg et al. (2007) suggested seven different algorithms for Best Value award.

Some of the advantages and disadvantages of Best Value as identified by the NCHRP Report 451 are outlined below (*Anderson and Russell 2001*):

#### *2.4.2.5.1 Advantages*

- Best Value allows for contractor innovation to improve quality, encourages effective quality control measures, and assures the agency of selecting a capable, qualified contractor.
- Reduction of project completion time: Schedule is often evaluated in Best Value proposals, resulting in more efficient well-planned construction schedules and also making the schedule a competitive item.

#### *2.4.2.5.2 Disadvantages*

- The number of contractors in a position to bid on a Best Value project may be smaller than in a traditional project. This may be due to the complexity of the required proposal, the stringent qualification process, or the complexity of the project itself.
- The agency resources required on a Best Value project increase during the writing of the Request for Proposals/Qualifications and during the evaluation of proposals. (Some agencies argue, however, that personnel requirements are often reduced during construction, because a Best Value project is better planned and executed than a traditional project.)

#### *2.4.2.6 Contractual alternatives summary*

The five contractual alternatives to liquidated damages presented in this section represent the most frequently used alternatives cited by the literature. While each of these methods has limitations, they have all been embraced to some degree by state DOTs in the U.S. and by other countries such as the United Kingdom and China. Each of these methods may be considered as an appropriate alternative to liquidated damages, depending on the nature of the project.

### **2.4.3 Teaming Methods**

Traditionally highway construction projects have been delivered with separate contracts with the designer and the contractor. This method, known as Design-Bid-Build (DBB), is both linear and compartmentalized. That is, the design phase is completed in its entirety, the construction project is bid, and a contractor builds the facility per the contract documents. This project delivery method impedes the integration of design and construction because it fragments the delivery process. DBB delivery separates the designer from the constructor and effectively removes incentives for the designer to create a constructible design. The result is unnecessarily long construction durations.

Alternative methods of project delivery, including Design-Build (DB) and CM/GC (CM-at-Risk), have recently gained momentum. These methods integrate the design and construction phases, thereby removing some of the issues inherent in the structure of DBB project delivery. DB project delivery involves a single contract between the Owner and a firm that is responsible for both design and construction. CM/GC contracting involves an increased scope of work for the general contractor where the contractor provides constructability advice during the design

phase. Both of these methods will be discussed in detail. In addition, a relatively new alternative approach in the U.S., referred to as Build-Operate-Transfer (BOT) is being more used by DOTs.

#### **2.4.3.1 Design-Build**

As previously mentioned, the design-bid-build project delivery method can be a significant barrier to schedule success. Fortunately, a new project delivery method, Design-Build, has gained popularity in recent decades. Relative to the traditional Design-Bid-Build, this method is structured to expedite project schedules.

A Design-Build project is characterized by the overlap in the design and construction phases. In this arrangement the builder and the designer have the same project goals and work concurrently. Furthermore, the construction phase can begin before the design phase has been completed. Thus the entire project duration is reduced. This arrangement may improve schedule performance in the following three ways:

- Elimination of an adversarial relationship between designer and builder;
- Designers consult with constructors in the design phase to improve constructability; and
- Designers and constructors both have a vested interest in the safety and health of workers.

Relative to DBB delivery, Design-Build projects achieve far superior schedule performance. Therefore, issuing Design-Build contracts may be seen as an alternative to liquidated damages. While not contractual, Design-Build projects are likely to achieve the same goals as liquidated damages: a project with few or no delays in construction schedule. Additionally, Design-Build projects also may decrease the total project duration because of the phase overlap.

#### **2.4.3.2 Build-Operate-Transfer (BOT)**

Since they have limited budgets, state highway agencies are becoming more and more interested in the possibility of promoting private funding to satisfy public demand for infrastructure development. For this purpose, concession contracts, also known as BOT (Build, Operate, Transfer) contracts, are being used more and more frequently as an alternative project delivery method. BOT contracts are part of a larger teaming concept called Public/Private Partnerships (PPPs).

Originating in the U.K., BOT contracts were conceived in an effort to develop infrastructure projects when large amounts of public funds are unavailable (*Franks 1998*). Also, most of the major infrastructure projects built in Hong Kong have utilized BOT contracting procedures. BOT contracts were seen as especially effective for underground rail projects (*Lee and Shen 1998*). In addition, highway and bridge projects have become a common type of project for which the BOT method of delivery is used.

In the BOT procurement system several investors typically form a consortium which provides funds for the construction of an infrastructure project. This consortium, also

known as the project promoter, funds construction and operates the completed project for a specified period of time on behalf of the public agency. According to Shen and Li (2002), in the BOT arrangement the funding consortium typically builds and operates the project for a stipulated period then transfers ownership of the project to the DOT.

The investors benefit from this contractual method because it gives the consortium monopoly power during a concession. During the concession period the consortium collects revenues from the users through tolls or tariffs in order to repay the costs to finance, build, maintain, and operate the facility and also to make a profit.

The owner agency benefits because the use of private funds allows the government to build more projects while using fewer public funds. The public sector wants to maximize social welfare by transferring the project's risks to the private entity; however, the investment risks should be reduced to acceptable levels so that the project is of interest for the private company. On the other hand, private companies want to know if they would be able to handle the risks involved in the concession agreement and still make a profit. It is very important to understand how to deal with the risks involved in BOT contracts not only to be able to allocate them efficiently, but also to establish adequate management measures to guarantee that the interests of the involved parties are protected.

This contracting method is useful for expediting projects because of the benefits to the funding consortium. When the construction phase of the project is completed earlier, the consortium receives compensation from extended use. The consortium is motivated to accelerate the construction process in order to start collecting revenues. This means a longer operation period and more revenues for the private firm.

#### **2.4.3.3 CM/GC**

Another emerging alternative project delivery method is CM/GC, or Construction Management/General Contractor. This method, also known as CM-GMP (CM-Guaranteed Maximum Price) or CM-At-Risk, evolved initially as a consultant-like service to provide construction level input during the design phase. With time, builders began to offer these services as an integrated package with the actual construction through contracts that provided pre-construction consulting with a Guaranteed Maximum Price to perform the construction.

According to Baker and Barsotti (2004) CM/GC has the same basic structure as Design-Bid-Build except for the timing of the award of the construction contract and the scope of work for the builder. Unlike Design-Bid-Build, the construction contract is awarded during the design phase with the intention of gaining construction expertise during design. This method is likely to increase the frequency and quality of constructability reviews. Improvement in construction schedule performance is expected as a direct result from the increased focus on constructability.

The CM/GC contract is, in essence, a cost-plus-fee contract with a guaranteed maximum price (GMP). It is the sum of the CM's (Construction Manager's) fee, the CM's contingency, the General Conditions Construction, all of the subcontracts, and an

estimate for unbid subcontracts (*Minchin Jr and Thakkar 2007*). Under this method the CM has agreed to pay the costs exceeding the GMP that are not a result of changes in the contract documents.

According to Clough and Sears (2000), the team approach created by the CM-at-Risk offers the owner the advantages of time savings, cost control and improved quality (*Clough and Sears 2000*). The owner/agency understanding of project requirements, the wisdom, experience, and technical expertise of architect-engineer and CM firms are combined (*Minchin Jr and Thakkar 2007*).

The advantages of this method are indicated by the non-adversarial relationship between the parties. The input of the CM during the review of the plans may prevent constructability issues or other errors, and the engineer may provide constructive recommendations to the CM. Minchin and Thakkar state that the CM-At-Risk procedure affords the owner more control over design than the Design-Build approach because the AE is under a separate contract with the Owner instead of being part of a joint venture with the contractors as is the case in Design-Build.

## **2.4.4 Construction Process Tools**

This section reviews two methods of project management that have been cited by the literature as effective strategies for ensuring schedule performance and reducing schedule risk. These two methods are largely Owner-controlled and both involve strategies that must be implemented during the design phase. First, constructability reviews will be highlighted. Several sections of this report have alluded to the importance of constructability reviews. This section will shed more light on the topic. A second method, prefabrication, will also be reviewed.

### **2.4.4.1 Constructability Reviews**

The Transportation Research Board meeting notes (*TRB 2002*) provide anecdotal evidence for the use of constructability reviews and constructability teams as a method of reducing construction schedule risk. TRB members strongly believed that efforts to ensure constructability should allow for feedback on design elements that significantly affect time or quality during actual construction. The authors offered the following best-practices for using constructability reviews to improve construction budget and schedule performance (*TRB 2002*):

- Conduct an intensive utility survey to minimize the risk by both the DOT and the contractor. If possible, the parties should consider hiring an outside entity (not the DOT or the contractor) to conduct and manage the utility work. If possible, develop ways that the contractor can be involved in moving the utilities.
- Develop a collaboration process where the contractor, utilities, ROW, designers DOT construction engineers, and local agencies work together to resolve potential issues during construction. This could help minimize any misunderstandings and expedite the change approval process.

- The DOT should consider designer incentives for improved constructability performance. For example, it is possible to pay the designer in phases on the basis of the quality of design, including appropriate incentive fees.
- To improve creativity, innovation and constructability, it was also suggested that the value engineering reward level be increased above the 50–50 split and include more incentive for time-based solutions.
- Investigate all the night work issues, including local noise ordinances, and seek alternatives. The DOT also could ensure special considerations for worker and public safety. To minimize night work, the DOT could allow as much material access as possible during the day to eliminate night work.
- Investigate all processes and materials that have weather restrictions and look for rational alternatives.
- Evaluate the delivery time and availability of materials before specifying the design. This reduces the risk associated with material delivery delays. Alternative materials should be considered in times of decreased availability unless necessary to complete the work.
- Optimize standardization to improve construction productivity.

Simply put, constructability review involves the up-front consideration of construction means, methods and issues during the design phase. If identified early, potential problems can be removed through design thereby reducing the risk of schedule delays. This process, when implemented effectively may improve productivity, standardization and predictability, thereby decreasing schedule risk and improving schedule performance. Therefore, this method should be seen as a viable alternative to liquidated damages or at least considered in combination with liquidated damages or other contractual methods.

#### ***2.4.4.2 Prefabrication***

In a case study of a bridge project in Ohio, Salem et al. (2006) found that prefabrication greatly contributed to the speed of construction. The increased use of prefabrication in the building construction industry has also resulted in a positive impact on schedule performance. It is intuitively apparent that prefabrication serves as an excellent method of expediting project schedule. When units are constructed off-site before the construction phase or early in it, the units may be delivered at the exact time that they are needed. Also, the time required to construct the units is dramatically reduced when the units are ordered during the design phase and when they are constructed in a controlled and standardized plant.

The Ohio DOT recognized the positive impact of including prefabricated units in their bridge construction because of a limited availability of contractors that were capable of post-tensioning. Prefabricators in the area were capable of post-tensioning their units, thereby improving reliability, quality and speed. The Ohio DOT feared that soon post-tension construction will be limited by the availability of contractors. Therefore, the best alternative was prefabricated units. These units can be constructed with high levels of quality, quickly and cheaply.



Due to the positive benefits on construction schedule it is suggested that prefabrication may be used as a method of construction schedule risk management. The standardization processes and experience with the Ohio DOT lead one to believe that prefabrication reduces uncertainty related to the actual construction times of specific units of a project. Therefore, this method, like constructability review, may be useful in improving construction schedule performance.

## **2.4.5 Other Alternate Methods used at ODOT**

### ***2.4.5.1 Work Sequence Requirements***

Work Sequence Requirements is a description placed within section 108.40a, Limitation of Operations for the Oregon Department of Transportation, for certain activities that must occur in a sequence or set of sequences. Multiple sets of sequences may be used on a single project. This tool is not used to specify the method for contractor work.

The method's purpose is to identify the required sets of work sequences and to provide the contractor with required methodologies he will use to complete the work. This is related to Limited On-Site processes (see below) but does not specify the exact time for completion of specific types of work.

#### *2.4.5.1.1 Advantages:*

- Informs contractor of required specific sequences of work;
- Used as a communication tool to integrate contractor's work with other pieces of work that may be performed by the contractor or other contractors on the project;
- Causes the contractor to estimate the job more efficiently to reduce the interference with other contractors; and
- Work Sequence Requirements are relatively easy to place into a specification and use.

#### *2.4.5.1.2 Disadvantages:*

- The contractor has control over the sequence and timing of his operations and may select other methods for completing the work.
- The schedule for completion is under contractor control, and time compression for work and advancing of schedules is left to the contractor's work efficiencies and resources.
- The owner maintains control of the final completion date but does not control the time compression for the project. Work Sequence Requirements can support schedule compressions but do not force the advancing of schedules.
- Where projects require compressed schedules and mandatory completion times, the use of Work Sequence Requirements will not guarantee that the schedule will be met; other tools will be needed to support the project completion.

#### **2.4.5.2 Intermediate Completions – Single and Multiple**

The Intermediate Completions method is used in establishing intermediate completion times within the schedule and defines these completion times in the project specifications. Single and multiple completions may be used. Completion times may be segments of work following each other and may also be segments of work embedded within larger segments of work that also have intermediate completion times.

The method's purpose is to identify segments of work within the total project schedule that have required completion dates. Dates are generally identified as calendar dates for completion. This tool is similar to the Limited On-Site (LOS) process discussed below but leaves control of the work and schedule in ODOT's hands. The contractor provides its best performance within schedule requirements. Incentives/disincentives are often used with intermediate completions.

##### **2.4.5.2.1 Advantages:**

- Identifies specific dates required for completion of segments of work;
- Communicates to the contractor certain critical work time requirements for project completion;
- Assists in coordinating activities of the prime contractor with those of utility and other contractors for the project; may or may not have a cost impact to the project, depending on the level of overtime needed and resources available to the contractor;
- Causes the contractor to estimate the job more efficiently to maintain a competitive bid;
- Causes the contractor to prioritize field production work to give this project priority over other projects that the contractor may have ongoing at the same time as this project;
- Incentive/disincentives are an important additional tool used to make this tool effective – the contractor is rewarded for earlier performance and penalized for late performance in addition to liquidated damages; and
- Intermediate Completions are relatively easy to place into a specification and use.

##### **2.4.5.2.2 Disadvantages:**

- When used with liquidated damages only, this tool is not easily enforced.
- Even with the use of this tool the contractor will have split interests between this and other projects and may not provide the highest level of priority to the project without incentive/disincentives.
- The contractor has control over the time compression for work, and advancing of schedules is under its control.
- Unknown conditions can affect the intermediate completion date.
- The Owner still controls the final completion date and the time compression for the project. Where projects require compressed schedules and mandatory

completion times, the use of Intermediate Completions cannot guarantee that the schedule will be met.

- Hyper-critical project schedules will require the use of other tools in combination with this tool.

#### **2.4.5.3 Limited On-Site (LOS)**

The Limited On-Site (LOS) method is a “schedule within a schedule” concept that has been used by the Oregon Department of Transportation. ODOT identifies a season for the work completion, and the contractor selects the start date for that work. Once mobilized, the contractor is not allowed to leave the site until the work is complete. In no case shall the contractor start later than the minimum days specified by ODOT prior to the final completion date.

This process allows the contractor to mobilize at his most advantageous time to complete the work and eliminates the possibility for multiple mobilizations and slow work progress. ODOT specifies the number of days allowed for the work within the season and the final completion date. This tool is generally used for paving work that is impacted by early season weather and fluctuating demands for resources from other projects.

This tool is similar to the Intermediate Completion date bid process with floating start times for the contractor. Multiple LOSs may be used in a single project.

##### **2.4.5.3.1 Advantages:**

- Allows the contractor to select the best time to start a project based on weather, contractor resources and workload;
- Reduces the inspection times on a project;
- Improves the pace for which a project is completed;
- Allows more competitive bidding, as the contractor selects his best time to start;
- Causes the contractor to estimate the job more efficiently to reduce the rental costs; this rewards the contractor with a competitive advantage at bid; and
- Limited On-Site is relatively easy to place into a specification and use.

##### **2.4.5.3.2 Disadvantages:**

- The contractor has control over the start time, and this may not be the best time for ODOT to manage the work.
- LOS does not accommodate needs for time compression for work and advancing of schedules, which is left to the contractor’s work efficiencies and resources.
- ODOT still controls the final completion date but does not control the start time for the project.
- LOS does not force the advancing of schedules.

#### **2.4.5.4 Restricted Flagging Hours**

Restricted Flagging Hours are used on hyper-critical schedules generally with day and night flagging to enforce the time limit allowed for a lane shut down. The method is a cap on the number of flagging hours that will be allowed by ODOT for a specific detour or other defined piece of work. Any additional flagging costs act as a medium level disincentive to the contractor to encourage efficient completion of work and the reopening of traffic lanes.

This tool is similar to incentive/disincentives and lane rentals, but without the incentive portion, as the contractor will get no reward for early completion of work. Its common use is for 24-hours/7-days-per-week road closures to encourage rapid completion of the work.

##### **2.4.5.4.1 Advantages:**

- This tool is a form of disincentive with a fixed completion time that places an additional penalty on the contractor for not meeting a critical completion time.
- The money the contractor puts into its bid for the rental is subsequently deducted as the lanes are closed and then re-opened.
- This method causes the contractor to estimate the job more efficiently to reduce the rental costs; this rewards the contractor with a competitive advantage at bid.
- In executing the work, if the contractor can find additional ways to reduce the time actually needed to complete the work, it then receives a bonus for the reduced time impacting the public.
- This method works very well where there is activity float time that can be captured in the schedule.

##### **2.4.5.4.2 Disadvantages:**

- The contractor has control over the time compression for work, and advancing of schedules is left to the contractor's work efficiencies and resources.
- This tool can complicate changes when the contractor is delayed through no fault of the contractor. The Owner still controls the final completion date but does not control the time compression for the project.

## **2.5 CHARACTERISTICS**

### **2.5.1 Introduction**

Today's construction industry is becoming increasingly concerned with the schedule performance of construction projects. Departments of Transportation (DOTs), politicians, and economists have realized the severe implications of schedule overruns (*Hulett 1995*). Historically, construction project performance was thought to be measured by cost, schedule and quality. However, Laufer and Tucker (1987) noted that schedule performance has become the

primary focus of the construction industry because of pressure from Owner agencies that have recognized the negative impacts of delays on resource allocation, cash-flow and time-to-market. Therefore, contractors have become increasingly pressured to complete projects in record time (*Kog et al. 1999*). Simply put, contractors are often evaluated first on schedule performance, and budget and quality are now secondary criteria.

In order to ensure that contractors will achieve planned schedule goals, many owner agencies have pursued controls to reduce risk associated with construction duration. In some cases, Owners even seek to accelerate work once the construction phase is underway. Construction acceleration is said to occur when work is accelerated to speed the progress in excess of original schedule (*Raid et al. 1994*). While construction acceleration is common, many Owners take measures before construction takes place in order to reduce schedule risks. Such methods include liquidated damages, A+B contracts and Design-Build project delivery. Despite efforts, there are project-specific characteristics that may limit the effectiveness of construction acceleration and management methods.

Many characteristics of construction projects inhibit or facilitate the adherence to construction schedule goals. While some factors depend on the decisions of the construction team, others may be identified before construction begins. Understanding the impact of these characteristics on schedule performance is vital to planning and risk management. Effective project delivery requires the consideration of these factors and their interaction with Owner-directed risk management and project acceleration methods.

This study explored literature related to characteristics that influence schedule performance and methods of schedule control that may be taken by owner agencies. Characteristics of projects that can be identified before the construction phase begins will be examined in this section. Additionally, controls and risk management methods that may be implemented before or during the development of a construction contract will be reviewed.

## **2.5.2 Project Characteristics**

According to Mulholland and Christian (1999), the characteristics of the internal and external project environments are important factors in determining whether there will be a schedule overrun. Such factors may be linked to the physical site, socioeconomic climate or design. Physical site characteristics may include traffic volume or ecological impact; socioeconomic factors may include politics or right-of-way acquisition; and design factors may include overall complexity and utility work. Additionally, there are some construction process characteristics that can often only be measured as the construction phase nears. While not the focus of this study, these factors are worth mentioning. The following section of this report is divided into four main segments as follows:

### Physical site characteristics

- Climatic and seasonal conditions
- Environmental complexity
- Noise restrictions
- Stochastic events

- Traffic volume

#### Socioeconomic and political characteristics

- Political sensitivity
- Safety concerns
- Right-of-way acquisition

#### Design characteristics

- Design complexity
- Constructability
- Utility work

#### Construction process characteristics

- Project management
- Equipment
- Shipment delays
- Conflict among project participants

##### ***2.5.2.1 Physical site characteristics***

As previously mentioned, physical site characteristics may influence schedule performance. On a typical project, many of these factors may be identified before the construction contract is drafted (*Mulholland and Christian 1999*). While there is always some degree of uncertainty related to the physical worksite, an individual who is familiar with the geographical region and the particular stretch of roadway may be able to identify schedule-related risks using professional judgment. Additionally, documents and data from previous work in this or a similar physical site may provide guidance.

While there are likely to be thousands of physical factors that influence schedule, the literature has noted five important physical factors that will be summarized here. These factors include climatic and seasonal conditions, environmental complexity, noise restrictions, stochastic events and traffic volume. These five characteristics have been discussed in the literature as physical factors that can be identified before the construction phase and may negatively impact highway construction schedules.

##### ***2.5.2.1.1 Climatic and seasonal conditions***

According to Iyer and Jha (2006), extreme climatic conditions such as unexpected storms take a heavy toll on the efficiency and productivity of the work and may cause difficulties in mobilizing the resources in time. Furthermore, if the size of the project is large, as is typical with highway construction, time overrun is likely. While harsh climatic conditions are not likely in the lower elevations of the Pacific Northwest, a major storm at higher elevations could result in a large,

negative impact on project performance(s). Rain is perhaps more of a concern at the lower elevations.

Rain can result in significant delays in project schedule and, according to El-Rayes and Moselhi (2001), highway construction operations are especially susceptible. A study of the Ohio Department of Transportation found that delays due to rain were common (Salem *et al.* 2006). Contractors reported substantial reductions in productivity on days when rain was heavy. The delay of construction schedule due to rain depends on the nature of that activity and the severity of the weather conditions (Hassanein and Moshelhi 2004). When severe, inclement weather can result in significant productivity losses and in some cases will halt operations altogether (El-Rayes and Moselhi 2001).

#### 2.5.2.1.2 *Environmental complexity*

For the purpose of this report environmental complexity refers to the extent to which ecological and archaeological factors negatively impact construction duration. Environmental factors may include permitting, actions taken to preserve local ecosystems during construction, and delays due to archaeological findings. While most ecological requirements are typically identified before the bidding phase, some unexpected issues with permitting may result during the construction phase. These factors can delay or even halt construction, depending on the nature of the activity and the impact to the environment (Sukumaran *et al.* 2006). The Oregon Department of Transportation specifically recognizes the potential impact of riparian and other water-based ecological risks. Likewise, Forkenbrock *et al.* (1990) have noted that archaeological issues can be especially problematic when dealing with subsurface utility work. Although rare, archaeological findings can cause extraordinary delays to highway projects.

#### 2.5.2.1.3 *Noise restrictions*

Noise restrictions was noted by many researchers as a factor that can delay projects, especially when projects have been fast-tracked or accelerated, or when events require the contractor to play “catch-up” (Amekudzi and Meyer 2005; FHWA 2006; Salem *et al.* 2006). When noise is not discussed with residents, business owners and other stakeholders, they may voice strong opposition, resulting in delays (FHWA 2006). Similar problems can also arise when construction projects deviate from planned work times, even when noise has been discussed with residents prior to construction. A study conducted by Salem *et al.* (2006) described a project in Ohio where noise ordinances prevented a contractor from working extended schedules, resulting in substantial delays even when planned schedule estimates were slightly high. That is, small increases in the schedule compounded, because the contractor was not allowed to work extended shifts to recover lost time. Lastly, Amekudzi and Meyer (2005) have noted the importance of including noise restrictions during the planning phase of a project.

#### *2.5.2.1.4 Stochastic events*

While literature regarding stochastic events is sparse, non-deterministic events pose substantial risks. Mulholland and Christian (1999) have noted how unplanned events can have a negative impact on the project schedule. More often than not, contractors experience schedule delays due to events that they did not (or could not) have planned for. While it is difficult to plan for stochastic events, they should be considered during construction schedule planning.

#### *2.5.2.1.5 Traffic volume*

The impact of traffic volume on the construction schedule can be significant when not managed effectively. High traffic volumes during peak hours of construction may adversely affect work patterns and processes, thereby reducing productivity (Sukumaran *et al.* 2006). A regular reduction in productivity ultimately results in substantial schedule overruns.

According to a study conducted in Colorado by Burritt and Guenther (1987), construction activities on I-70 in Colorado's Glenwood Canyon were adversely affected by high daily traffic volumes. The construction team could not safely or productively accommodate existing traffic volumes and, as a result, the construction schedule suffered greatly.

### **2.5.2.2 Socioeconomic and political characteristics**

Socioeconomic and political factors exhibit great influence over project performance. Delays, change orders, and project acceleration are all common and depend heavily on public input and political agendas. Other factors such as public safety, access management, and right-of-way (ROW) acquisition can be contentious. These factors have been described in detail by Sukumaran *et al.* (2006) and Rogge and Hallowell (2007).

Three factors that can be classified as socioeconomic or political are included in this review. These factors include political sensitivity, safety concerns, and ROW acquisition. These three characteristics have been discussed in literature as important factors that may prevent a project from meeting and exceeding schedule goals. One should note that the following headings may include a broad range of events.

#### *2.5.2.2.1 Political sensitivity*

Political sensitivity is defined here as the influence of politicians, special interest groups, legal factors, and interested socioeconomic and political constituencies. These factors can influence schedules greatly because politicians and economists can influence project team members. Problems arise when volatile stakeholders change the project scope, goals and requirements. Restrictions that result can include operating hour limitations that have been placed on a project by local, state or federal agencies (Sukumaran *et al.* 2006). Restrictions on construction operating times can have substantial impacts on schedule performance for obvious reasons.



A study conducted by Iyer and Jha (2006) indicated that some projects could not even begin construction on time and other projects had to be delayed mid-construction due to a volatile socioeconomic climate. Socioeconomic constituencies may impact multiple projects and interfere with the delivery of the entire DOT program. One must be cognizant of the potential for a volatile political/socioeconomic climate and plan accordingly. In most DOTs upper management have a feel for the political climate; this knowledge should be communicated to project planning committees before construction.

#### 2.5.2.2.2 *Safety concerns*

The safety of the public and the construction workers should be a concern for every project. Accidents on construction sites can result in substantial costs, loss of productivity, and schedule overruns (Hinze 1997). According to Blincoe (1996), minimization of delays due to freeway and construction worker incidents is vital to achieving schedule goals. In some cases, accidents due to vehicle crashes can close a freeway and halt construction. Likewise, construction worker injuries are likely to delay projects significantly due to losses in productivity (Huang and Hinze 2006). Therefore, maintaining a safe worksite for both workers and the public is crucial to schedule success.

Hancher and Taylor (2001) have noted that nighttime incidents are especially problematic. These accidents result in delays that need to be considered in terms of their impact on the construction schedule. Many researchers have shown that designing a facility with construction safety and/or public safety in mind is likely to remove hazards (Behm 2004; Gambatese 2004; Gambatese 1998; Hecker et al. 2004; Toole 2005; Weinstein et al. 2005).

#### 2.5.2.2.3 *Right-of-way acquisition*

While most ROW acquisition activity occurs during the design phase of a transportation project, it has been cited by many ODOT area managers as a factor that results in significant delays (Rogge and Hallowell 2007). When the design phase and construction phase overlap, or when construction begins before ROW has been acquired, significant delays can occur. Delays are especially likely when the DOT and the landowner cannot reach an agreement. Substantial negotiation time or condemnation proceedings can result in delays. It is also more likely to have delays due to ROW acquisition when the project is insourced, because ODOT is less likely (than consultants) to force condemnation and move forward with construction (Rogge and Hallowell 2007).

While the focus of Walterscheid (2006) is Design-Build project delivery, he offers robust suggestions for minimizing the negative impact of ROW acquisition on schedule performance:

- The ROW certification process can be incorporated into the contract by including language that prevents construction from commencing until all

property has been acquired and relocations have been completed. To comply with this requirement, large, multi-year construction projects could be phased or segmented to allow ROW activities to be completed in phases, thereby allowing certification for each section.

- Require the submission of written acquisition and relocation procedures to the State DOT for approval prior to commencing ROW activities. Prioritized appraisal, acquisition, and relocation strategy should be included up-front.
- Require contractor submission of a written relocation plan which provides reasonable time frames for the orderly relocation of residents and businesses on the project. Time frames should be based on the estimated time required to acquire the ROW and to relocate families in accordance with stipulated legal requirements and time frames. Accordingly, ROW acquisition schedules will not be compressed in the event other preceding ROW activities miss their target dates.

### **2.5.2.3 Design characteristics**

Design factors that negatively affect construction schedules and budgets are typically the result of a design oversight, lack of communication among the Owner, designer and contractor, or misinterpretation of specifications and plans. Design factors, unlike the political and socioeconomic climate, may be controlled internally. That is, these factors can be identified and mitigated before construction begins. When factors such as design complexity, constructability, and utility work are identified, the negative impacts can be better controlled through planning and management. It is important to understand how these factors may negatively influence the construction schedule in order to manage them effectively. A discussion of three important design characteristics is provided as follows.

#### **2.5.2.3.1 Design complexity**

While the size of the project has been found to have little effect on schedule performance, many factors related to design – such as complexity, constructability and clarity of plans and specifications – may have a substantial impact (*Ford et al. 2004*). Kog et al. (1999) have cited the lack of consideration of construction means and methods as the “main culprit” of design schedule growth. Other factors such as complexity and clarity of design documents may also impact schedule performance. For example, contractors have reported that lack of clarity in subsurface characteristics or structural design may lead to delays, especially when a significant request for design clarification is issued. Worse yet, substantial delays are likely when contractors misinterpret complex or unclear designs and are required to perform rework.

#### **2.5.2.3.2 Constructability review**

It is widely accepted that constructability review and contractor involvement during construction is a method that aids in meeting goals in the construction phase. Alternatively, lack of consideration of construction means and methods during the design phase can result in confusion over plans and specifications that

results in significant schedule and budget overruns (*Toole 2005*). While not apparent to contractors during the bidding phase, design features may present problems midway through construction where the severity of impact on the schedule is greatest.

Constructability is typically compromised when designers have a lack of knowledge regarding the means and methods of construction or the work site. It is important to understand the capabilities of the designer or their lack thereof. Designs that present problems during construction must be tracked and managed effectively. According to Kog et al. (1999), the presence of a constructability program is a key determinant of schedule success. Likewise Ford et al. (2004) have shown that there is a negative correlation between time invested in constructability review and schedule overruns. One should note that constructability may be linked, in part, to design complexity.

#### *2.5.2.3.3 Utility work*

Delays due to coordination with utility companies and uncertainty related to the actual construction of utilities may result in schedule delays (*TRB 2002*). In a study conducted for the Oregon Department of Transportation, Rogge and Hallowell (2007) indicated that utility interference and unexpected delays associated with utility construction reduced overall schedule performance. Coordination with utility companies was cited as the most uncertain task and often resulted in schedule delays. The lack of innovative solutions to utility construction was cited as the primary issue facing modern utility work. A study conducted by the Transportation Research Board (*TRB 2002*) indicated that the following improvements are necessary for time-sensitive construction:

- Utility industry responsiveness;
- Incentive-based utility agreements;
- Corridor approaches to utility agreements;
- Means for highway owners and their contractors to perform utility work; and
- Nondestructive tools to help locate and pinpoint utilities.

Understanding the relationship between each of the utility factors listed above and their impact on construction schedule is essential. It is expected that, as these factors improve, uncertainty and risk associated with utility construction will reduce. For the time being, however, one must understand the ramifications of poor responsiveness, lack of agreements between contractors and utility companies, and poor utility location tools.

#### *2.5.2.4 Construction process characteristics*

The following characteristics are project specific but may only be evident when construction is imminent. While the Owner and designer may influence several of these characteristics, they are largely influenced by the contractor or the entire project team. These factors have been included because the literature recognizes a strong relationship

between the factors and schedule performance. The four most important of these project characteristics will be covered in this section.

#### *2.5.2.4.1 Project management*

Kog et al. (1999) have outlined three ways that project management can positively or negatively impact schedule performance. The project manager's time devoted to the project, frequency of meetings, and experience are the most influential aspects of project management. The study by Kog et al. (1999) strongly suggests that the more time the project manager spends on a project, the greater the chance for the project to achieve schedule goals. In order to achieve "good" schedule performance, the project manager must fully concentrate on one project at a time and concentrate efforts on the key schedule determinants. Unfortunately, most state DOTs require project managers to oversee multiple projects at a time. The result is that a project manager is only moderately familiar with a project and, in many cases, has trouble defining what the key determinants are. Similarly, the frequency with which project managers hold meetings with project personnel has also been correlated with schedule performance.

Cohenca-Zall et al. (1994) have noted that the regularity of meetings held by the project manager is linked to project performance. If no constructability review program is implemented, a "good" schedule performance can be achieved when the project manager holds four to six meetings per month with other project personnel. When a constructability review program has been implemented, a "slightly good" schedule performance can be achieved with less than two meetings per month.

The project manager's experience has also been correlated with schedule performance. The experience of the project manager is one of the most influential factors in determining the success of a project schedule (Kog et al. 1999). Despite the fact that no two construction projects are identical, projects are similar enough that knowledge from one project can be transferred to another. Two studies have indicated that the experience of the project manager with projects of a similar size and duration contribute positively to the schedule performance of the current project (Iyer and Jha 2006; Kog et al. 1999). Past experiences allow a project manager to foresee potential barriers to efficient construction.

#### *2.5.2.4.2 Equipment*

Another factor cited by two prominent articles on construction scheduling is the impact of equipment problems on overall schedule performance (Salem et al. 2006; Sukumaran et al. 2006). Both articles show that some project delays on highway construction projects are directly attributable to equipment problems. Salem et al. (2006) noted two equipment delays on a highway construction case study. Both delays were preventable in that the contractor could have ensured that equipment was readily available. Another case study conducted by Salem et

al. (2006) noted that construction was slowed by equipment breakdown and that storing spare equipment was cost prohibitive.

#### *2.5.2.4.3 Shipment delays*

Similar to equipment, one case study noted that a shipment delay of deck units caused a one half day delay in a project. To make matters worse, this project was a fast track project, and the delay resulted in poor schedule performance (*Salem et al. 2006*). While shipment delays are hard to predict, effective project managers take steps to ensure timely delivery.

#### *2.5.2.4.4 Conflict among project participants*

The final factor covered by this study is the potential conflict among project participants. Iyer and Jha (2006) note that conflict among project participants can lead to division among the team and lack of cooperation between the conflicting groups. Conversely, the commitment of project participants to schedule goals and strong teamwork is associated with adherence to schedule goals.

While this report has presented the most salient project characteristics related to schedule performance, one should note that there are many other factors that have not been reviewed here. Mulholland and Christian (1999) provide a comprehensive list of factors that may affect the ability of a project to meet schedule goals. This list is shown in Table 2.3.

### **2.5.3 Prioritized List of Project Characteristics**

The literature review of project characteristics that are associated with construction schedule risks uncovered significant findings. A review of ODOT risk management procedures and preconstruction planning methods confirmed many of these characteristics. Overall, the following characteristics have been suggested as those that pose the most substantial schedule risks:

- Climatic and seasonal conditions
- Environmental complexity
- Noise restrictions
- Stochastic events
- Traffic volume
- Political sensitivity
- Safety concerns
- Right-of-way acquisition
- Design complexity
- Constructability
- Utility work
- Project management
- Equipment

- Shipment delays
- Conflict among project participants

The characteristics listed above represent a subset of the comprehensive list, shown in Table 2.3, produced by Mulholland and Christian (1999). The authors believe that evaluating the relationships between these characteristics and alternatives to liquidated damages will result in a unique and useful schedule risk management tool.

**Table 2.3: Factors impacting schedule goals**

Factors	
Drawing control process	Trades productivity
Environment impact assessment	Construction turnover coordination
Location and number of engineering centers	Design errors
Engineering resource qualifications and pool depth	Scope-related quantity increases
Engineering estimate	Percent complete of engineering at start of site work
Project scope definition	Design changes during construction
Early engineering deliverables	Constructability reviews
Technology	Contract strategy
Design criteria	Differing site conditions
Engineering and procurement interfacing	Availability of equipment and material
Engineering productivity	Loss control program
Engineering resources requirements	Regulatory delays
Material substitution procedure	Location
Site investigation	Site management staffing
Vendor bid greater than estimate	Weather effects
Long lead items equipment and bulk material	Construction mistakes
Identification of equipment and material	Site stores management
Management methods and systems	Defective materials
Specification changes affecting manufacturing	Site access
Vendor quality control	Third-party overview
Vendor drawing control	Start-up plan
Warranties	Major equipment plan
Procurement document control process	Management experience
Manufacturing process	Project management budget
Material management organization	Project organizational model and implementation
Bid evaluation and purchase order cycle	Project control process
Vendor performance	Project procedures
Transportation concerns	Definition of authority and responsibility
Vendor labor problems	Scope definition and estimate
Temporary facilities	Financial/funding
Approved for construction drawings	External actions
Codes and standards	Management resource pool
Standards of contract documents	Owner quality assurance
Contractor selection process	Project complexity
Existing facilities	Project duration
Government permits	Project schedule
Labor relations	Commitment to the schedule
Labor resource planning	Records management
Quality control	Regulatory reporting
Safety	Change order control
Site management process	

## 2.6 LITERATURE REVIEW SUMMARY

This project focuses on timeliness as the sole criterion for method selection. A review of Multi-Criteria Decision Models (MCDA Models), however, has shown that they are designed to mediate among many criteria. Therefore, the existing MCDA models are not sufficient for solving the narrow time-based problem of this study. In practice, however, it would be fully expected that any methods selected with timeliness as a sole criterion would need to be mediated against other goals. To recognize this ultimate circumstance, MCDA methods should not be disregarded in this study's model development, but rather the model should be developed in a manner that can be expanded to utilize MCDA methodologies.

This literature review has revealed that there is a significant volume of material on methods for ensuring project timeliness, and this review has identified many characteristics that appear important to the selection of those timeliness methods. The vast majority of this information is provided as a set of advisory documents that describe ideal project characteristics, or sometimes characteristics to avoid, that will favor the use of a particular method. Most of these advisory documents provide direction in terms of "yes" or "no" matching of characteristic versus method. The authors found no existing models that recognize characteristics as circumstantial continuums. For example, traffic loads associated with a particular project may be measured with many values, not just as the presence or absence of "heavy traffic."

Further, models for systematically choosing among alternate methods appear to be not prevalent in the industry, and appear to be focused mostly on the selection of alternative contracting methods. The few software models available appear to be modeled on decision-tree techniques, similar in nature to the written guidance documents found in only a handful of state transportation agencies. Only one instance of software-based evaluation was discovered; in that case (UTAH LTAP) the major input was criterion priorities (or weights), with a modified probabilistic summation of method effectiveness factors. Specific project characteristics were not assessed.





### 3.0 DEVELOPING A MODEL SCHEMA

The next phase of this study was to develop a system for standardized selection of methods for enhancing the timely delivery of ODOT transportation projects; in this case, delivery could include all of the phases of design, procurement and or construction management, although the focus here was largely on construction delivery. This tool was designated as the Methods Selection Tool (MSeT). The general intent of the tool was to provide an objective, repeatable, and scalable means for establishing the timeliness effectiveness of a particular method, given a unique project profile.

Here, a project profile was comprised of a set of project-specific evaluations of standard characteristics. This profile was then used to calculate timeliness effectiveness scores for a variety of project delivery methods, yielding a prioritized list of potential methods from which a manager may design an implementation strategy. Further, it is recognized that while timeliness is a critical criterion for any project, other competing criteria may also exist, and balancing across those criteria will ultimately be required. To that end, this model was developed to allow for future development into a Multi-Criteria Decision Analysis (MCDA) process.

#### 3.1 CHARACTERISTICS

Characteristics are features or conditions that may exist on one or more projects, and are also factors in the successful application of one or more of the methods. There are four major categories of characteristics, which were noted in the previous section. Characteristics which are reasonably objectively measurable are the most valuable in the modeling developed in this project.

Establishment of a set of generic project characteristics that encompass the major goals and measures of a project is important in implementation of the Methods Selection Tool, and many such characteristics have been documented in prior studies, as discussed earlier. A list of a subset of these characteristics is shown in Table 3.1 for illustration. The listing in Table 3.1 is not exhaustive and should be added to from existing lists and experience as other factors are discovered.

**Table 3.1: Sample project characteristics**

<b>Characteristic</b>	<b>Measure</b>
Urbanness	Population density immediately surrounding the project
Complexity	Degree to which project exhibits
Traffic Volume	Traffic counts
...	
Political Sensitivity	Subjective measure of amount and goal alignment of project stakeholders and interested parties

For the purpose of model development, the list of characteristics may be represented as a vector matrix as shown in Equation 3-1:

$$\mathbf{A} = \begin{pmatrix} \text{Urbanness} \\ \text{Complexity} \\ \text{Traffic Volume} \\ \vdots \\ \text{Political Sensitivity} \end{pmatrix} = \begin{pmatrix} a_1 \\ a_2 \\ a_3 \\ \vdots \\ a_n \end{pmatrix} \quad (3-1)$$

Since many different characteristics, with many different measures, will be used as factors of method effectiveness, it will be useful to establish a fixed scale length with no units, thus facilitating comparison among characteristics. The range of each characteristic is established here on a scaled rating system that spans a numeric range common for all characteristics; for simplicity, this scale length has been set as 1-10. For example, a characteristic variable may be *political sensitivity*, and the scale may be from 1=*no public focus on project* to 10=*strong public, media, and legislative focus on project*. Let each characteristic be denoted by the letter  $a$ , and let the total number of characteristics be denoted by the letter  $n$ . Continuing the example, if *political sensitivity* were the seventh entry of, say, 15 characteristics, then *political sensitivity* would have an index of  $a_7$  and the entire list would contain  $n = 15$  characteristics.

Utilizing this scale, each characteristic is represented by integer values ranging from 1 to 10, indicating a stepped continuum of characteristic conditions. For example, the *Urbanness* vector may be represented by a condition of 1, indicating *highly rural*, to a value of 10, indicating *highly urban*. This will establish the range of conditions of the characteristic. The vector  $\mathbf{A}$ , then, expands to a matrix as shown in Equation 3-2.

$$\mathbf{A} = \begin{pmatrix} \text{Urbanness} & \text{rural} & \cdots & \text{urban} \\ \text{Complexity} & \text{simple} & \cdots & \text{complex} \\ \text{Traffic Volume} & \text{low} & \cdots & \text{high} \\ \vdots & \vdots & \cdots & \vdots \\ \text{Political Sensitivity} & \text{no interest} & \cdots & \text{multiple interests} \end{pmatrix} = \begin{pmatrix} a_{1,0} & a_{1,1} & \cdots & a_{1,10} \\ a_{2,0} & a_{2,1} & \cdots & a_{2,10} \\ a_{3,0} & a_{3,1} & \cdots & a_{3,10} \\ \vdots & \vdots & \cdots & \vdots \\ a_{n,0} & a_{n,1} & \cdots & a_{n,10} \end{pmatrix} \quad (3-2)$$

## 3.2 METHODS

Methods are defined as contracting arrangements or management procedures that may be utilized during project development. Standard methods are those methods which are customarily and regularly used within ODOT for project development and are generally defined in the Oregon Standard Specifications for Construction, in Oregon Standard Design Practice Manuals. Alternative methods are those which deviate from standard methods; approval to use the alternative methods may or may not be within the authority of the manager implementing the method. Guidance for approval required should be included with the detailed description of each method in a fully-implemented system.

Methods may be generally classified into three major groups, as indicated earlier. Table 3.2 provides a partial listing of these methods; the earlier discussion in the prior chapter contains a more thorough enumeration of the methods. Since the interest here is in evaluation of methods to improve upon standard performance, the list in Table 3.2 contains procedures which vary from standard methods.

**Table 3.2: Sample listing of contractual and practice methods**

Category	Method
Teaming	Design-Bid-Build
Teaming	Design-Build
Teaming	CM/GC
...	
Selection Process	A+B

For model development purposes, each method has been denoted by the letter  $t$ , and the total number of methods is denoted by the letter  $m$ . If CM/GC were the third in a list of, say, 20 methods, then it would have an index of  $t_3$  and the entire list would contain  $m = 20$  methods. The methods may be represented as a vector matrix as shown in Equation 3-3:

$$\mathbf{T} = \begin{pmatrix} \text{Design-Bid-Build} \\ \text{Design-Build} \\ \text{CM/GC} \\ \vdots \\ \text{Lane Rental} \end{pmatrix} = \begin{pmatrix} t_1 \\ t_2 \\ t_3 \\ \vdots \\ t_m \end{pmatrix} \quad (3-3)$$

### 3.3 CORRELATION BETWEEN METHODS AND CHARACTERISTICS

#### 3.3.1 Effectiveness Function

It is desired to apply, on any particular project, those methods which will most effectively deliver the project in a timely manner and which will do so under the conditions in which the project will operate, called the project profile. This process is shown graphically in Figure 3.1.

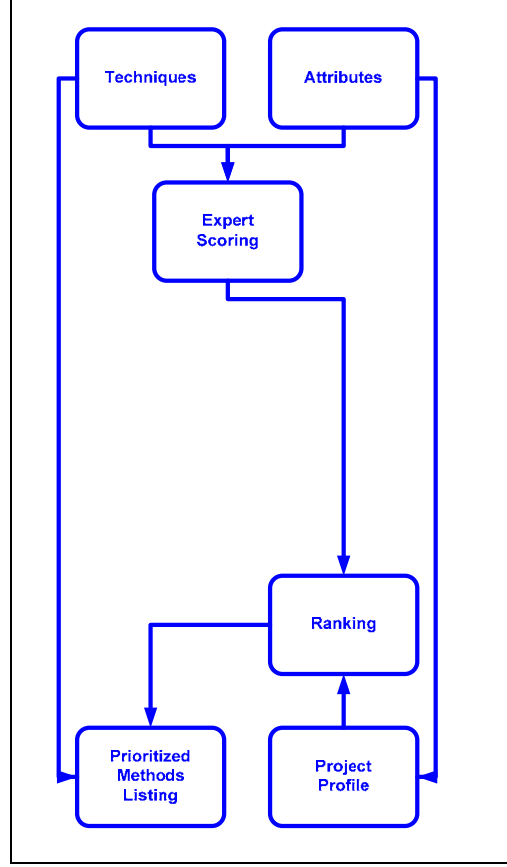


Figure 3.1: Graphical model of Methods Selection Tool (MSeT)

To this end, a correlation must be made between the methods available and the project's attributes. This correlation is defined by the Effectiveness Function (EF). This function is based on Equation 3-4:

$$e = f(a_{i,q}, t_j) \quad (3-4)$$

Where:

$e$  = the timeliness effect the method  $t_j$  will have, considering the condition  $a_{i,q}$

$t_j$  = the timeliness method under consideration

$a_{i,q}$  = a range value of a project-specific attribute condition

This project used expert opinion to create an initial working set of effectiveness relationships as described by Equation 3-4. These relationships are comprised of a set of parameters to be used in the Effectiveness Function, Equation 3-4, and which define the effect of a given method at a given value of a project characteristic. For simplicity, effectiveness was established within the range of -10 to 10, with -10 equivalent to a potential schedule delay of 50% or more, and 10 representing a potential schedule acceleration of 50% or more.

For example, if the third method were (CM/GC) ( $t_3$ ) and the seventh characteristic were *political sensitivity* ( $a_7$ ) then a set of parameters may be established to represent the effectiveness of CM/GC under conditions of *political sensitivity*. This set of parameters will be denoted as  $v_{7,3}$ .

### 3.3.2 Project Profile

Each project's characteristics must be individually scored for its particular situation, creating a project profile. The scores will be captured in a single-row matrix of values. This matrix (referred to herein as the *Project Profile Vector*) will be denoted by  $\mathbf{P}$ , containing  $n$  values – one for each characteristic. Continuing with our example, perhaps the project is only moderately *politically sensitive* (characteristic  $a_7$ ), yielding a score of 5. The result would be a matrix value of  $p_7 = 5$ . Such scoring would occur for each project characteristic.

### 3.3.3 Effectiveness Function Values Matrix

The Effectiveness Function values matrix ( $V_{i,j}$ ), shown in Equation 3-4 represents the generic “effectiveness” parameters of a particular method applied within the range of a particular characteristic. To establish the factors of the Effectiveness Function (EF), a matrix may be developed that is populated by evaluation of the timeliness effect of a method for each characteristic value indicated in the Project Profile. This matrix would serve as a sort of expert system data bank, to be used to create objective assessments of method effectiveness. Once established by a central office or manager, this matrix would remain relatively stable. Maintenance of the matrix would include periodic review and updating of the matrix scores, and the addition or subtraction of either generic project characteristics or available methods. Graphically, the function to be established is shown conceptually in Figure 3.2.

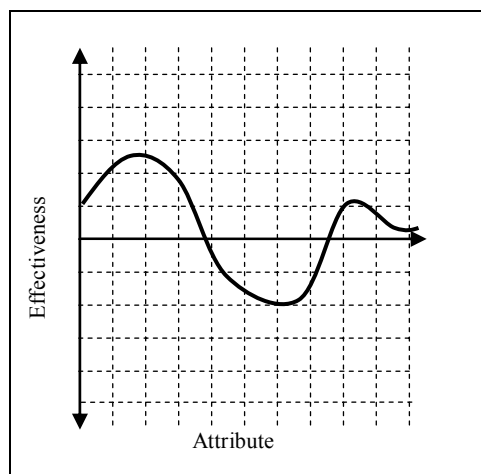


Figure 3.2: Conceptual schema of characteristic/method relationship

### 3.3.4 Effectiveness Function Scheme

Several different function schemes for Equation 3-4 were considered. The intent was to find a scheme that is simple enough to be readily understood by a typical project user, yet robust enough to model complex relationships. Several graphically simple relationship formulas were evaluated:

**Alternate 1: Distance from Point of Maximum Effectiveness.** In this alternate, the relationship between timeliness effect and characteristic value is described by a single parameter, representing the point of maximum effectiveness of the method on the characteristic range, expressed as a constant,  $a_{\max}$ ; in this case, effectiveness has no value, but is merely a score. The effectiveness score is simply a measure of the distance that a project's characteristic measure differs from the point  $a_{\max}$ , yielding an effectiveness measure as in Equation 3-5, derived from the generalized Equation 3-4; the larger the difference, the lesser the fit. As is shown in Figure 3.3, it is only the magnitude of the difference, not the sign that is important; so the value is taken as the absolute value of the difference.

$$e = |p - v_{\max}| \quad (3-5)$$

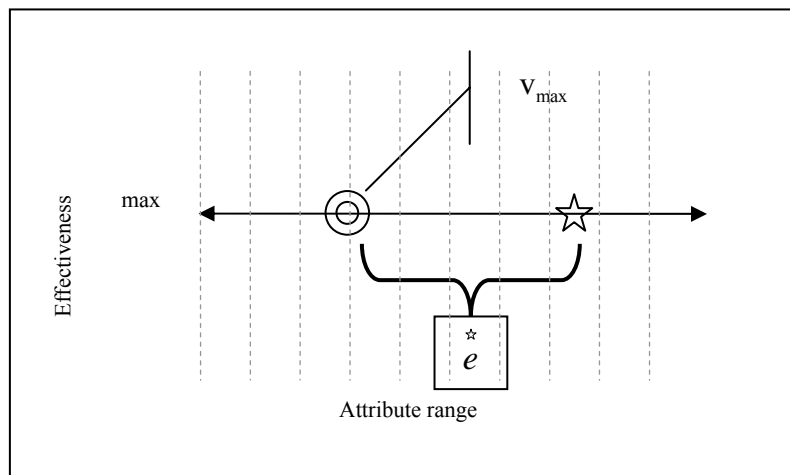


Figure 3.3: Point of maximum effectiveness for a given method

This alternate is largely unsatisfying, as it presumes that a single maximum effectiveness point exists across the characteristic range. Further, it doesn't distinguish among the effectiveness possibilities for various methods.

**Alternate 2: Y-intercept of triangle, defined by apex.** To address the lack of distinction in effectiveness among methods, maximum effectiveness is described in two dimensions on a geometric plane – a characteristic score on the  $Y$  axis, and an effectiveness score on the  $X$  axis.

In this approach, the effectiveness of a method is envisioned as being described in a triangular fashion, where the maximum value occurs at a point along the characteristic range of 0 to 10 (labeled as  $v_1$ ), and the maximum effect possible is established as a value from 0 to 10 (labeled as  $v_2$ ). The Effectiveness Function, established from the generalized function in Equation 3-4, is then as shown in Equation 3-6, and graphically in Figure 3.4.

$$e = \frac{v_2}{v_1} p \quad 0 \leq p \leq v_1$$

$$e = \frac{v_2(10-p)}{(10-v_1)} \quad v_1 \leq p \leq 10 \quad (3-6)$$

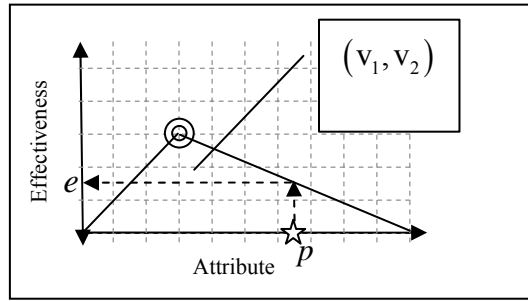


Figure 3.4: Effectiveness as Y-intercept, defined by apex

While this function establishes a value of effectiveness that varies by both method and characteristic score, some limitations remain. Effectiveness is defined only as positive values, not addressing the situation in which a method actually harms a project's schedule. Further, there is an implicit assumption that only one point exists at which the method is most effective.

**Alternate 3: Trapezoidal Effectiveness Function.** To resolve the limitations identified in using a triangular, positive-domain effectiveness function, the effectiveness scale is expanded to include the possibility for negative values (signifying harm to the project's timeliness); the scale of effectiveness is established from -10 to 10. Further, by envisioning a trapezoidal geometry, it is possible to establish a plateau-like effectiveness function that recognizes that maximum method effectiveness may occur over a range of characteristic values, as illustrated in Figure 3.5.

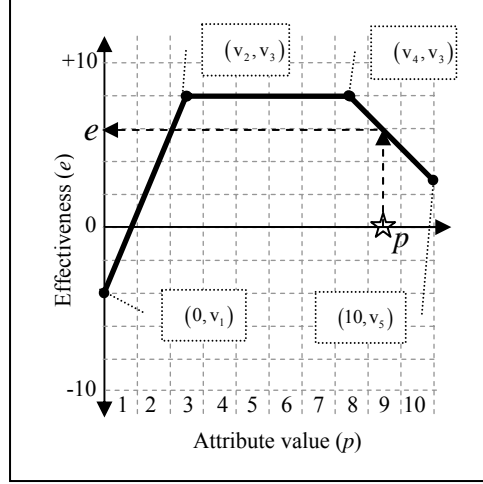


Figure 3.5: Trapezoidal effectiveness function

Five parameters (defining four points of fit as shown in Figure 3.5) are established to describe this situation. These five parameters are as follows and applied in Equation 3-7:

- $v_1$  = effectiveness at lowest attribute value  $-10 \leq v_1 \leq 10$
- $v_2$  = attribute value at start of maximum effectiveness plateau  $1 \leq v_2 \leq 10$
- $v_3$  = maximum effectiveness for technique  $v_1 \leq v_3 \leq 10$
- $v_4$  = attribute value at end of maximum effectiveness plateau  $v_2 \leq v_4 \leq 10$
- $v_5$  = effectiveness at highest attribute value  $-10 \leq v_5 \leq v_3$

$$\begin{aligned}
 e &= \frac{v_3 - v_1}{v_2} p + v_1 & 0 \leq p \leq v_2 \\
 e &= v_3 & v_2 \leq p \leq v_4 \\
 e &= \frac{v_2(v_5 - v_3)}{(10 - v_4)}(p - v_4) & v_4 \leq p \leq 10
 \end{aligned}
 \tag{3-7}$$

The effectiveness score of a method is allowed to be different on either the high or low end of the characteristic boundary; a central zone is available across the characteristic range in which the method is equally and fully effective.

The trapezoidal effectiveness function is a highly flexible model and could be useful over a wide variety of conditions. The function requires establishment of five parameters, and it assumes that one plateau of effectiveness exists. This model may satisfactorily cover most situations, as it provides significant flexibility in defining an effectiveness function, and it allows for mathematical modeling of results. The constraint of this model is that it assumes one plateau. Further, since it requires that five parameters be defined, it may become less intuitive for definition of the parameters.



**Alternate 4: Discrete Effectiveness Function.** The focus of the previous three effectiveness function alternatives has been to discover a geometrically simple, mathematically-based solution for describing the relationship between characteristic value and method effectiveness. Rather than using mathematical functions to describe the relationships, a more “analog” model may be developed, as shown in Figure 3.6, in which there is a one-to-one correspondence between integer-based characteristic values (range of 1 to 10) and integer-based effectiveness values (range of -10 to 10). To define these relationships, 10 parameter values would need to be identified for each method/characteristic combination. Although this may seem burdensome, the intuitive nature of this style of information capture may smooth the process of receiving expert input, and the flexibility to freely describe highly complex relationships may improve accuracy.

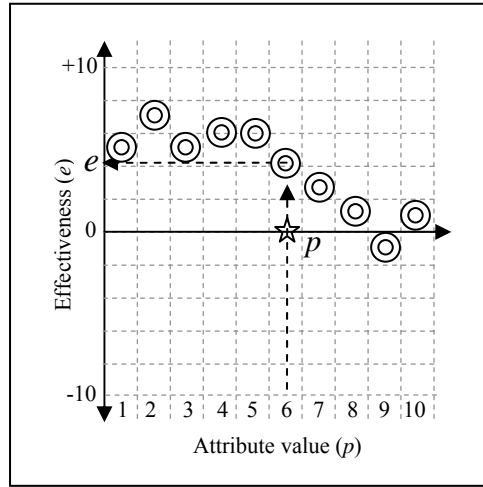


Figure 3.6: Discrete (analog) effectiveness function

Ten parameters are established to describe the effectiveness function, each an effectiveness value that corresponds to the 1-10 scale of the Characteristic. These are shown in Equation 3-8.

$$e = v_p, \text{ where } p = \text{attribute value score (1-10),}$$

$$\text{and } v_p \in (v_1 \quad v_2 \quad \cdots \quad v_{10}) \quad (3-8)$$

The effectiveness function, which uses prescribed effectiveness values that correspond to integer characteristic scores, is a highly flexible means of describing a potentially complex relationship between timeliness effectiveness and characteristic. In addition, the process of establishment of effectiveness values appears to be intuitively simple to describe and accomplish. For these reasons, the modeling in this research proceeded with an effectiveness function that uses this analog technique.

### 3.4 METHOD TOTAL EFFECTIVENESS

The previous section developed alternatives for scoring the effectiveness of a method, given a particular characteristic score. Of value is understanding how effective a method will be under a set of characteristics (a *project profile*). For this research, it was assumed that the total effectiveness for a method (considering the entire project profile) is simply the average of the individual effectiveness scores for each characteristic, as reflected in Equation 3-9.

$$E = \frac{\sum_{a=1}^n e_n}{n} \quad (3-9)$$

### 3.5 PRIORITIZING METHODS AND CHARACTERISTICS

In order to develop and test the model, a subset of the identified characteristics and methods was required. In production mode, the model is expected to be populated by many correlations between characteristics and methods. Each characteristic ( $a_i$ ) will be matched with a method ( $t_j$ ), as pictured in Table 3.3. As is evident, the number of characteristic/method combinations (effectiveness evaluations) is the product of the number of characteristics times the number of methods. Further, each cell of the matrix is populated by ten correlated analog effectiveness/characteristic values (see “**Alternate 4: Discrete effectiveness function**” above). The result is a 3-dimensional matrix with  $n*m*10$  cells.

This research project’s success depended both on having a reasonably complete model, as well as on having sufficient expert input into establishment of the values. Too many items would tax the ability of the researchers to gain expert input within this study’s limitations, while too few items would not provide a robust test. A decision was made to establish five characteristics and five methods as the initial test parameters, thereby accomplishing both goals. It was thus necessary to establish  $5*5*10 = 250$  values to populate the expert matrix for testing purposes.

**Table 3.3: Structure of effectiveness table**

	$t_1$	$t_2$	$t_3$	$t_4$
$a_1$				
$a_2$				
$a_3$				
$a_4$				

The short-listed characteristics and methods are shown in Table 3.4 and Table 3.5.

**Table 3.4: Characteristic subset for modeling**

<b>Characteristic</b>
Traffic Volume
Political Sensitivity
Design Complexity
ODOT Staffing level
Public Safety Concern
Utilities
Right-of-Way
Size

**Table 3.5: Method subset for modeling**

<b>Method</b>
<u>Team Structure</u>
General Contractor (Baseline)
Design Build
Construction Management
BOT
<u>Selection Process</u>
Lump Sum (Baseline)
A + B
A + Q
Qualifications only



## 4.0 RANKING METHODS VIS-À-VIS CHARACTERISTICS

### 4.1 OVERVIEW

The Methods Selection Tool (MSeT) is a model that is designed to establish a centralized “expert system” that contains relationships correlating pre-selected project characteristics to methods, measuring timeliness effectiveness. In order to test the system, a small group of experts at ODOT were asked to evaluate the method/characteristic relationships for a selected subset of methods and characteristics.

To obtain expert input, a set of forms was developed to capture expert opinions regarding the effectiveness of a particular method (refer to Table 3.5), given a particular characteristic (refer to Table 3.4). The experts were asked to create a graphic representation of the correlation, following the “**Alternate 4: Discrete effectiveness function**,” described in Section 3 and shown in Figure 3.6. A description of these forms is provided in Appendix B.

Six experts met during a half-day meeting to establish the correlations between methods and characteristics; this was a difficult task as these important individuals were extremely busy. The process used was a modified Nominal Group Process. To obtain the collective opinion, each individual was first asked to form their opinion (Round 1) on the degree of timeliness that a given method would deliver against a baseline. Next, the individual opinions were shown to the group and significant discussion ensued. The group re-evaluated the scores and came to consensus on the values (Round 2). This process continued for each of the contracting techniques. These discussions were translated into graphical representations of the correlation matrices. Finally, towards the end of the meeting, the scores were once again reviewed openly (Round 3), final adjustments were made, and the correlation matrices and graphical representations were again constructed. Round 3 was helpful as insight had been gained through the entire session that could be applied to the initial data values.

This technique was useful for gathering expert opinion. The selection of the initial group with multiple perspectives and open discussion helped avoid myopic biases that could occur with just one or two individuals. Although there was some indication of control biases (individuals deferring opinion to others with more organizational power), this bias was reduced through the Round 1 private opinion gathering and through facilitation by the author.

Through this process the expertise of each individual played a role in scoring the effectiveness values, and the group then reached agreement on the degree of timeliness that a given method would deliver against a baseline. The group’s responses were then tabulated. They are shown below in Tables 4.1 through 4.6 and graphically depicted in Figures 4.1 through 4.8. The following sections present a summary of the general discussion surrounding the assessment of various methods.

## 4.2 TEAMING METHODS

Alternative teaming methods – Design-build, Construction Management (CM/GC) and Build-Operate-Transfer – were compared against a baseline of the General Contractor teaming method. In the baseline situation, a General Contractor is selected after the full development of the project design and is tasked solely with the actual construction of the project. The alternative methods were assessed in terms of their effect on the project’s timeliness. Timeliness was scored based on the expected effect of the alternative method to produce a schedule change, considering the project characteristic. The rating was based on a scale of change from a reasonably developed schedule on a project using the baseline method as follows: +10 = schedule improvement by 50% or greater; 0 = no schedule improvement; -10 = schedule delay by 50% or greater. Ratings between the points noted were proportionately adjusted.

### 4.2.1 Design-Build

Design-build is a method whereby design and construction are performed by one entity. It is characterized by the provision of design and construction services from one entity. Oftentimes this entity is a joint venture made up of one designer partner and one builder partner; less frequently the design-build capabilities may be housed within one firm. In most circumstances, the design-builder is selected and begins work very early in the process, before significant design work has been completed by the agency.

Design-build has a potential for decreasing project time through “fast-tracking,” i.e., starting construction before full completion of the design; these gains may be significant. However, as shown in Table 4.1, design-build may be of little value (or in some cases actually contribute to delay) under conditions of high political sensitivity, or prevalent public safety or right-of-way concerns; under less severe conditions, however, the design-build method may be very useful.

**Table 4.1: Timeliness ratings using Design-Build method**

Characteristic	Characteristic Condition Level									
	1	2	3	4	5	6	7	8	9	10
Political sensitivity	5	5	5	4	4	4	4	1	0	-2
Public safety	5	4	4	3	3	2	2	2	1	0
Right-of-Way	5	5	5	6	5	4	3	2	1	0
Utility interference	5	5	5	5	5	5	5	4	4	2
Traffic volume	5	5	4	4	4	4	4	4	3	3
design complexity	1	2	3	4	4	4	2	1	0	-1
ODOT staffing level	5	5	5	5	5	5	5	5	5	5
Project size	0	2	4	5	5	5	5	4	3	2

Design-build followed another distinct pattern, however, under the characteristics of project size and design complexity. When a project is a small size or is simple in design, design-build is less effective, increasing in effectiveness as a project moves toward the mid-range in design complexity or size, and finally losing effectiveness again as either project size or design complexity increases. During the expert discussion, it was expressed that design-build often “locks-in” design parameters early in a project, and as a project evolves it becomes very difficult to react to scope changes that were undiscovered at the time of contracting. Such changes are prevalent in very large and complex undertakings, so design-build in these circumstances may actually hamper the effort toward timely delivery.

#### 4.2.2 CM/GC (CM-at-Risk)

CM/GC (Construction manager/ general contractor) is a method whereby the contractor is selected coincident with early design and is often called “Construction Management at Risk.” The contractor participates in design decisions and is responsible for estimates and schedules. The contractor has the right to contract specified portions of the work, unless ODOT objects; limits may be attached to the amount of self-perform work allowed. The contractor signs a contract to perform design-phase consultation and a provisional contract to perform the construction, if the contractor and agency can agree on a maximum price before construction work begins.

Table 4.2 shows the timeliness ratings assigned to the CM/GC method.

**Table 4.2: CM/GC (CM-at-Risk) timeliness assessment**

Characteristic	Characteristic Condition Level									
	1	2	3	4	5	6	7	8	9	10
Political sensitivity	2	2	2	3	3	3	3	4	4	5
Public safety	2	2	3	3	3	3	3	3	4	4
Right-of-Way	2	2	3	3	3	3	3	3	4	4
Utility interference	2	2	3	3	3	4	4	2	1	1
Traffic volume	2	2	2	2	2	2	2	2	2	2
design complexity	0	1	2	2	3	4	4	4	4	4
ODOT staffing level	2	2	2	2	2	2	2	2	2	2
Project size	-1	-1	-1	0	1	2	3	4	5	6

The principle advantages of this form of teaming are that a close working relationship with the CM/GC is generally developed, and constructability information is obtained early in the development process, which can be incorporated into the design. The timeliness advantage

occurs generally due to the CM/GC's thorough understanding of the design before the design is complete and the ability of the agency to issue preliminary work packages to start work before all design has completed.

In general, CM/GC is expected to improve timeliness under conditions of increasing complexity among most of the project characteristics. There are two notable exceptions, however – utility interference and project size. In the case of utility interference, high levels of utility interference may create construction-phase complications that lead to potential slowing for contractual change-order reasons, negating some of the advantage gained through the CM/GC process. Finally, it was recorded that CM/GC has little, and perhaps negative, timeliness advantage when projects are small. Essentially, the expectation is that the added overhead of dealing with a third party (the CM/GC) during the design phase is not offset with time efficiency gains—these projects are generally simple in nature and the designers have sufficient experience to properly structure the work without outside help.

### **4.2.3 Build-Operate-Transfer (BOT)**

The Build-Operate-Transfer (BOT) method is an alternative type of teaming arrangement whereby the agency contracts with a single entity to undertake the design, construction, financing, and eventual operation of a facility. Often, these arrangements are accompanied by tolls through which the BOT contractor is compensated for its investment; however, other sources of income, including tax revenues, may be used in addition to or as an alternate to tolls as a source of payment to the BOT contractor.

The BOT method has been used less frequently for project delivery than other methods. Further, it is used more commonly in the Eastern U.S. than in the Western U.S. One of the more important features of this method is the ability to fund a project through private equity. This private funding may allow a project to become viable much earlier than if the project were relying on legislative funding. The matrix developed for this delivery method (Table 4.3) does not account for this potential early start in the absence of readily-available public funding; rather, the assumption is that either public or private funding are equally available, and the ability to deliver on a timely basis is related to the conditions of the form of project delivery.



**Table 4.3: Build-Operate-Transfer timeliness assessment**

Characteristic	Characteristic Condition Level									
	1	2	3	4	5	6	7	8	9	10
Political sensitivity	4	4	4	3	3	2	2	0	-1	-3
Public safety	4	4	4	4	4	3	3	3	2	2
Right-of-Way	4	4	4	4	2	2	0	0	0	-1
Utility interference	4	4	3	3	2	2	0	0	-1	-2
Traffic volume	2	2	3	3	3	3	4	4	5	5
design complexity	0	0	1	2	3	3	2	2	1	0
ODOT staffing level	-1	0	0	0	0	1	1	2	2	2
Project size	-2	-2	-1	0	0	0	0	0	0	0

With significant focus on cost-efficient delivery, the contractor responsible for project construction may be somewhat intolerant to project changes. Any such changes may require a significant amount of time to resolve, due to the potential delayed revenue start dates (especially for toll facilities) and changes in the pro-forma cost structures. Thus, this form of delivery method will be less effective toward and in fact may detract from, the timely delivery of the project.

BOT projects present a mixed picture of potential timeliness effectiveness. This may be the result of several factors, including the establishment of fixed contractual conditions at the earliest stages of the project, making it difficult to react to changes, and (due to the newness of this form of contracting) creating a slow project start as ODOT management wrestles with the legal and political factors surrounding this form of contract. Specifically, it can be seen by examination that timeliness effectiveness drops off, and may cause slowing, as project complexity increases (especially significant with political sensitivity). The significant factor that doesn't follow this trend is traffic volume; this effect is likely due to the revenue-generating nature of BOT work – the higher the traffic volume, the more likely that the BOT contractor would be willing to work through problems and seek quick solution to begin revenue generation through tolling or similar measures.

#### 4.2.4 Observations of the Teaming Methods Scoring

The results of the scoring of teaming methods were graphed, providing a means of visually comparing among the three focal methods and the baseline (GC) method. These graphs are shown in Figures 4.1 through 4.4. Generally, it may be noted that the teaming methods identified for testing the model could be expected to provide time advantage to the projects, with some exceptions. Most notably, as the project becomes more complicated, certain methods (such as Design-Build) that “lock-in” design early tend to lose the ability to maintain schedule advantages, and in some circumstances may actually create schedule delay. Further, as the

projects become smaller in size, the more complicated teaming structures (such as CM/GC) tend to increase administrative overhead to the point of slowing the projects. More detailed discussions about each teaming option occurs in the preceding sections.

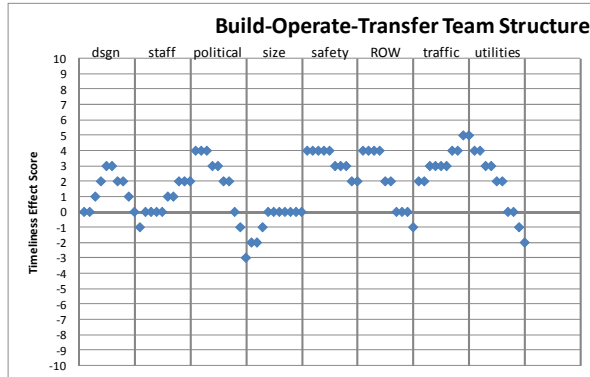


Figure 4.1: BOT team structure scores

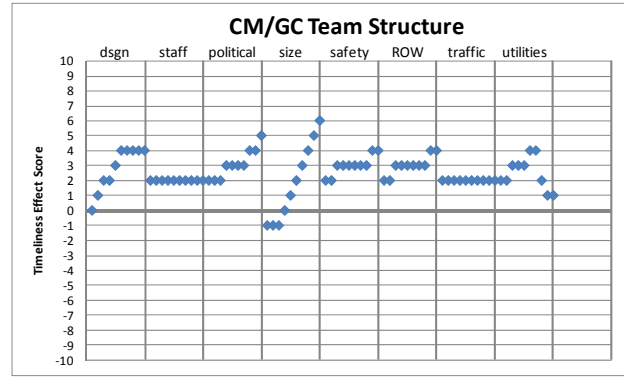


Figure 4.2: CM/GC team structure scores

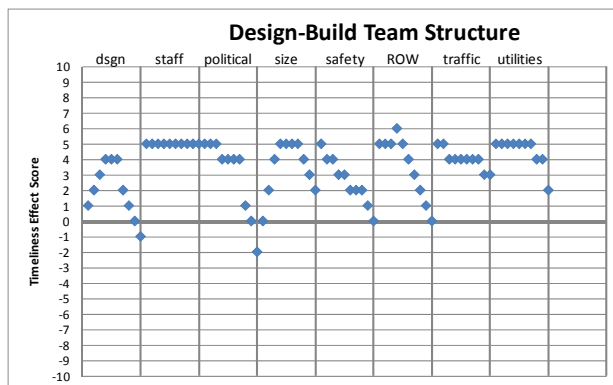


Figure 4.3: DB team structure scores

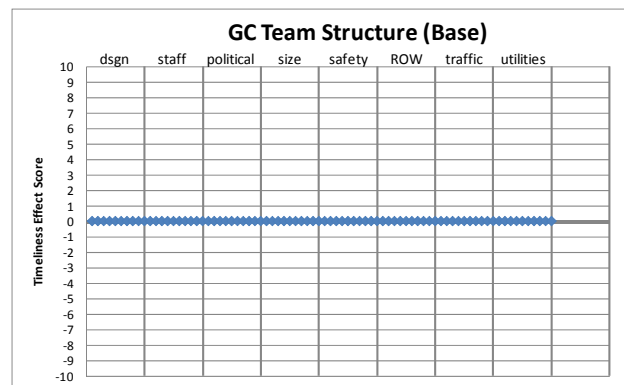


Figure 4.4: GC (base) team structure scores

### 4.3 SELECTION PROCESS METHODS

In addition to the teaming structure, a method must be chosen to select the appropriate construction provider. Three potential alternate methods for selection of the construction entity are listed here. Theoretically, any of the three may be used with any of the teaming methods; however, as a practical matter, some selection/teaming combinations are infrequently used, such as Qualifications-Only method with the General Contractor form of project delivery.

The three alternate methods were scored in terms of their effect on a project's timeliness. Timeliness was scored based on the expected effect of the alternative method to produce a schedule change, considering the project characteristic. The rating was based on a scale of

change from a reasonably developed schedule on a project using the baseline method (low-price) as follows: +10 = schedule improvement by 50% or greater; 0 = no schedule improvement; -10 = schedule delay by 50% or greater. Ratings between the points noted were proportionately adjusted.

### 4.3.1 A+B (Cost plus Time)

The A+B process requires that a proposer provide both an estimate of time and cost for delivering a project. The estimate of time to completion is generally used in a formula to establish a comparative score that allows for selection based on the best combination of price and schedule. An exemption to the normal bid process is required for this method.

The A+B method of contracting requires that the proposer thoroughly examine the project from both a cost and a schedule point of view. The expectation is that preconditions are exposed and considered at the time of proposal; further, it is expected that the critical nature of time in the project is emphasized to the proposers and they are therefore more creative in establishing the timeliest means of project construction. Table 3.9 shows the expert scoring values for the effects of various project characteristics on timeliness under the A+B selection method.

**Table 4.4: A+B selection method scoring**

Characteristic	Characteristic Condition Level									
	1	2	3	4	5	6	7	8	9	10
Political sensitivity	4	4	4	4	4	4	4	4	4	4
Public safety	4	4	4	3	3	3	2	2	1	1
Right-of-Way	4	4	3	3	2	2	1	0	0	-1
Utility interference	4	4	4	3	3	2	2	1	-1	-2
Traffic volume	4	4	4	4	4	4	4	4	4	4
design complexity	1	1	2	2	3	3	3	4	4	4
ODOT staffing level	4	4	4	4	4	4	4	4	4	4
Project size	1	1	1	2	2	3	3	4	4	4

Where the project is not complex, there is likely to be little advantage, since it is expected that most proposers have routinely developed highly efficient methods of construction and therefore have little to offer for more timely delivery. Further, since the schedule is locked-in at the time of the proposal, conditions that may change or be discovered may create contractual difficulties and reduce schedule advantages, perhaps even to the point of loss of time compared to the baseline selection method. Such conditions may include strong public safety concerns, difficult right-of-way issues, and significant and undefined utility interferences.

### 4.3.2 A+Q (Cost plus Qualifications)

A + Q is a proposal process that includes special work experience as a component of the selection process, in addition to price. The contractor's expertise is considered along with the price in a scoring process to determine the best-value contractor. An exemption to the normal selection method (low-price) is required for this style of bidding.

The A+Q method strives to select a builder that has demonstrated the ability to adapt to the agency's specific project goals. While price is an important consideration in selection, a team approach toward project problem solving is also important. Table 3.10 shows the scoring values for the effects of various project characteristics on timeliness under the A+Q selection method.

**Table 4.5: A+Q selection method scoring**

Characteristic	Characteristic Condition Level									
	1	2	3	4	5	6	7	8	9	10
Political sensitivity	0	0	0	0	0	0	0	0	-1	-1
Public safety	0	0	0	0	0	0	1	1	1	1
Right-of-Way	0	0	0	0	0	1	1	1	1	0
Utility interference	1	1	1	2	2	2	1	1	0	-1
Traffic volume	1	1	1	2	2	2	1	1	1	1
design complexity	0	0	0	1	1	1	2	2	3	4
ODOT staffing level	4	4	4	4	4	4	4	4	4	4
Project size	1	1	1	2	2	3	3	3	3	3

In this method, it is expected that the successful proposer will be flexible in dealing with potential project problems. However, this method of selection differs from the A+B method in that it does not emphasize time as a critically-important goal of the agency. Therefore, the principal advantage lies in conditions where challenges are discovered as the project proceeds, and the team-nature of the successful proposer is a catalyst in resolving issues quickly and proactively.

The A+Q selection method does not emphasize time as an important selection criterium, and is most often used when a contractor is selected during the preconstruction period. Under most conditions, this early involvement is beneficial to project timeliness. However, where conditions such as a difficult political environment or complex utility issues exist, the potential for construction-phase problems and contract changes indicates that projects may actually suffer slowing under this method.

### 4.3.3 Qualifications-Only

In a Qualifications-Only selection process, professional construction providers are selected solely based on their qualifications. Price for the work is negotiated only after selection. Unreasonable price negotiations may lead to rejection and selection of the runner-up or re-solicitation.

The difficulty encountered with a Qualifications-Only selection is that use of this method is very rare at ODOT, and therefore requires special permissions; and it may be difficult to implement since few within the agency are experienced or trained in this method. Table 3.11 shows the scoring values for the effects of various project characteristics on timeliness under the Qualifications-Only selection method.

**Table 4.6: Qualifications-Only selection method scoring**

Characteristic	Characteristic Condition Level									
	1	2	3	4	5	6	7	8	9	10
Political sensitivity	0	0	0	0	0	0	0	2	2	2
Public safety	-1	-1	0	0	0	0	1	1	2	2
Right-of-Way	-1	-1	-1	0	0	0	2	2	3	3
Utility interference	-1	0	0	1	2	2	1	0	0	-1
Traffic volume	-1	-1	0	0	1	1	1	1	2	2
design complexity	-1	-1	0	0	1	1	1	2	3	3
ODOT staffing level	0	0	1	1	1	2	2	3	3	4
Project size	-1	-1	-1	0	0	0	1	1	2	3

As shown in the table, when compared against the much more common low-price method, a qualifications-only project has little advantage, and it may actually create delay in a simple project. The amount of effort required to ensure fair negotiations may cause delay, and the monopoly nature of the negotiations may require a third party's involvement in evaluating any price proposals. However, when applied to a complex project that may likely encounter many changes, a Qualifications-Only selection process may likely mean that the project will be performed by a firm that has been chosen by its ability to respond quickly and fairly to such changes. In this case, this method is expected to offer gains of time over the baseline case – the low-price method.

### 4.3.4 Observations of the Selection Process Scoring

When viewing the graphs of the timeliness effect scores across the three selection process methods and the baseline low-price method (Figures 3.11 through 3.14), it may be noted that in

general each of the methods discussed herein have the promise of improving schedule under most circumstances. However, the A+B method, with its clear focus on time, presents the most significant opportunity for improvement over the base, low-price selection process, with the notable exceptions of complex utility or ROW conditions.

These selection processes are generally less effective at schedule improvement, however, for projects that are simple in nature, as those simple projects are generally well-understood and efficiently performed as a base condition. And, in those cases where pricing is locked in, discovery of unexpected change conditions may cause a degradation of schedule advantage—perhaps even to the point of slight schedule loss due to difficulty of dealing with changes under less well-understood contractual conditions.

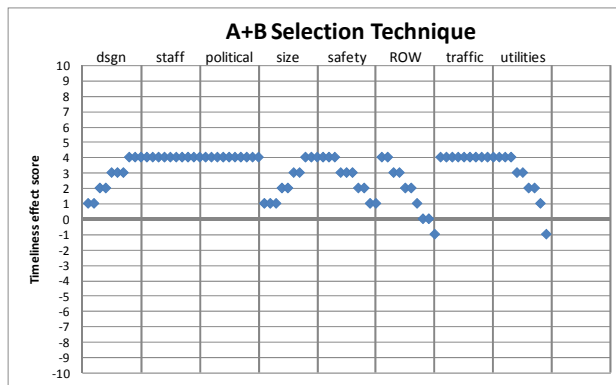


Figure 4.5: A+B selection process scores

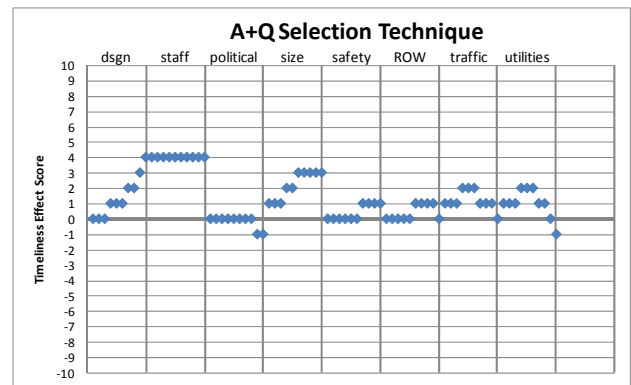


Figure 4.6: A+Q selection method scores

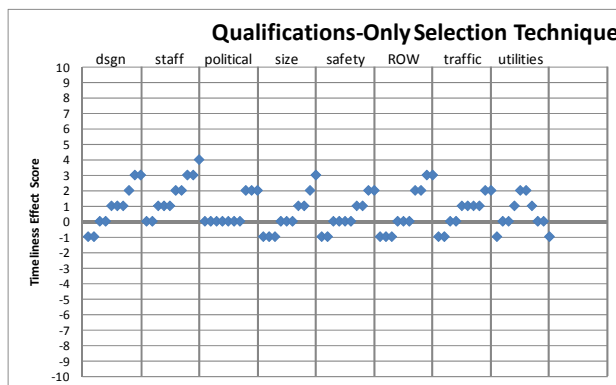


Figure 4.7: Qualifications-Only selection method scores

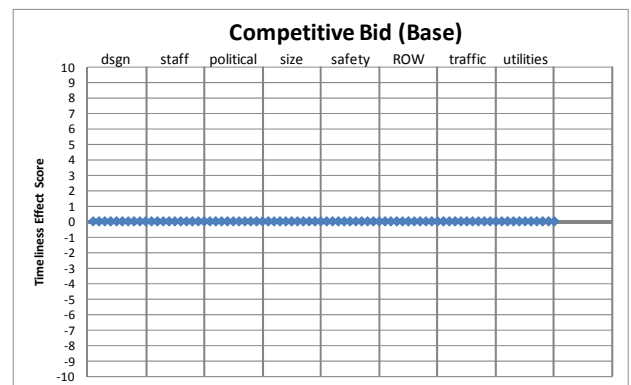


Figure 4.8: Low-price (base) selection method scores

## **4.4 SUMMARY**

Six individuals from ODOT were chosen for their expertise and contrasting perspectives in their experience of alternative contracting methods. These individuals were provided material explaining the proposed model and its theoretical underpinnings, and they participated in an additional discussion of the proposed model as a group. The individuals met to provide data to populate the model. The meeting consisted of asking for a collective opinion about the degree of success of a particular contracting method, given various project factors.

The results indicated that all of the alternative project delivery methods hold promise to reduce project time. However, this general rule does not hold in all circumstances. In certain complex situations, project delivery methods which involve early contractor price or performance guarantees may interfere with the ability to be flexible as project issues are discovered in the field. Further, certain alternative techniques require significant overhead – higher than normal administration or special permission. The cost of this overhead may be a schedule hindrance when projects are small.





## 5.0 MODEL TRIALS

The purpose of the model trials was to evaluate whether the model would provide recommendations for timeliness methods that were substantially similar to those that would be provided by a group of experts. To accomplish this, six test projects were developed, varying the characteristics for each project. These project profiles were entered into the MSeT model to produce a list of recommended, prioritized methods for each project. The resulting recommendations were then qualitatively compared against the earlier-gathered opinions of the expert panel, as described in the previous chapter.

### 5.1 TEST PROJECTS

Project profiles for six test projects were developed. These project profiles were represented by differing combinations of the focal project characteristics, listed in Table 3.4. The characteristic combinations were chosen to reflect potential real-world projects, while at the same time providing a wide cross-section of conditions. For each characteristic, a scale value was provided and a brief description of the test project was included; these descriptions are listed in Appendix C. Table 5.1 lists the combinations of characteristics and scores that correspond to the descriptions in Appendix C.

**Table 5.1: Test project profiles used for validation**

Characteristic	Project Profile Scores					
	Project A	Project B	Project C	Project D	Project E	Project F
Traffic Volume	1	8	3	3	9	3
Political Sensitivity	5	7	5	4	9	5
Design Complexity	3	4	5	3	8	6
ODOT Staffing Level	2	2	2	4	7	6
Public Safety Concern	2	5	6	8	8	8
Utilities	1	1	5	2	8	1
Right-of-Way	1	1	1	4	5	1
Size	4	2	2	3	8	5

These projects may be best visualized when plotted on “radar charts,” as shown collectively in Figure 5.1. These charts are especially helpful when the nature of the scale is in the same direction. In the case of these factors, a smaller number generally means a less complex project situation. Therefore, for example, Project A appears to be less complex than the other projects, as the area bounded by the plot is less than that of the other graphs. However, since the timeliness factor is a different function for each characteristic, the effect of the characteristic scores can only be determined through the algorithms described earlier in this report.

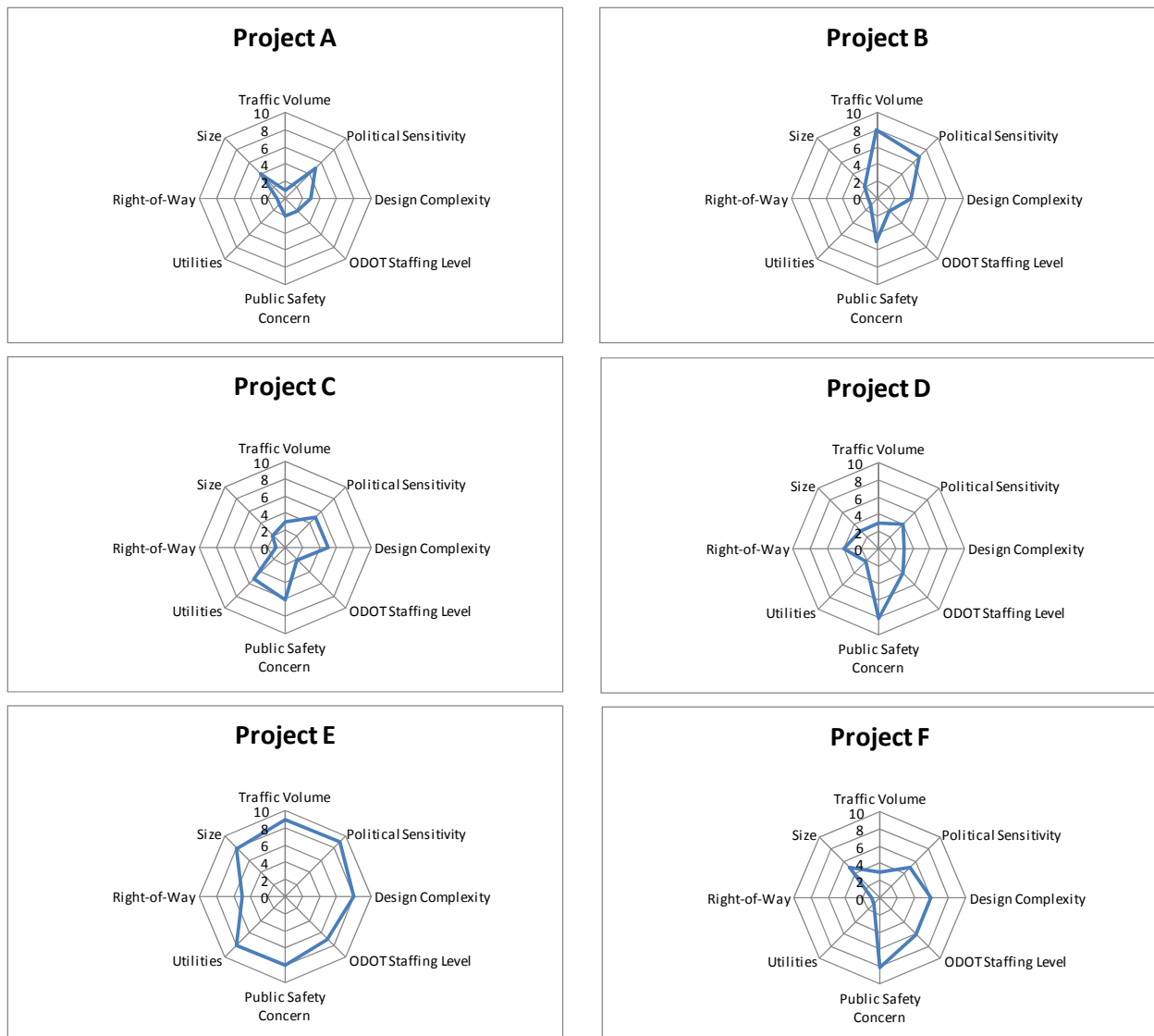


Figure 5.1: Test Projects A-F radar charts

## 5.2 TEST PROJECT TRIALS METHOD SCORES

The project profiles noted in Table 5.1 were entered into the model, and Table 5.2 lists the results. The results are intended to provide recommendations for selection of alternative methods, where project timeliness is paramount. It should be noted that in conditions other than emphasis on timeliness (such as emphasis on low cost or on high quality), other recommendations may be appropriate.

The results may be interpreted as the expectation that a particular method will improve a schedule as follows: +10 = schedule improvement by 50% or greater; 0 = no schedule improvement; -10 = schedule delay by 50% or greater. Ratings between the points noted are

proportionately adjusted. For example, in Table 5.2 the A+B selection method is expected to improve the schedule of Project A by a score of +3.5, or 35% of the 50% schedule improvement associated with a +10 score, i.e., a 17.5% schedule improvement. Of course, this value should be considered a broad estimate only, since many compounding factors may be involved. However, as a relative measure of the alternatives available, it is useful for determining which methods should be most strongly considered for improving project timeliness.

**Table 5.2: Method scores for test projects**

	<b>Model Methods Scores</b>					
	<b>Project A</b>	<b>Project B</b>	<b>Project C</b>	<b>Project D</b>	<b>Project E</b>	<b>Project F</b>
<b>Selection Methods</b>						
Low Price (Baseline)	0	0	0	0	0	0
A+B	3.50	3.25	3.25	3.00	3.125	3.375
A+Q	1.00	1.00	1.125	1.00	1.375	1.25
Qualifications Only	-0.50	-0.25	0.125	0.125	1.25	0.25
<b>Teaming Methods</b>						
GC (Baseline)	0	0	0	0	0	0
Design-Build	4.50	4.00	3.875	4.125	3.00	4.25
CM/GC	1.875	1.875	2.125	2.00	3.00	2.625
BOT	2.25	2.25	2.00	2.125	1.50	2.375

### 5.3 ANALYSIS AND SUMMARY

The charts shown in Figure 5.2 provide a graphical representation of the relative recommendations of methods for the six test projects. For all test project profiles, the selection process of A+B (cost and time) is significantly preferred for improving project timeliness over the three other comparison methods, Low-price, A+Q, and Qualifications-Only. The Qualifications-Only process is worth consideration only as the projects become larger and more complex, as in the case of Project E.

In terms of teaming method, the model significantly favors the design-build method for those projects shown, except in the case of Project E, which is a very large, complex project. This confirms the expert opinions that design-build projects tend to “box-in” the design early, which can create difficulty when a complex project must react to field changes.

The model results for selection methods align well with the preferences of the experts, as shown in Figures 4.5 through 4.8 in the previous chapter. Thus, the model may be relied upon to reflect a result similar to expert opinion. Similarly, the teaming methods prioritized by the model closely align with the expert opinion-based ratings shown in Figures 4.1 through 4.4.

While the model results are consistent with expert opinion, they may be considered valid only within the confines of the limited selection of project characteristics and timeliness methods chosen for testing of the Methods Selection Tool. Further, these results are valid only under the condition that timeliness is a primary objective for the choice of alternative methods. The tool

may easily be expended under a production mode by adding additional methods and characteristics, then developing the relationship between the two. It is the assumption of this research that this model will move forward into production, and that a database of the important factors will be maintained for actual use.

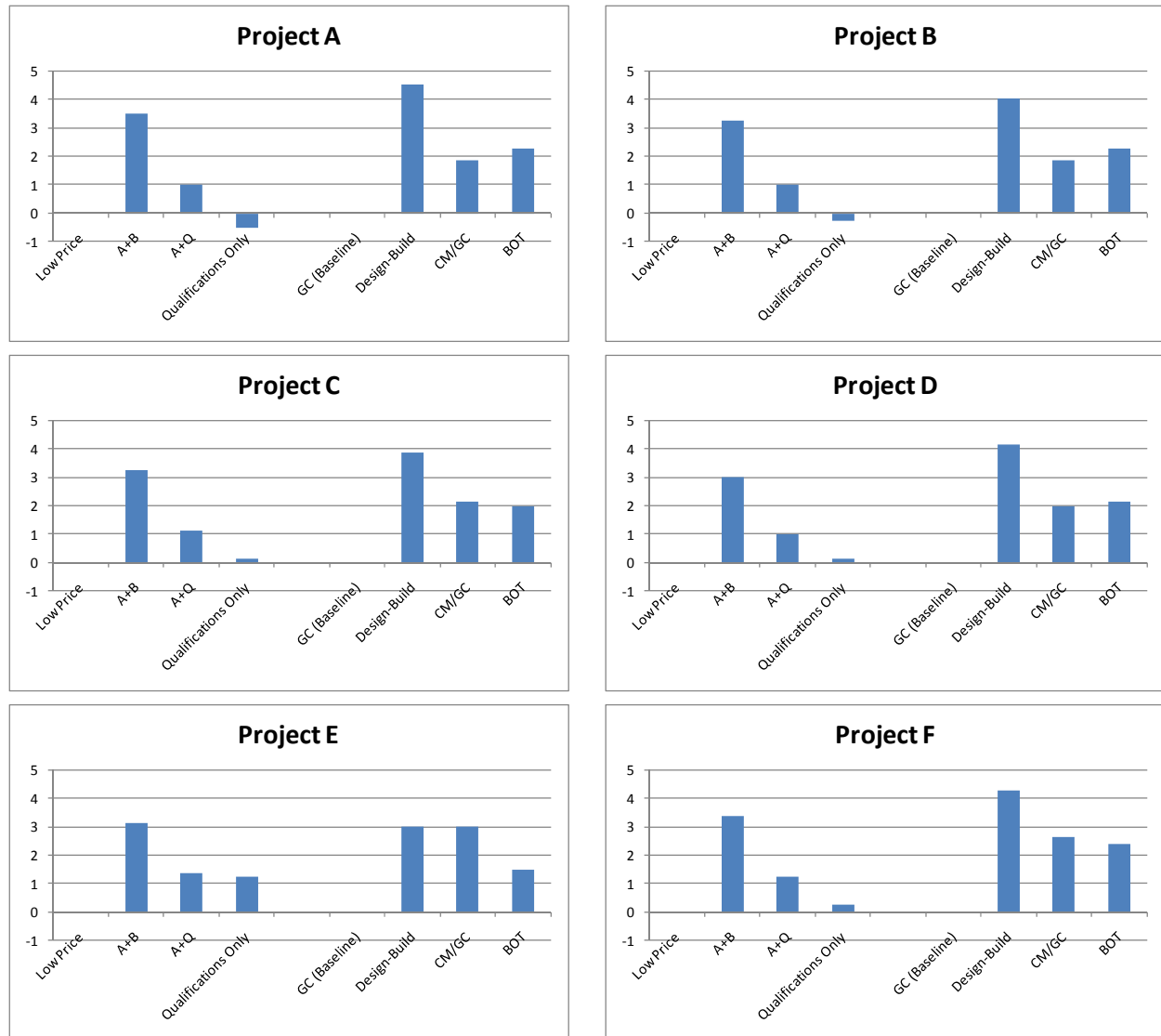


Figure 5.2: Test Projects A-F method scores

## **6.0 IMPLEMENTATION**

It was the intent of this project to model a methods selection tool that would be accessible, both in terms of the underlying structure and in terms of physically enabling both managers and users access to the program. Utilizing a web-based format achieves the latter goal; restricting the structure to the basic mathematics described in the previous section achieves the former.

### **6.1 WEB-BASED, SERVER-SIDE CONFIGURATION**

The proposed model was developed and tested as a server-based tool, with access provided to both manager and user through HTML and PHP-script pages, which were accessible from a public Internet connection. This same implementation may be useful for full-scale implementation at the enterprise level (beyond the scope of this project). For purposes of security, access to these pages may be restricted by requiring registered users to supply an access password. The calculation of the results would be accomplished by a processing module located on the central server. Figure 6.1 presents a schematic representation of this system, and the test model (available on the date of this report) may be accessed at <http://cce.oregonstate.edu/research/odottools/newsite> .

#### **6.1.1 System Software**

The Methods Selection Tool (MSeT) model was implemented for testing and research purposes, using HTML and PHP/SQL coding to develop web pages that acquire input and calculate the prioritized methods. The purpose of this development was to create a simplified model for testing the concepts and algorithms, not to create a production system. As such, the model produced is insufficient for institutionalization and must be adapted to any existing procedures and internal regulations for data integrity and security. Within those constraints, the rough early developmental code that was used to create the experimental model is included in Appendix D.

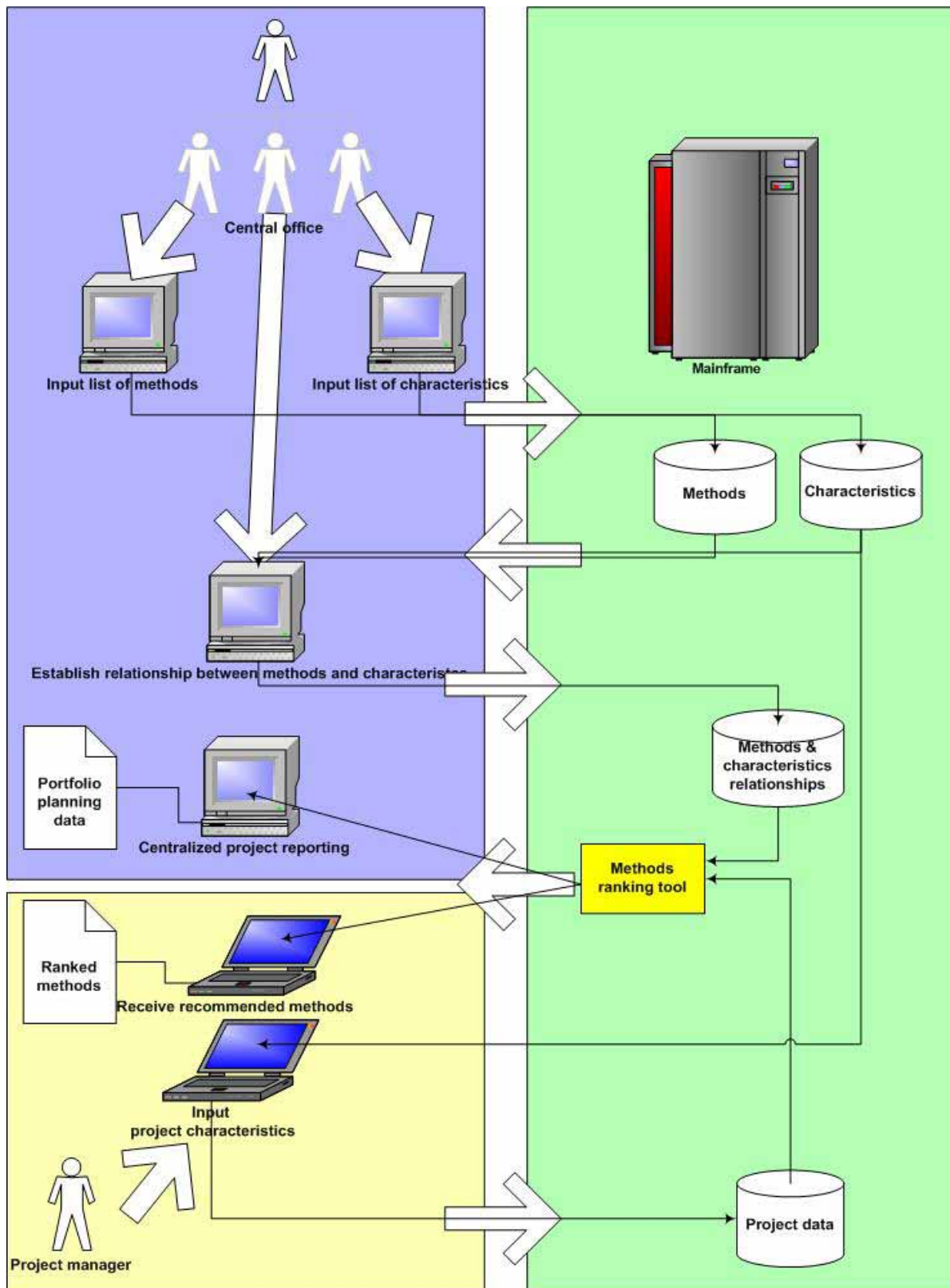


Figure 6.1: Methods Selection Tool (MSeT) schematic

Web pages were developed in accordance with the site map schema shown below:

## Site Map

1. Main
  - 1.1. Base
    - 1.1.1. Characteristics List
      - 1.1.1.1. Characteristics Add
      - 1.1.1.2. Characteristics Detail
      - 1.1.1.3. Characteristics Modify (Not implemented)
      - 1.1.1.4. Characteristics Delete (Not implemented)
    - 1.1.2. Methods List
      - 1.1.2.1. Methods Add
      - 1.1.2.2. Methods Detail
      - 1.1.2.3. Methods Modify
      - 1.1.2.4. Methods Delete
    - 1.1.3. Char/Meth Matrix
      - 1.1.3.1. Methods List
      - 1.1.3.2. Char/Meth
      - 1.1.3.3. Characteristics List
      - 1.1.3.4. Char/Meth Scoring
  - 1.2. Project List
    - 1.2.1. Project Review/Modify
      - 1.2.1.1. Project Add
      - 1.2.1.2. Project Delete (Not Implemented)
      - 1.2.1.3. Proj/Char List
      - 1.2.1.4. Prioritized Methods
      - 1.2.1.5. Characteristic Assessment

## 6.2 DATABASE STRUCTURE

The database structure utilizes six separate tables. These tables are briefly characterized below:

- Characteristics – a listing of the individual independent variables (project attributes) that affect the selection of various project development methods (project methods).
- Methods – a listing of the individual methods or techniques used at various stages of the project development that are alternatives to consider when attempting to expedite a project. The success of these methods is dependent upon the project characteristics or attributes.
- Projects – the detailed information about the projects themselves.
- Charmeth – the repository for the expert-opinion based relationships between how successfully a particular method will improve the schedule of a project, given the status of a particular project characteristic.
- Projchar – this table holds the “project profile” – a listing of the ratings of the various characteristics on a particular project.

- Projmeth – this table holds the results of the ranked methods, given a particular project profile and the experts’ opinions regarding the likely success of a method on a project with those particular characteristics.

This database was structured for experimental purposes using a MySQL database. Some fields were included merely for demonstration purposes, and may be disregarded. In a production database, these tables may be expanded considerably and likely integrated within a larger project-related database. A table relationship graphic from the MySQL database is included in Appendix E for reference purposes.

## 6.3 SUMMARY

This project may be implemented 1) through providing solution options at the operating levels of ODOT (documented through appropriate means, such as modifications to the Oregon Standard Specifications, memos of practice, and other similar documents); and 2) through upper management initiative to create awareness among those operating personnel of the need to regularly evaluate the use of time-enhancing methods on schedule-critical projects.

Potential benefits of implementation include the following:

- Increased on-time project performance;
- More consistent project performance, leading to a strengthened ability to manage corridor-wide delays and improve traffic mobility;
- Additional use of design, contract, or project management tools for enhancing schedule performance; and
- Increased internal awareness of the importance of schedule performance.



## 7.0 CONCLUSION

Project timeliness is an important goal in any transportation improvement project. On certain projects timeliness is a high priority due to factors such as public need for access to living areas, safe movement of traffic, and movement of transit. In recent years, alternative methods of project delivery have evolved, providing many choices to the highway project manager for improving the timely delivery of projects.

Projects vary considerably in their characteristics: some are small, some large; some are complicated, some simple; some are urban, some rural. As found in this study, this wide variety of projects can, exhibit different results when subjected to different project delivery methods. Therefore, this study has sought to propose a model that considers various project conditions in determining which delivery method would be most likely to encourage timely delivery under the project's unique characteristics. The problem is complex, as there are many delivery methods and many characteristics to consider; and this complex combination of methods and characteristics may affect project timeliness as inhibitors, encouragers, or both.

A variety of theoretical models were considered, leading to development of the Methods Selection Tool (MSeT). Ultimately, it was found that most of the existing theoretical models worked within the environment of competing goals; this project, however, focused on the single goal of timeliness. An objective of this study was to create a repeatable model for methods selection. In order to accomplish this, a new algorithm was developed. This algorithm was based on acquisition of expert opinion that may be used in a model that systematically considers unique project conditions. Given objective input regarding project conditions, the model will provide repeatable recommendations for project delivery methods.

Future research would do well to expand this model to consider the effects of competing goals. In such a future effort, existing decision models, as described herein, should prove very useful. Such model expansion would require the acquisition of expert opinion related to the effect of project delivery methods on parallel goals such as cost efficiency, quality, or others. Further work with the models would expand base knowledge of these methods and would capture project delivery experience gained over the past several decades.



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## **APPENDICES**



## **APPENDIX A: DATA FOR MULTI-CRITERIA DECISION MODEL EXAMPLES**



## APPENDIX A: DATA FOR MULTI-CRITERIA DECISION MODEL EXAMPLES

The following data is used in the discussion of Multi-Criteria Decision Models (MCDAs), in the body of the report. The cells of the following matrix “A” are populated with a score that represents the performance of an alternative method—represented by the rows, under a certain criteria (or goal)—represented by the columns.

$$A = \begin{bmatrix} 25 & 20 & 15 & 30 \\ 10 & 30 & 20 & 30 \\ 30 & 25 & 30 & 10 \end{bmatrix}$$

The matrix “W,” below, represents the weighted importance of the various criteria (or goals) that are indicated by the columns in matrix “A”, above.

$$W = \begin{bmatrix} 0.20 & 0 & 0 & 0 \\ 0 & 0.15 & 0 & 0 \\ 0 & 0 & 0.40 & 0 \\ 0 & 0 & 0 & 0.25 \end{bmatrix}$$

The table below shows the two matrices combined into a format that illustrates the relationship among the alternatives, goals, and weights.

Criteria					
<u>Goals&gt;</u>		<u>C<sub>1</sub></u>	<u>C<sub>2</sub></u>	<u>C<sub>3</sub></u>	<u>C<sub>4</sub></u>
<u>Alts.</u>	<u>Weights&gt;</u>	<u>0.20</u>	<u>0.15</u>	<u>0.40</u>	<u>0.25</u>
A <sub>1</sub>		25	20	15	30
A <sub>2</sub>		10	30	20	30
A <sub>3</sub>		30	25	30	10





## **APPENDIX B: TIMELINESS EFFECT INPUT**



## APPENDIX B: TIMELINESS EFFECT INPUT

In order to establish a generic relationship between Characteristics and Methods, as they relate to Timeliness Effect, an expert panel was convened and asked to complete the following form for each Method under consideration. The initial results were then displayed and the panel discussed and reached a round-one consensus on the relationships. At the end of the data gathering, the panel then performed a final review and adjusted values in order to provide for consistency of scores across methods.

For brevity, the following shows an example of the input form for the ***Design-Build Teaming Method*** and for the ***A+B Selection Method***. Similar forms were produced for each of the alternate teaming and selection methods

## Timeliness Effect Input Instructions

### Instructions:

On the next several pages you will find a series of worksheets designed to gather input about the *timeliness effect*<sup>1</sup> of a particular project delivery *method* under the condition of a particular project *characteristic*. These graphical representations will establish a set of generic conditions that will be used later in a model designed to assess an effect score for a method for a particular project. An example follows on the next page.

Your inputs will be used to validate a model, proposed and developed under the ODOT research project *SPR 646: ALTERNATIVES TO LIQUIDATED DAMAGES FOR ENSURING PROJECT PERFORMANCE AND ADHERENCE TO COMPLETION DATES*. The inputs you provide will be combined with input from others, and will form a portion of the validation data.

In the example, the graphics represent the effect on timeliness that the use of the *Design-Build* method (as opposed to the baseline *General Contractor* method) will have, considering projects which exhibit certain degrees of *Design Complexity* or *Political Sensitivity*. In this instance, for example, if a project was considered not at all complex (*Complexity* of 1), then the addition of the design-build method would have only a slight positive effect (represented by the star at a *Complexity* rating of 1 and a *Timeliness Effect* rating of +1), compared to using a General Contractor. Similarly, the use of *Design-Build* on a highly politically-charged project (*Political Sensitivity* of 10) may actually have a slowing effect (represented by the star at *Political Sensitivity* rating of 10, and a *Timeliness Effect* rating of -3), again—compared to using a General Contractor.

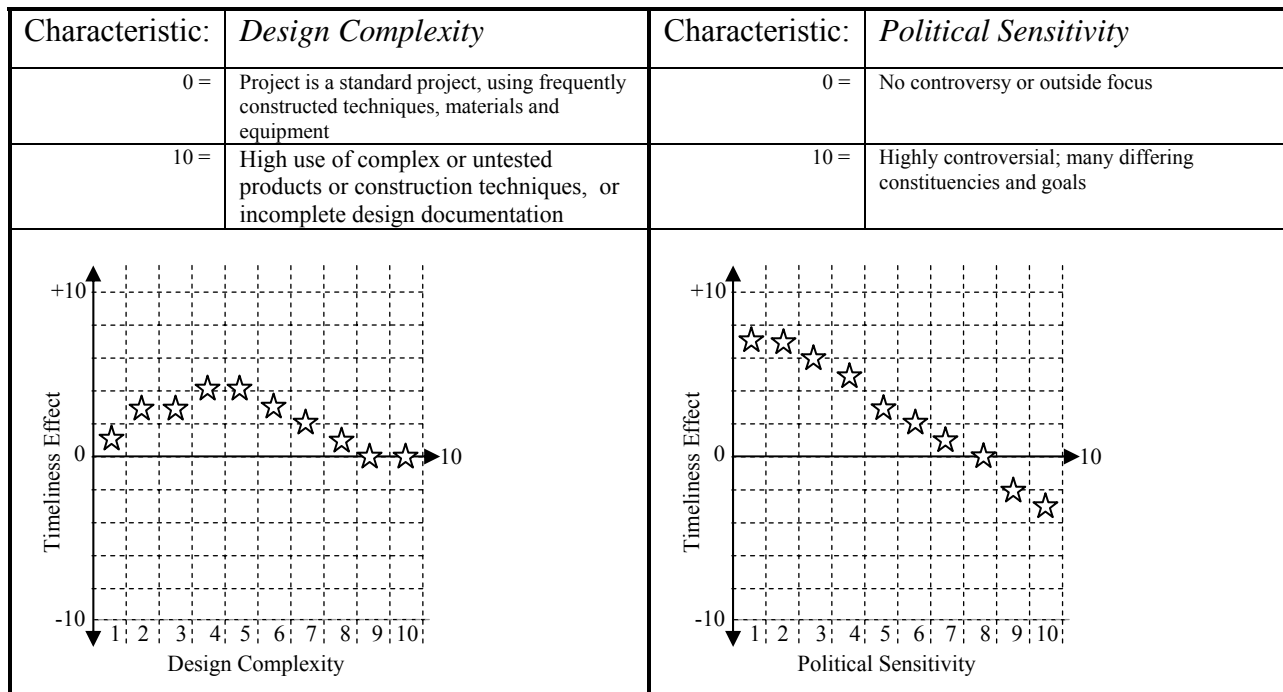
Following the example is a series of forms on which you will be asked to score, for each characteristic condition of 1 through 10, the effect that the method would have on accelerating or slowing a project, if the method had been used instead of the baseline method. In indicating your scores, you may use a star, a dot, or a line to represent how timeliness effect will vary over the characteristic's range. If you have any questions, please contact me as indicated two pages later.

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<sup>1</sup> *Timeliness Effect* is scored based on the expected effect of an alternative technique to produce a schedule change, considering the project characteristic. The rating is based on a scale of change from a reasonably-develop schedule on a project using the baseline technique as follows:  
+10 = schedule improvement by 50% or greater; 0 = no schedule improvement; -10 = schedule delay by 50% or greater. Ratings between the points noted are proportionately adjusted.

**Example:** Generic relationships between the *Method of Design-Build* contract delivery and two *Characteristics*—*Design Complexity* and *Political Sensitivity*—have been hypothetically established as follows (this is an example only; please rate these later as you believe appropriate):

<b>Alternative Method:</b>	<b><i>Design-Build</i></b>
Baseline Method:	<i>General Contractor</i>



The compounded effect of the *Design-Build* method on a project with the characteristics of being simple (characteristic level of 1) and highly politically charged (characteristic level of 10) would be an average effect of -1 (average of {+1, -3}).

On the following forms, you will rate the following methods:

<b>METHOD</b>
<u>Team Structure</u>
General Contractor (Baseline)
• <b>Design Build</b>
• <b>Construction Management</b>
• <b>Build Operate Transfer (BOT)</b>
<u>Selection Process</u>
Low-price (Baseline)
• <b>A + B</b>
• <b>A + Q</b>
• <b>Qualifications only</b>

For the following characteristics:

CHARACTERISTIC
• Traffic Volume
• Political Sensitivity
• Design Complexity
• ODOT Staffing level
• Public Safety Concern
• Utilities
• Right-of-Way
• Size

# Timeliness Effect Input Form

## Instructions:

Please graphically indicate (following the example in the instructions) the *timeliness effect*<sup>2</sup> of the rated project delivery *method* for all 10 conditions of the particular project *characteristic*. These graphical representations will establish a set of generic relationships that will be used later to assess an effect score for a method on a particular project with specific characteristics.

<b>Alternative Method:</b>		<b><u>Design-Build</u></b>	
Baseline Method:		<i>General Contractor</i>	

Characteristic:	<b><i>Traffic Volume</i></b>	Characteristic:	<b><i>Political Sensitivity</i></b>
0 =	No traffic affected; detours not required or easily accomplished	0 =	No controversy or outside focus
10 =	Large traffic counts and long detours required; roadway blocked for significant periods of time.	10 =	Highly controversial; many differing constituencies and goals
Characteristic:	<b><i>Design Complexity</i></b>	Characteristic:	<b><i>OOT Staffing Level</i></b>
0 =	Project is a standard project, using frequently constructed methods, materials and equipment	0 =	Staffing fully available, including replacement staff as needed
10 =	High use of complex or untested products or construction methods, or incomplete design documentation	10 =	Staffing is severely limited

<sup>2</sup> *Timeliness Effect* is scored based on the expected effect of the alternative technique to produce a schedule change, considering the project characteristic. The rating is based on a scale of change from a reasonably-develop schedule on a project using the baseline technique as follows:  
+10 = schedule improvement by 50% or greater; 0 = no schedule improvement; -10 = schedule delay by 50% or greater. Ratings between the points noted are proportionately adjusted.

# Timeliness Effect Input Form

## Instructions:

Please graphically indicate (following the example in the instructions) the *timeliness effect*<sup>3</sup> of the rated project delivery *method* all 10 conditions of the particular project *characteristic*. These graphical representations will establish a set of generic relationships that will be used later to assess an effect score for a method on a particular project with specific characteristics.

<b>Alternative Method:</b>		<b>Design-Build</b>	
Baseline Method:		General Contractor	
Characteristic:	<b>Public Safety Concern</b>	Characteristic:	<b>Utilities</b>
0 =	No concern over public safety;	0 =	No public utilities affected by the project
10 =	High likelihood of public harm; highly constricted access for EMS vehicles and staff	10 =	High incidence of utility crossing; poor utility locations; many underground locations; utilities serving large populations
<p>Timeliness Effect</p> <p>Public Safety</p>		<p>Timeliness Effect</p> <p>Utilities</p>	
Characteristic:	<b>Right-of-Way</b>	Characteristic:	<b>Size</b>
0 =	All right-of-way issues resolved	0 =	Cost < \$1,000,000
10 =	Right-of-way issues unresolved; highly controversial; likely court challenges	10 =	Cost > \$100,000,000
<p>Timeliness Effect</p> <p>Right-of-Way</p>		<p>Timeliness Effect</p> <p>Climate</p>	

<sup>3</sup> *Timeliness Effect* is scored based on the expected effect of the alternative technique to produce a schedule change, considering the project characteristic. The rating is based on a scale of change from a reasonably-develop schedule on a project using the baseline technique as follows:  
+10 = schedule improvement by 50% or greater; 0 = no schedule improvement; -10 = schedule delay by 50% or greater. Ratings between the points noted are proportionately adjusted.



Please graphically indicate (following the example in the instructions) the *timeliness effect*<sup>4</sup> of the rated project delivery *method* all 10 conditions of the particular project *characteristic*. These graphical representations will establish a set of generic relationships that will be used later to assess an effect score for a method on a particular project with specific characteristics.

<b>Alternative Method:</b>		<b>A+B Selection Process</b>	
Baseline Method:		Low-price	
Characteristic:	<b><i>Traffic Volume</i></b>	Characteristic:	<b><i>Political Sensitivity</i></b>
0 =	No traffic affected; detours not required or easily accomplished	0 =	No controversy or outside focus
10 =	Large traffic counts and long detours required; roadway blocked for significant periods of time.	10 =	Highly controversial; many differing constituencies and goals
Characteristic:	<b><i>Design Complexity</i></b>	Characteristic:	<b><i>OOT Staffing Level</i></b>
0 =	Project is a standard project, using frequently constructed techniques, materials and equipment	0 =	Staffing fully available, including replacement staff as needed
10 =	High use of complex or untested products or construction techniques, or incomplete design documentation	10 =	Staffing is severely limited

<sup>4</sup> *Timeliness Effect* is scored based on the expected effect of the alternative technique to produce a schedule change, considering the project characteristic. The rating is based on a scale of change from a reasonably-develop schedule on a project using the baseline technique as follows:  
+10 = schedule improvement by 50% or greater; 0 = no schedule improvement; -10 = schedule delay by 50% or greater. Ratings between the points noted are proportionately adjusted.

## Timeliness Effect Input Form

### Instructions:

Please graphically indicate (following the example in the instructions) the *timeliness effect*<sup>5</sup> of the rated project delivery *method* all 10 conditions of the particular project *characteristic*. These graphical representations will establish a set of generic relationships that will be used later to assess an effect score for a method on a particular project with specific characteristics.

<b>Alternative Method:</b>		<b>A+B Selection Process</b>	
Baseline Method:		<i>Low-price</i>	

<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 15%;">Characteristic:</td> <td><b><i>Public Safety Concern</i></b></td> </tr> <tr> <td>0 =</td> <td>No concern over public safety;</td> </tr> <tr> <td>10 =</td> <td>High likelihood of public harm; highly constricted access for EMS vehicles and staff</td> </tr> </table> <div style="text-align: center;"> <p>Public Safety</p> </div>	Characteristic:	<b><i>Public Safety Concern</i></b>	0 =	No concern over public safety;	10 =	High likelihood of public harm; highly constricted access for EMS vehicles and staff	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 15%;">Characteristic:</td> <td><b><i>Utilities</i></b></td> </tr> <tr> <td>0 =</td> <td>No public utilities affected by the project</td> </tr> <tr> <td>10 =</td> <td>High incidence of utility crossing; poor utility locations; many underground locations; utilities serving large populations</td> </tr> </table> <div style="text-align: center;"> <p>Utilities</p> </div>	Characteristic:	<b><i>Utilities</i></b>	0 =	No public utilities affected by the project	10 =	High incidence of utility crossing; poor utility locations; many underground locations; utilities serving large populations
Characteristic:	<b><i>Public Safety Concern</i></b>												
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Characteristic:	<b><i>Utilities</i></b>												
0 =	No public utilities affected by the project												
10 =	High incidence of utility crossing; poor utility locations; many underground locations; utilities serving large populations												
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 15%;">Characteristic:</td> <td><b><i>Right-of-Way</i></b></td> </tr> <tr> <td>0 =</td> <td>All right-of-way issues resolved</td> </tr> <tr> <td>10 =</td> <td>Right-of-way issues unresolved; highly controversial; likely court challenges</td> </tr> </table> <div style="text-align: center;"> <p>Right-of-Way</p> </div>	Characteristic:	<b><i>Right-of-Way</i></b>	0 =	All right-of-way issues resolved	10 =	Right-of-way issues unresolved; highly controversial; likely court challenges	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 15%;">Characteristic:</td> <td><b><i>Size</i></b></td> </tr> <tr> <td>0 =</td> <td>Cost &lt; \$1,000,000</td> </tr> <tr> <td>10 =</td> <td>Cost &gt; \$100,000,000</td> </tr> </table> <div style="text-align: center;"> <p>Climate</p> </div>	Characteristic:	<b><i>Size</i></b>	0 =	Cost < \$1,000,000	10 =	Cost > \$100,000,000
Characteristic:	<b><i>Right-of-Way</i></b>												
0 =	All right-of-way issues resolved												
10 =	Right-of-way issues unresolved; highly controversial; likely court challenges												
Characteristic:	<b><i>Size</i></b>												
0 =	Cost < \$1,000,000												
10 =	Cost > \$100,000,000												

**THANK YOU!**

<sup>5</sup> *Timeliness Effect* is scored based on the expected effect of the alternative technique to produce a schedule change, considering the project characteristic. The rating is based on a scale of change from a reasonably-develop schedule on a project using the baseline technique as follows:

+10 = schedule improvement by 50% or greater; 0 = no schedule improvement; -10 = schedule delay by 50% or greater. Ratings between the points noted are proportionately adjusted.

## **APPENDIX C: TEST PROJECT PROFILES**



## APPENDIX C: TEST PROJECT PROFILES

### Project A

Project description: This project is a bridge crossing of the Willamette River, approximately 250 feet in length. The structural material is yet to be determined. It is expected to be two traffic lanes wide, with a pedestrian and bicycle passageway incorporated. Approach work is minor, mainly a slight configuration of the existing roadway.

Project characteristics:

- Traffic at this crossing is very high; however, alternative crossings are available close-by, so the work itself will not be affected by the traffic.
- Politically, this project is favored for completion; it is, however, closely monitored by environmental groups who have concerns over river contamination and disturbance.
- The project is essentially straight-forward, complicated only in the abutment work at the river banks.
- Adequate levels of staffing are available within ODOT.
- This project is an important crossing for the public safety vehicles of the adjacent communities, however, the adjacent crossings are sufficient for stable safety service.
- Utilities are well-documented and all rights-of-way and easements are obtained.

<b>Project A Profile</b>	Traffic Volume	Political Sensitivity	Design Complexity	ODOT Staffing Level	Public Safety Concern	Utilities	Right-of-Way	Size
Score	1	5	3	2	2	1	1	6

### Project B

Project description: This project is a paving grind and inlay approximately 22 miles in length. It is expected to be two traffic lanes wide and improvements to four lanes wide over 5 miles of the existing roadway which includes a climbing lane for 3 of the 5 miles of widening. ADT is high and guardrail, striping and significant signage will be incorporated. Approach work is minor with one change of configuration to an onramp at the base of the climbing lane.

Project characteristics:

- Traffic is very high; setting is rural with two urban sections at the ends of the project.
- Politically, this project is favored for completion; however, the climbing lane will require some clearing and slope stabilization.
- The project is essentially straight-forward, complicated only by the stability of slopes in the climbing lane area.
- Adequate levels of staffing are available within ODOT.

- This project is an important due to heavy trucking in the corridor and safety concerns for passing site distances in the climbing area. The inlay work is required preservation work that could delay one year.
- Utilities are well-documented and all rights-of-way and easements are obtained.

<b>Project B Profile</b>	Traffic Volume	Political Sensitivity	Design Complexity	ODOT Staffing Level	Public Safety Concern	Utilities	Right-of-Way	Size
Score	8	7	4	2	5	1	1	2

## Project C

Project description: This project is a concrete rubilization and paving project approximately 4 miles in length. It is expected to be four traffic lanes wide and a reduction in final grade of 12” to accommodate overpass clearance requirements. ADT is very high and guardrail, striping and significant signage will be incorporated. Approach and ramp work is will require accommodations for the changes in elevations. The project is landlocked on both sides and no additional space is available for traffic diversions.

Project characteristics:

- Traffic is very high; setting is urban.
- Politically, this project is favored for completion; however, current traffic flows must be maintained in the corridor due to local requirements.
- The project is essentially straight-forward, complicated by mobility restrictions, night work requirements and night noise work restrictions.
- Adequate levels of staffing are available within ODOT.
- This project is an important due to the growing failure of the existing surface. The project is 4 years beyond the present life of the road structure.
- Utilities are not well-documented and no additional rights-of-way and easements are available.

<b>Project C Profile</b>	Traffic Volume	Political Sensitivity	Design Complexity	ODOT Staffing Level	Public Safety Concern	Utilities	Right-of-Way	Size
Score	1	5	3	2	2	1	1	6

## Project D

Project description: This project is a widening of a present 2 lane project into 4 lanes with a cut into an existing deep embankment. The paving project approximately 1.5 miles in length. This is a coastal location and soils are very sandy. ADT is very medium and seasonal. Multiple approaches are available for slope stabilization. No alternate routes are available to detour traffic and local trucking must be maintained to communities along the corridor.

Project characteristics:

- Traffic is medium with local commuter connections.
- Politically, this project is favored for completion; but must maintain a local setting for tourism.
- The project is essentially straight-forward, complicated by the need to maintain an 80' deep cut in sand. Night work is preferred in the summertime.
- Adequate levels of staffing are available within ODOT for the roadway design but expertise is not available in house for the wall designs.
- This project is an important to the local jurisdictions and architectural review of the types of slope stabilization must meet local approval.
- Utilities are well-documented but no significant changes can be financed by local community. Additional rights-of-way and easements are available but must be taken from local businesses that support the architectural improvements but not the expansion from 2 to 4 lanes.

<b>Project D Profile</b>	Traffic Volume	Political Sensitivity	Design Complexity	ODOT Staffing Level	Public Safety Concern	Utilities	Right-of-Way	Size
Score	1	5	3	2	2	1	1	6

## Project E

Project description: This is a major reconstruction of a high-travelled state highway through a very busy commercial district in a high population center. The project consists of several bridges and fly-overs, and due to constricted working area, must be accomplished in multiple stages.

Project characteristics:

- Traffic is heavy on the existing highway, and detours must be constantly maintained for passage of commercial traffic.
- This project passes through multiple political jurisdictions and is expected to be extensively scrutinized in the public media..
- The project is constrained to the existing right-of-way, which is already heavily constructed and significant amounts of demolition will be required...
- This project will stretch the in-house design capability of ODOT.
- Disruption to local business and delay of commuter traffic are of great concern.

- Safety to the travelling and pedestrian public is also a concern.
- Due to the age of the existing infrastructure, utility locations are suspect and significant unexpected situations are anticipated.
- Construction easements are negotiated, but will be monitored heavily.

<b>Project E Profile</b>	Traffic Volume	Political Sensitivity	Design Complexity	ODOT Staffing Level	Public Safety Concern	Utilities	Right-of-Way	Size
Score	9	9	8	7	8	8	5	8

## Project F

Project description: This project is a rebuilding of a coastal tunnel interior liner. The project is approximately .4 miles in length of two lanes. ADT is very medium and seasonal. A single access is available from each end and minimal staging area is available. No alternate routes are available to detour traffic and local trucking must be maintained to communities along the corridor.

Project characteristics:

- Traffic is medium with local commuter connections.
- Politically, this project is favored for completion; but work is not allowed during the summer months due to the local setting for tourism.
- The project is essentially straight-forward, removing old timber and reline with gunite. The tunnel is oval in shape with a maximum clearance of 17' 6". Night work is required and truck traffic must be maintained for 8 hours each day.
- Adequate levels of staffing are not available within ODOT for the tunnel design.
- This project is an important to the local jurisdictions and architectural review
- No utilities or rights-of-way are required for the project.
- An active eagle nest was recently reported on the south entrance above the top of the tunnel. Local residents reported fledglings roosting in the nest the year previous.

<b>Project F Profile</b>	Traffic Volume	Political Sensitivity	Design Complexity	ODOT Staffing Level	Public Safety Concern	Utilities	Right-of-Way	Size
Score	1	5	3	2	2	1	1	6



## **APPENDIX D: MODEL TESTING CODE**



## APPENDIX D: MODEL TESTING CODE

### Site Map

The following is a list of web pages established as a schematic model for implementation of the methods selection tool. This schematic model was implemented solely for the purpose of testing the concepts developed in the research project, and is not intended to be a fully-functioning production program. However, the concepts included herein may be useful in developing a live selection tool. The software used for this implementation is HTML/PHP, using a MySQL database. The software was developed using Adobe Dreamweaver. Following this brief introduction is a listing of a screen shot of the various pages, along with the actual code.

1. Method Selection Tool Home Page
  - 1.1. Management Section Home
    - 1.1.1. Characteristic List
      - 1.1.1.1. Characteristic Add
      - 1.1.1.2. Characteristic Detail
        - 1.1.1.2.1. Characteristic Modify (Not implemented)
        - 1.1.1.2.2. Characteristic Delete (Not implemented)
    - 1.1.2. Method List
      - 1.1.2.1. Method Add
      - 1.1.2.2. Method Detail
        - 1.1.2.2.1. Method Modify
        - 1.1.2.2.2. Method Delete (Not implemented)
    - 1.1.3. Characteristic by Method—Method Choice
      - 1.1.3.1. Characteristic by Method Matrix
        - 1.1.3.1.1. Characteristic by Method Rating
  - 1.2. Project Section Home
    - 1.2.1. Project Add
    - 1.2.2. Project Detail/Modify
      - 1.2.2.1. Project Delete (Not Implemented)
    - 1.2.3. Project Characteristic Profile
      - 1.2.3.1. Project Characteristic Rating
      - 1.2.3.2. Project Method Rating

# Method Selection Tool Home



## NOTE

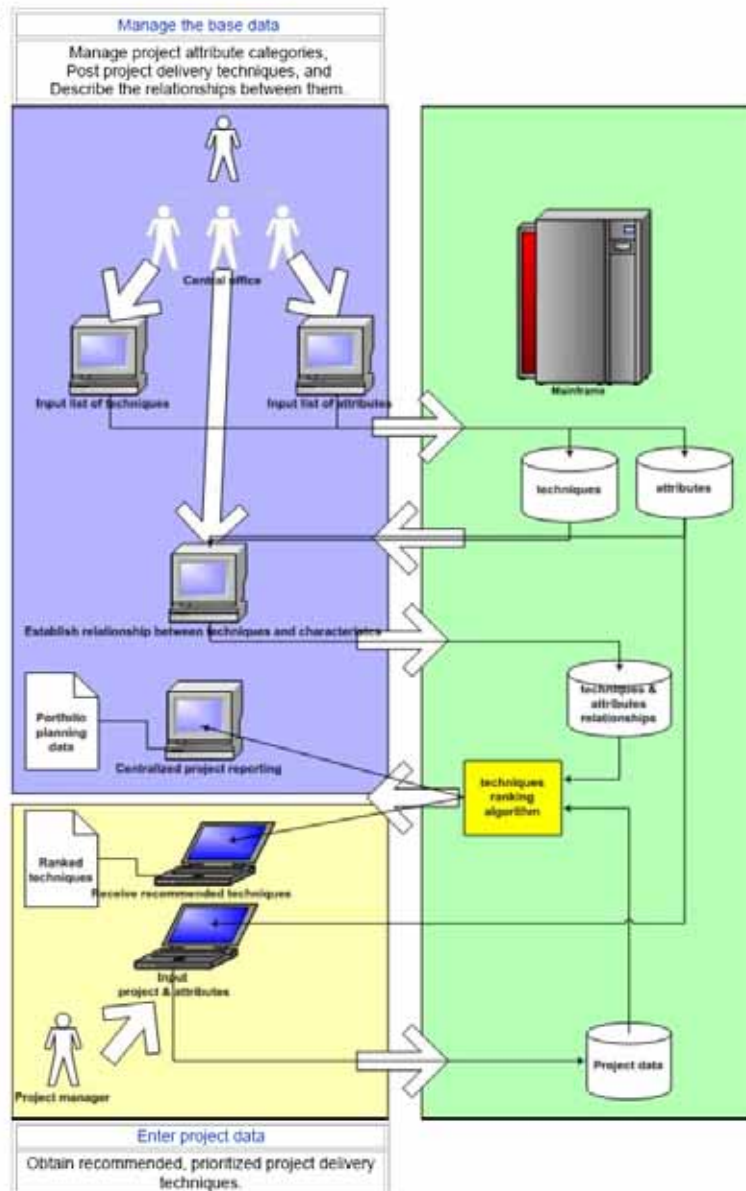
This is an experimental website, created by researchers at Oregon State University for developmental and demonstration purposes only. It is not endorsed by the Oregon Department of Transportation (ODOT), and may contain inaccurate or incomplete information.

For further information, contact [David N. Sitaris, PhD](#)

The purpose of this proposed tool is to provide a basis for deciding whether to use several available contracting and project administrative techniques. This tool is in development and may contain incomplete or inaccurate information. A rough draft document which explains the tool development may be viewed [here](#).

## Welcome to the project delivery Techniques Selection Tool!!

Below you may manage the centralized, [base data](#); or, you may describe [project data](#) to obtain a prioritized list of techniques which may help keep your project timely.



```

<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<html>
<head>
<title>Project Methods Section Tool</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
</head>

<body>

<table width="697" border="0" cellpadding="0" cellspacing="0">
  <!--DWLayoutTable-->
  <tr>
    <td width="697" height="59" valign="top" bgcolor="#43526C"></td>
  </tr>
  <tr>
    <td height="92" valign="top" bgcolor="#FFFF66"> <div align="center">
      <p><u><font size="-2">NOTE</font></u></p>
      <p><font size="-2"><u>This is an experimental website, created by
researchers
      at Oregon State University for developmental and demonstration
purposes
      only. It is not endorsed by the Oregon Department of Transportation
      (ODOT), and may contain inaccurate or incomplete
information</u></font></p>
      <p><font size="-2"><u>For further information, contact: <a
href="mailto:david.sillars@oregonstate.edu">David
      N. Sillars, PhD</a> </u></font></p>
    </div></td>
  </tr>
</table>
<table width="698" border="0" cellpadding="0" cellspacing="0">
  <!--DWLayoutTable-->
  <tr>
    <td width="157" rowspan="4" valign="top" bgcolor="#6699FF"> The purpose
of
    this proposed tool is to provide a basis for deciding whether to use
several
    available contracting and project administrative methods. This tool is
in
    development and may contain incomplete or inaccurate information. A
rough
    draft document which explains the tool development may be viewed <a
href="Documents/Methods%20Selection%20Tool.pdf">here</a>.</td>
    <td width="18" height="243" rowspan="3" valign="top"><!--
DWLayoutEmptyCell-->&nbsp;</td>
    <td width="523" valign="top"> <p>
      <h1 align="center">Welcome to the project delivery</h1>
      <h1 align="center">Methods Selection Tool!!</h1>
      <p align="center">Below you may manage the centralized, <a
href="#basedatalink">base data</a>; or, you may describe <a
href="#projectdatalink">project data</a> to obtain a prioritized list of
methods which may help keep your project timely.</p>
      <p align="left">&nbsp;</p>
    </td>
  </tr>
  <tr>
    <td>
  </td>
  </tr>
  <tr>
    <td>
  </td>
  </tr>
</table>

```

```
  |
```

## Management Section Home



### NOTE

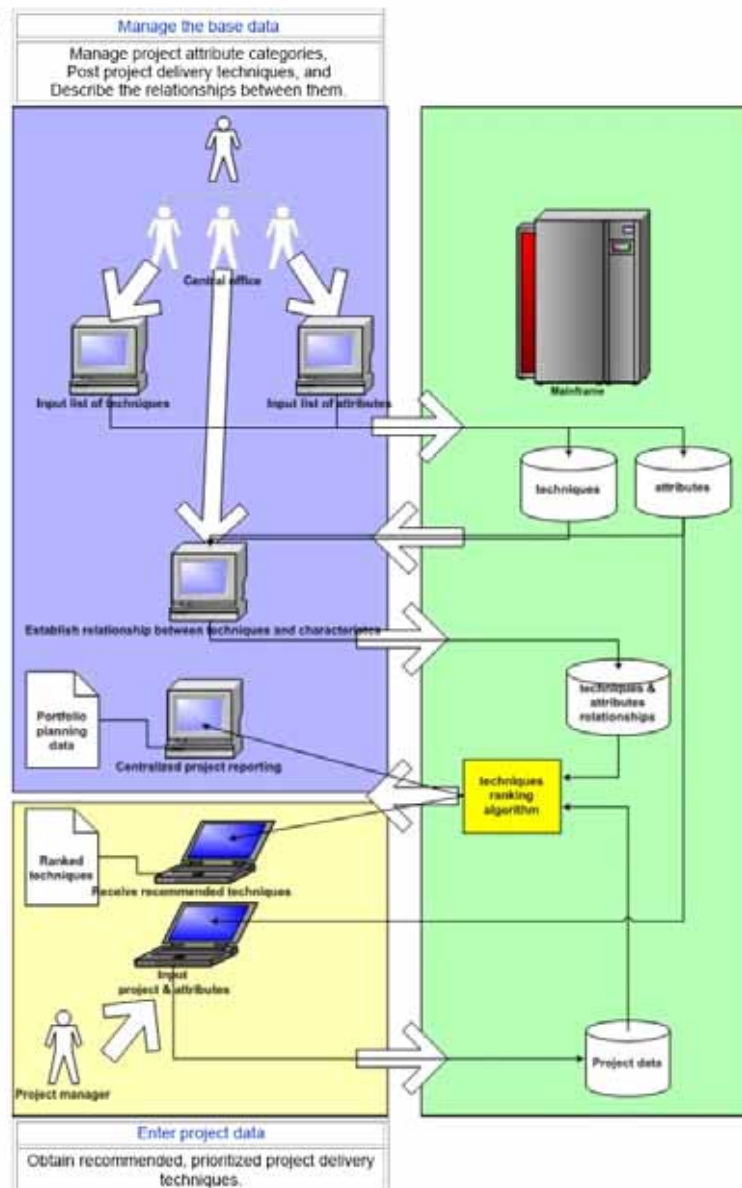
This is an experimental website, created by researchers at Oregon State University for developmental and demonstration purposes only. It is not endorsed by the Oregon Department of Transportation (ODOT), and may contain inaccurate or incomplete information.

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The purpose of this proposed tool is to provide a basis for deciding whether to use several available contracting and project administrative techniques. This tool is in development and may contain incomplete or inaccurate information. A rough draft document which explains the tool development may be viewed [here](#).

## Welcome to the project delivery Techniques Selection Tool!!

Below you may manage the centralized, [base data](#); or, you may describe [project data](#) to obtain a prioritized list of techniques which may help keep your project timely.



```

<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<html>
<head>
<title>Management Home</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
</head>

<body>

<table width="719" border="0" cellpadding="0" cellspacing="0">
  <!--DWLayoutTable-->
  <tr>
    <td width="719" height="80" valign="top"><h1 align="center">ODOT Project
Delivery<br>
    Methods Selection Tool </h1>
    </td>
  </tr>
</table>
<table width="719" border="0" cellpadding="0" cellspacing="0">
  <!--DWLayoutTable-->
  <tr>
    <td width="278" height="108" valign="top"><p>This section of the MSeT
allows
    the OPD to manage the:</p>
    <ul>
      <li><a href="CharacteristicsSection/charlist.php">Project
Characteristics</a> list,</li>
      <li><a href="MethodsPages/methlist.php">Delivery Methods</a> list,
and</li>
      <li><a href="Char_Meth/charmethmlist.php">Characteristics *
Methods</a>
        matrix.</li>
    </ul></td>
    <td width="441" valign="top"><div align="center">Return to <a
href="index.htm">MSeT
    Home Page</a></div></td>
  </tr>
  <tr>
    <td colspan="2" valign="top"></td>
  </tr>
</table>

<map name="attrdblblink">
<area shape="poly"
coords="200,71,186,95,187,120,202,151,209,162,208,212,188,212,187,224,276,226
,277,215,271,210,269,152,249,120" href="CharacteristicsSection/charlist.php">
<area shape="poly"
coords="109,71,94,95,47,153,36,164,36,211,14,210,13,224,116,227,117,217,101,2
14,102,160,114,155,121,121,123,95" href="MethodsPages/methlist.php">
<area shape="poly"
coords="151,71,162,71,173,95,177,302,177,376,176,385,274,384,276,397,8,397,9,
383,111,382,118,300,143,94" href="Char_Meth/charmethmlist.php">
<area shape="poly" coords="409,420" href="#"><area shape="poly"
coords="409,420,412,460,431,467,464,468,487,462,488,420,463,411,438,410"
href="Char_Meth/charmethmlist.php">

```



```

<area shape="poly"
coords="462,263,463,299,485,307,508,305,533,298,533,262,515,254,484,254"
href="CharacteristicsSection/charlist.php">
<area shape="poly"
coords="377,261,376,301,401,308,426,309,446,302,448,262,426,254,400,253"
href="MethodsPages/methlist.php">
<area shape="poly" coords="576,337,582,373,582,232" href="#">
</map></body>
</html>

```

## Characteristic List

## Attributes Lists

Link	external characteristics	Type
<a href="#">pol</a>	Political sensitivity	external
<a href="#">row</a>	Right-of-Way	external
<a href="#">safe</a>	Public safety	external
<a href="#">trfk</a>	Traffic volume	external
<a href="#">util</a>	Utility interference	external
Link	internal characteristics	Type
<a href="#">dsgn</a>	design complexity	internal
<a href="#">size</a>	Project size	internal
<a href="#">staf</a>	ODOT staffing level	internal

Records 1 to 8 of 8

[Add Attribute](#)

[Return to Management Home](#)

```

<?php require_once('../Connections/odottools.php'); ?>
<?php
$currentPage = $HTTP_SERVER_VARS["PHP_SELF"];

$maxRows_characteristicsall = 10;
$pageNum_characteristicsall = 0;
if (isset($HTTP_GET_VARS['pageNum_characteristicsall'])) {
    $pageNum_characteristicsall = $HTTP_GET_VARS['pageNum_characteristicsall'];
}
$startRow_characteristicsall = $pageNum_characteristicsall *
$maxRows_characteristicsall;

mysql_select_db($database_odottools, $odottools);
$query_characteristicsall = "SELECT * FROM characteristics ORDER BY chartype
ASC, charkey";
$query_limit_characteristicsall = sprintf("%s LIMIT %d, %d",
$query_characteristicsall, $startRow_characteristicsall,
$maxRows_characteristicsall);

```

```

$characteristicsall = mysql_query($query_limit_characteristicsall,
$odottools) or die(mysql_error());
$row_characteristicsall = mysql_fetch_assoc($characteristicsall);

if (isset($_HTTP_GET_VARS['totalRows_characteristicsall'])) {
    $totalRows_characteristicsall =
$_HTTP_GET_VARS['totalRows_characteristicsall'];
} else {
    $all_characteristicsall = mysql_query($query_characteristicsall);
    $totalRows_characteristicsall = mysql_num_rows($all_characteristicsall);
}
$totalPages_characteristicsall =
ceil($totalRows_characteristicsall/$maxRows_characteristicsall)-1;

$queryString_characteristicsall = "";
if (!empty($_HTTP_SERVER_VARS['QUERY_STRING'])) {
    $params = explode("&", $_HTTP_SERVER_VARS['QUERY_STRING']);
    $newParams = array();
    foreach ($params as $param) {
        if (strpos($param, "pageNum_characteristicsall") == false &&
            strpos($param, "totalRows_characteristicsall") == false) {
            array_push($newParams, $param);
        }
    }
    if (count($newParams) != 0) {
        $queryString_characteristicsall = "&" . implode("&", $newParams);
    }
}
$queryString_characteristicsall =
sprintf("&totalRows_characteristicsall=%d&s", $totalRows_characteristicsall,
$queryString_characteristicsall);
?>

<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<html>
<head>
<title>Characteristic List</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
</head>

<body>

<table width="715" border="0" cellpadding="0" cellspacing="0">
    <!--DWLayoutTable-->
    <tr>
        <td width="715" height="60" valign="top"><h1
align="center">Characteristics
Lists</h1></td>
    </tr>
    <tr>
        <td height="90" valign="top">&nbsp; <table border="1">
            <?php
                $oldchartype = '%';
                do {
                    if ($oldchartype != $row_characteristicsall['chartype'])
                    {
                        ?>

```

```

        <tr>
            <td width="63">Link</td>
            <td width="401"><h4 align = "center"><?php echo
$row_characteristicsall['chartype'], " characteristics"?></h4></td>
            <td width="173">Type</td>
        </tr>
    <?php
        $oldchartype = $row_characteristicsall['chartype'];
    }
    ?>
<tr>
    <td>
        <?php $linkstart = '<a href="chardetail.php?key='; $linkend =
'">'; ?>
        <?php echo
$linkstart,$row_characteristicsall['charkey'],$linkend,$row_characteristicsal
l['charkey']; ?></a>
        <td bgcolor="#FFFF66"><?php echo
$row_characteristicsall['charname']; ?></td>
        <td bgcolor="#FFFF66"><?php echo
$row_characteristicsall['chartype']; ?></td>
    </tr>
    <?php } while ($row_characteristicsall =
mysql_fetch_assoc($characteristicsall)); ?>
</table></td>
</tr>
<tr>
    <td height="19" valign="top">&nbsp; Records <?php echo
($startRow_characteristicsall + 1) ?> to <?php echo
min($startRow_characteristicsall + $maxRows_characteristicsall,
$totalRows_characteristicsall) ?> of <?php echo $totalRows_characteristicsall
?> </td>
</tr>
<tr>
    <td height="27" valign="top"><div align="left">&nbsp;
        <table border="0" width="50%" align="left">
            <tr>
                <td width="23%" align="center">
                    <?php if ($pageNum_characteristicsall > 0) { // Show if not
first page ?>
                        <a href="<?php printf("%s?pageNum_characteristicsall=%d%s",
$currentPage, 0, $queryString_characteristicsall); ?>">First</a>
                        <?php } // Show if not first page ?>
                    </td>
                <td width="31%" align="center">
                    <?php if ($pageNum_characteristicsall > 0) { // Show if not
first page ?>
                        <a href="<?php printf("%s?pageNum_characteristicsall=%d%s",
$currentPage, max(0, $pageNum_characteristicsall - 1),
$queryString_characteristicsall); ?>">Previous</a>
                        <?php } // Show if not first page ?>
                    </td>
                <td width="23%" align="center">
                    <?php if ($pageNum_characteristicsall <
$totalPages_characteristicsall) { // Show if not last page ?>

```

```

        <a href="<?php printf("%s?pageNum_characteristicsall=%d%s",
$currentPage, min($totalPages_characteristicsall, $pageNum_characteristicsall
+ 1), $queryString_characteristicsall); ?>">Next</a>
        <?php } // Show if not last page ?>
    </td>
    <td width="23%" align="center">
        <?php if ($pageNum_characteristicsall <
$totalPages_characteristicsall) { // Show if not last page ?>
            <a href="<?php printf("%s?pageNum_characteristicsall=%d%s",
$currentPage, $totalPages_characteristicsall,
$queryString_characteristicsall); ?>">Last</a>
            <?php } // Show if not last page ?>
        </td>
    </tr>
</table>
</div></td>
</tr>
<tr>
    <td height="19" valign="top"><p><a href="charadd.php"><br>
        Add Characteristic</a></p>
    </td>
</tr>
<tr>
    <td height="43" valign="top"><p>Return to <a
href=" ../managementhome.htm">Management
        Home</a></p>
    </td>
</tr>
<tr>
    <td height="3"></td>
</tr>
</table>
</body>
</html>
<?php
mysql_free_result($characteristicsall);
?>

```

## Characteristic Add

**Add an Attribute**

Key:

Maximum of 4 characters

Name:

Description:

Type:

"external" or "internal"

Score 01 description

Score 05 description

Score 10 description

[Return to Attributes List](#)

```

<!-- Program to add a characteristic - charadd.php -->
<?php require_once('../Connections/odotools.php'); ?>
<?php
function GetSQLValueString($theValue, $theType, $theDefinedValue = "",
$theNotDefinedValue = "")
{
    $theValue = (!get_magic_quotes_gpc()) ? addslashes($theValue) : $theValue;

    switch ($theType) {
        case "text":
            $theValue = ($theValue != "") ? "'" . $theValue . "'" : "NULL";
            break;
        case "long":
        case "int":
            $theValue = ($theValue != "") ? intval($theValue) : "NULL";
            break;
        case "double":
            $theValue = ($theValue != "") ? "'" . doubleval($theValue) . "'" :
"NULL";
            break;
        case "date":
            $theValue = ($theValue != "") ? "'" . $theValue . "'" : "NULL";
            break;
        case "defined":
            $theValue = ($theValue != "") ? $theDefinedValue : $theNotDefinedValue;
            break;
    }
    return $theValue;
}

```

```

}

$editFormAction = $HTTP_SERVER_VARS['PHP_SELF'];
if (isset($HTTP_SERVER_VARS['QUERY_STRING'])) {
    $editFormAction .= "?" . $HTTP_SERVER_VARS['QUERY_STRING'];
}

if ((isset($HTTP_POST_VARS["MM_insert"])) && ($HTTP_POST_VARS["MM_insert"] ==
"form2")) {
    $insertSQL = sprintf("INSERT INTO characteristics (charkey, charname,
chardescr, chartype, charval01descr, charval05descr, charval10descr) VALUES
(%s, %s, %s, %s, %s, %s, %s)",
        GetSQLValueString($HTTP_POST_VARS['charkey'], "text"),
        GetSQLValueString($HTTP_POST_VARS['charname'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['chardescr'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['chartype'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['charval01descr'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['charval05descr'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['charval10descr'],
"text"));

    mysql_select_db($database_odottools, $odottools);
    $Result1 = mysql_query($insertSQL, $odottools) or die(mysql_error());

    require_once('../Population/populatecharmeth.php');
    require_once('../Population/populateprojchar.php');

    $ckey = GetSQLValueString($HTTP_POST_VARS['charkey'], "text");
    $insertGoTo = "chardetail.php?key=".$ckey;
    header(sprintf("Location: %s", $insertGoTo));
}
?>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<html>
<head>
<title>Add a Method</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
</head>

<body>

<table width="666" border="0" cellpadding="0" cellspacing="0">
  <!--DWLayoutTable-->
  <tr>
    <td width="666" height="51" valign="top"><h1 align="center">Add a
characteristic</h1>
    </td>
  </tr>
  <tr>
    <td height="351" valign="top"><form name="form1" method="post" action="">

```

```

    </form>      <form method="post" name="form2" action="<?php echo
$editFormAction; ?>">
      <table align="left">
        <!--DWLayoutTable-->
        <tr valign="baseline">
          <td width="96" height="24" align="right" valign="top"
nowrap>Key:</td>
          <td colspan="3" valign="top" bgcolor="#FFFF66"><input type="text"
name="charkey" value="" size="32">
          </td>
          <td colspan="2" valign="top">Maximum of 4 characters</td>
          <td width="10">&nbsp;</td>
        </tr>
        <tr valign="baseline">
          <td height="24" align="right" valign="top" nowrap>Name:</td>
          <td colspan="5" valign="top" bgcolor="#FFFF66"><input type="text"
name="charname" value="" size="32">
          </td>
          <td>&nbsp;</td>
        </tr>
        <tr valign="baseline">
          <td height="88" align="right" valign="middle"
nowrap>Description:</td>
          <td colspan="5" align="left" valign="top"
bgcolor="#FFFF66"><textarea name="chardescr" cols="80" rows="4"></textarea>
          </td>
          <td>&nbsp;</td>
        </tr>
        <tr valign="baseline">
          <td height="24" align="right" valign="top" nowrap>Type:</td>
          <td colspan="5" align="left" valign="top"
bgcolor="#FFFF66"><input type="text" name="chartype" value="" size="32">
          &quot;external&quot; or &quot;internal&quot;          </td>
          <td>&nbsp;</td>
        </tr>
        <tr valign="baseline">
          <td height="23" colspan="2" align="right" valign="top"
nowrap><div align="center">Score
          01 description</div></td>
          <td colspan="3" valign="top"><div align="center">Score 05
description</div>
          </td>
          <td width="207" valign="top"><div align="center">Score 10
description</div>
          </td>
          <td>&nbsp;</td>
        </tr>
        <tr valign="baseline">
          <td height="72" colspan="2" align="right" valign="top" nowrap
bgcolor="#FFFF66"><div align="left">
          <textarea name="charval01descr" cols="28" rows="3"></textarea>
          </div></td>
          <td colspan="3" valign="top" bgcolor="#FFFF66"><textarea
name="charval05descr" cols="28" rows="3"></textarea>
          </td>
          <td valign="top" bgcolor="#FFFF66"><textarea name="charval10descr"
cols="28" rows="3"></textarea>

```

```

        </td>
      <td>&nbsp;</td>
    </tr>
    <tr valign="baseline">
      <td height="26" colspan="3" align="right" valign="top"
nowrap><input type="submit" value="Insert Record">
      </td>
      <td width="75">&nbsp;</td>
      <td width="102">&nbsp;</td>
      <td>&nbsp;</td>
      <td></td>
    </tr>
    <tr>
      <td height="5"></td>
      <td width="100"></td>
      <td width="14"></td>
      <td></td>
      <td></td>
      <td></td>
      <td></td>
    </tr>
  </table>
  <input type="hidden" name="MM_insert" value="form2">
</form>      <p>&nbsp;</p>
</td>
</tr>
<tr>
  <td height="29" valign="top">Return to <a
href="charlist.php">Characteristics List</a></td>
</tr>
</table>
</body>
</html>

```

## Characteristic Detail

### Attribute Detail

Key	Name	Type
pol	Political sensitivity	external
Description		
Politically sensitive project; may include general public, media, or legislative, gubernatorial focus		
Scoring range		
Value=01	Value=05	Value=10
Project has little impact to public or environment	Visible project that has general impact to public or environment; any public comment has been resolved	Highly controversial project that has a significant public or environmental impact and for which controversy continues. Strong public, media, and legislative/ gubernatorial focus exists.

[Modify Attribute](#)

[Delete Attribute](#)

[Return to Attributes List](#)



```

<?php require_once('../Connections/odottools.php'); ?>
<?php
$key = $_GET['key'];
$colname_characteristicfocus = "1";
if (isset($HTTP_GET_VARS['key'])) {
    $colname_characteristicfocus = (get_magic_quotes_gpc()) ?
    $HTTP_GET_VARS['key'] : addslashes($HTTP_GET_VARS['key']);
}
mysql_select_db($database_odottools, $odottools);
$query_characteristicfocus = sprintf("SELECT * FROM characteristics WHERE
charkey = '%s'", $colname_characteristicfocus);
$characteristicfocus = mysql_query($query_characteristicfocus, $odottools) or
die(mysql_error());
$row_characteristicfocus = mysql_fetch_assoc($characteristicfocus);
$totalRows_characteristicfocus = mysql_num_rows($characteristicfocus);
?>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<html>
<head>
<title>Characteristic Detail</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
</head>

<body>

<table width="715" border="0" cellpadding="0" cellspacing="0">
  <!--DWLayoutTable-->
  <tr>
    <td width="715" height="55" valign="top"><h1
align="center">Characteristic
    Detail</h1></td>
  </tr>
  <tr>
    <td height="179" valign="top"><table border="1">
      <tr>
        <td width="168">Key</td>
        <td width="254">Name</td>
        <td width="271">Type</td>
      </tr>
      <tr>
        <td bgcolor="#FFFF66"><?php echo
$row_characteristicfocus['charkey']; ?></td>
        <td bgcolor="#FFFF66"><?php echo
$row_characteristicfocus['charname']; ?></td>
        <td bgcolor="#FFFF66"><?php echo
$row_characteristicfocus['chartype']; ?></td>
      </tr>
      <tr>
        <td colspan="3"><div align="center">Description</div></td>
      </tr>
      <tr bgcolor="#FFFF66">
        <td colspan="3"><?php echo $row_characteristicfocus['chardescr'];
?></td>
      </tr>
      <tr>
        <td colspan="3"><div align="center">Scoring range </div></td>
      </tr>
    </table>
  </td>
  </tr>
</table>

```

```

        <tr>
            <td><div align="center">Value=01</div></td>
            <td><div align="center">Value=05</div></td>
            <td><div align="center">Value=10</div></td>
        </tr>
        <tr>
            <td bgcolor="#FFFF66"><div align="center"><?php echo
$row_characteristicfocus['charval01descr']; ?></div></td>
            <td bgcolor="#FFFF66"><div align="center"><?php echo
$row_characteristicfocus['charval05descr']; ?></div></td>
            <td bgcolor="#FFFF66"><div align="center"><?php echo
$row_characteristicfocus['charval10descr']; ?></div></td>
        </tr>
    </table></td>
</tr>
<tr>
    <td height="19" valign="top"><!--DWLayoutEmptyCell-->&nbsp;</td>
</tr>
<tr>
    <td height="64" valign="top"><p><a href="charmodify.htm">Modify
Characteristic</a></p>
    <p><a href="chardelete.htm">Delete Characteristic</a></p></td>
</tr>
<tr>
    <td height="32" valign="top">Return to <a
href="charlist.php">Characteristics
List</a></td>
</tr>
</table>
</body>
</html>

```

## Characteristic Modify (Not Implemented)

This proposed section was not implemented.

## Characteristic Delete (Not Implemented)

This proposed section was not implemented.

## Method List

## Techniques List

Key	Type	select methods
<a href="#">ab</a>	select	A+B Price and time Qualifications process
<a href="#">aq</a>	select	A+Q Price and Qualifications selection process
<a href="#">ls</a>	select	BASE Lump-sum (hard bid, low-bid) selection proces
<a href="#">qo</a>	select	Qualifications-only selection process
Key	Type	struct methods
<a href="#">bot</a>	struct	Build operate transfer (or Public Private Partners
<a href="#">cmar</a>	struct	construction management at risk
<a href="#">db</a>	struct	design-build
<a href="#">gc</a>	struct	BASE General Contractor form of team structure

Records 1 to 8 of 8

[Add a Technique](#)

[Management Home Page](#)

```
<?php require_once('../Connections/odottools.php'); ?>
<?php
$currentPage = $HTTP_SERVER_VARS["PHP_SELF"];

$maxRows_methodsall = 10;
$pageNum_methodsall = 0;
if (isset($HTTP_GET_VARS['pageNum_methodsall'])) {
    $pageNum_methodsall = $HTTP_GET_VARS['pageNum_methodsall'];
}
$startRow_methodsall = $pageNum_methodsall * $maxRows_methodsall;

mysql_select_db($database_odottools, $odottools);
$query_methodsall = "SELECT * FROM methods ORDER BY methtype, methkey";
$query_limit_methodsall = sprintf("%s LIMIT %d, %d", $query_methodsall,
$startRow_methodsall, $maxRows_methodsall);
$methodsall = mysql_query($query_limit_methodsall, $odottools) or
die(mysql_error());
$row_methodsall = mysql_fetch_assoc($methodsall);

if (isset($HTTP_GET_VARS['totalRows_methodsall'])) {
    $totalRows_methodsall = $HTTP_GET_VARS['totalRows_methodsall'];
} else {
    $all_methodsall = mysql_query($query_methodsall);
    $totalRows_methodsall = mysql_num_rows($all_methodsall);
}
$totalPages_methodsall = ceil($totalRows_methodsall/$maxRows_methodsall)-1;
```

```

$queryString_methodsall = "";
if (!empty($_HTTP_SERVER_VARS['QUERY_STRING'])) {
    $params = explode("&", $_HTTP_SERVER_VARS['QUERY_STRING']);
    $newParams = array();
    foreach ($params as $param) {
        if (strpos($param, "pageNum_methodsall") == false &&
            strpos($param, "totalRows_methodsall") == false) {
            array_push($newParams, $param);
        }
    }
    if (count($newParams) != 0) {
        $queryString_methodsall = "&" . implode("&", $newParams);
    }
}
$queryString_methodsall = sprintf("&totalRows_methodsall=%d%s",
$totalRows_methodsall, $queryString_methodsall);
?>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<html>
<head>
<title>Methods List</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
</head>

<body>

<table width="715" border="0" cellpadding="0" cellspacing="0">
<!--DWLayoutDefaultTable-->
<tr>
<td height="95" colspan="2" valign="top"><h1 align="center">Methods
List</h1></td>
</tr>
<tr>
<td height="73" colspan="2" valign="top"><table width="100%" border="1">
<?php
    $oldmethtype = '';
    do {
        if ($oldmethtype != $row_methodsall['methtype'])
        {
            ?>
<tr>
<td width="9%"> <div align="center">Key</div></td>
<td width="8%"> <div align="center">Type</div></td>
<td width="83%"> <div align="center"><h4><?php echo
$row_methodsall['methtype'], " methods";?></h4></div></td>
</tr>
<?php
    $oldmethtype = $row_methodsall['methtype'];
    }
    ?>
<tr>
<td>
<?php $linkstart = '<a href="methdetail.php?key='; $linkend =
'">'; ?>

```

```

                <?php echo
$linkstart,$row_methodsall['methkey'],$linkend,$row_methodsall['methkey'];
?></a></td>
                <td bgcolor="#FFFF66"><?php echo $row_methodsall['methtype'];
?></td>
                <td bgcolor="#FFFF66"><?php echo $row_methodsall['methname'];
?></td>
            </tr>
            <?php } while ($row_methodsall = mysql_fetch_assoc($methodsall)); ?>
        </table></td>
    </tr>
    <tr>
        <td width="585" height="29" valign="top">                <div
align="center">&nbsp;Records
        <?php echo ($startRow_methodsall + 1) ?> to <?php echo
min($startRow_methodsall + $maxRows_methodsall, $totalRows_methodsall) ?> of
<?php echo $totalRows_methodsall ?> </div>
        <td width="130">&nbsp; </td>
    </tr>
    <tr>
        <td height="47" valign="top">&nbsp;
            <table border="0" width="50%" align="center">
                <tr>
                    <td width="23%" align="center">
                        <?php if ($pageNum_methodsall > 0) { // Show if not first page ?>
                            <a href="<?php printf("%s?pageNum_methodsall=%d%s", $currentPage,
0, $queryString_methodsall); ?>">First</a>
                        <?php } // Show if not first page ?>
                    </td>
                    <td width="31%" align="center">
                        <?php if ($pageNum_methodsall > 0) { // Show if not first page ?>
                            <a href="<?php printf("%s?pageNum_methodsall=%d%s", $currentPage,
max(0, $pageNum_methodsall - 1), $queryString_methodsall); ?>">Previous</a>
                        <?php } // Show if not first page ?>
                    </td>
                    <td width="23%" align="center">
                        <?php if ($pageNum_methodsall < $totalPages_methodsall) { // Show
if not last page ?>
                            <a href="<?php printf("%s?pageNum_methodsall=%d%s", $currentPage,
min($totalPages_methodsall, $pageNum_methodsall + 1),
$queryString_methodsall); ?>">Next</a>
                        <?php } // Show if not last page ?>
                    </td>
                    <td width="23%" align="center">
                        <?php if ($pageNum_methodsall < $totalPages_methodsall) { // Show
if not last page ?>
                            <a href="<?php printf("%s?pageNum_methodsall=%d%s", $currentPage,
$totalPages_methodsall, $queryString_methodsall); ?>">Last</a>
                        <?php } // Show if not last page ?>
                    </td>
                </tr>
            </table>
        <td>&nbsp;
    </tr>
    <tr>
        <td height="27" colspan="2" valign="top"><a href="methadd.php">Add a
Method</a></td>
    </tr>

```

```
<tr>
  <td height="25" colspan="2" valign="top"><a
href=" ../managementhome.htm">Management
  Home Page</a></td>
</tr>
<tr>
  <td height="41">&nbsp;</td>
  <td>&nbsp;</td>
</tr>
</table>
</body>
</html>
<?php
mysql_free_result($methodsall);
?>
```

## Method Add

## Add a Technique

Key:	<input type="text"/>	4 characters only	Type:	<input type="text"/>
Name:	<input type="text"/>			
Description:	<input type="text"/>			
Purpose:	<input type="text"/>			
Related to:	<input type="text"/>			
Advantage:		Disadvantage:		
<input type="text"/>		<input type="text"/>		

[Return to Techniques List](#)

```

/* Program to add a method - methadd.php */
<?php require_once('../Connections/characteristics.php'); ?>
<?php
function GetSQLValueString($theValue, $theType, $theDefinedValue = "",
$theNotDefinedValue = "")
{
    $theValue = (!get_magic_quotes_gpc()) ? addslashes($theValue) : $theValue;

    switch ($theType) {
        case "text":
            $theValue = ($theValue != "") ? "'" . $theValue . "'" : "NULL";
            break;
        case "long":
        case "int":
            $theValue = ($theValue != "") ? intval($theValue) : "NULL";
            break;
        case "double":
            $theValue = ($theValue != "") ? "'" . doubleval($theValue) . "'" :
"NULL";
            break;
        case "date":
            $theValue = ($theValue != "") ? "'" . $theValue . "'" : "NULL";
            break;
        case "defined":
            $theValue = ($theValue != "") ? $theDefinedValue : $theNotDefinedValue;
            break;
    }
    return $theValue;
}

$editFormAction = $HTTP_SERVER_VARS['PHP_SELF'];
if (isset($HTTP_SERVER_VARS['QUERY_STRING'])) {
    $editFormAction .= "?" . $HTTP_SERVER_VARS['QUERY_STRING'];
}

if ((isset($HTTP_POST_VARS["MM_insert"])) && ($HTTP_POST_VARS["MM_insert"] ==
"form2")) {
    $insertSQL = sprintf("INSERT INTO methods (methkey, methname, methdescr,
methtype, methpurpose, methreltdto, methadv, methdisadv) VALUES (%s, %s, %s,
%s, %s, %s, %s, %s)",
        GetSQLValueString($HTTP_POST_VARS['methkey'], "text"),
        GetSQLValueString($HTTP_POST_VARS['methname'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['methdescr'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['methtype'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['methpurpose'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['methreltdto'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['methadv'], "text"),
        GetSQLValueString($HTTP_POST_VARS['methdisadv'],
"text"));

    mysql_select_db($database_characteristics, $characteristics);
    $Result1 = mysql_query($insertSQL, $characteristics) or die(mysql_error());
}

```



```

require_once('../Population/populatecharmeth.php');

$insertGoTo = "methdetail.php";
if (isset($HTTP_SERVER_VARS['QUERY_STRING'])) {
    $insertGoTo .= (strpos($insertGoTo, '?')) ? "&" : "?";
    $insertGoTo .= $HTTP_SERVER_VARS['QUERY_STRING'];
}
header(sprintf("Location: %s", $insertGoTo));
}
?>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<html>
<head>
<title>Add a Method</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
</head>

<body>

<table width="715" border="0" cellpadding="0" cellspacing="0">
  <!--DWLayoutDefaultTable-->
  <tr>
    <td width="715" height="51" valign="top"><h1 align="center">Add a
Method</h1></td>
  </tr>
  <tr>
    <td height="67" valign="top"><form name="form1" method="post" action="">

      </form>
      <form method="post" name="form2" action="<?php echo $editFormAction;
?>">

        <table align="center">
          <!--DWLayoutTable-->
          <tr valign="baseline">
            <td width="85" height="24" align="right" valign="top"
nowrap>Key:</td>
            <td width="39" valign="top"><input type="text" name="methkey"
value="" size="6">
            </td>
            <td colspan="2" valign="top">4 characters only</td>
            <td width="65" align="right" valign="top" nowrap>Type:</td>
            <td width="214" valign="top"><input type="text" name="methtype"
value="" size="32">
            </td>
          </tr>
          <tr valign="baseline">
            <td height="24" valign="top"><div align="right">Name:</div></td>
            <td colspan="5" valign="top"><input type="text" name="methname"
value="" size="80">
            </td>
          </tr>
          <tr valign="baseline">
            <td height="72" align="right" valign="top"
nowrap>Description:</td>
            <td colspan="5" valign="top"><textarea name="methdescr" cols="80"
rows="3"></textarea>

```

```

</td>
    </tr>
    <tr valign="baseline">
        <td height="72" align="right" valign="top" nowrap>Purpose:</td>
        <td colspan="5" valign="top"><textarea name="methpurpose"
cols="80" rows="3"></textarea>
        </td>
    </tr>
    <tr valign="baseline">
        <td height="56" align="right" valign="top" nowrap>Related
to:</td>
        <td colspan="5" valign="top"><textarea name="methreltdto"
cols="80" rows="2"></textarea>
        </td>
    </tr>
    <tr valign="baseline">
        <td height="24" colspan="3" align="right" valign="top"
nowrap><div align="center">Advantage:</div>
        </td>
        <td colspan="3" valign="top"><div
align="center">Disadvantage:</div>
        </td>
    </tr>
    <tr valign="baseline">
        <td height="72" colspan="3" valign="top"><textarea name="methadv"
cols="43" rows="3"></textarea>
        </td>
        <td colspan="3" valign="top"><textarea name="methdisadv"
cols="43" rows="3"></textarea>
        </td>
    </tr>
    <tr valign="baseline">
        <td height="26" colspan="6" valign="top"><input type="submit"
value="Insert Record">
        </td>
    </tr>
    <tr>
        <td height="5"></td>
        <td></td>
        <td width="163"></td>
        <td width="20"></td>
        <td></td>
        <td></td>
    </tr>
</table>
<input type="hidden" name="MM_insert" value="form2">
</form>
<p>&nbsp;</p>
</td>
</tr>
<tr>
    <td height="29" valign="top">Return to <a href="methlist.php">Methods
List</a></td>
</tr>
<tr>
    <td height="112">&nbsp;</td>
</tr>

```

```

</table>
</body>
</html>

```

## Method Detail

### Technique Detail

<u>Key</u>	<u>Name</u>	<u>Type</u>
ab	A+B Price and time Qualifications process	select
<b>Description</b>		
This process requires the contractor provide a proposal that includes time as a component in the selection process of the low bidder for a project. The completion time forwarded within the contractors ?proposal? becomes the completion time for the project and the start time for liquidated damages. Incentives/disincentives are almost always used with this process. The disincentive is applied as a separate element in addition to liquidated damages. This bid process provides the ?best value? of cost and time for completion of work. An exemption to the normal bid process is required for this style of bidding.		
<b>Purpose</b>		
This bid method is used to allow the contractor propose on work based on its best work schedule and cost. When time becomes a cost element in the proposal process, the contractor must put an emphasis on reduction of float time to perform the work in the most efficient manner possible. The contractor with the shortest time along with the best price is selected for the work. After the contract is awarded, a second benefit is realized by ODOT in that the contractor must give this project priority over other work that is being performed by the contractor, in order to meet his completion date. This procurement method is used for most work categories.		
<b>Related to:</b>		
This is similar to the intermediate completion date bid process with a fixed start date and where the contractor has control of the completion date. Incentives and disincentives are usually combined with this process.		
<b>Advantages</b>		<b>Disadvantages</b>
Allows the contractor to select the best time to start a project based on weather, contractor resources and workload. Causes the project to take on a higher priority over other contractor work. Improves the pace for which a project is completed. Causes the contractor to estimating the job more efficiently reducing impacts to traffic and businesses. Tends to favor contractors that operate on a more efficient basis.		The exemption process can slightly increase the design costs for the project. The contractor has control over the completion time and may not be the shortest time for completion of the work. Unknowns to construction do have a negative impact on this process. The project first cost (bid proposal) may be slightly higher than the low dollar bid and the lowest bid may not be the successful based upon time. Owner still controls the start time but does not control the final completion time for the project.

[Modify Technique](#)

Delete Technique

Caution!!!!!!!!!!!!!!!!!!!!!!!!!!!!!! Method will be deleted as soon as you select this link!!!!!!!!!!!!!!!!!!!!!!

[Return to Techniques List](#)

```

<?php require_once('.../Connections/odottools.php'); ?>
<?php
$key = $_GET['key'];
$colname_methodfocus = "1";
if (isset($_HTTP_GET_VARS['key'])) {

```

```

    $colname_methodfocus = (get_magic_quotes_gpc()) ? $_HTTP_GET_VARS['key'] :
addslashes($_HTTP_GET_VARS['key']);
}
mysql_select_db($database_odottools, $odottools);
$query_methodfocus = sprintf("SELECT * FROM methods WHERE methkey = '%s'",
$colname_methodfocus);
$methodfocus = mysql_query($query_methodfocus, $odottools) or
die(mysql_error());
$row_methodfocus = mysql_fetch_assoc($methodfocus);
$totalRows_methodfocus = mysql_num_rows($methodfocus);
?>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<html>
<head>
<title>Method Detail</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
</head>

<body>

<table width="706" border="0" cellpadding="0" cellspacing="0">
  <!--DWLayoutTable-->
  <tr>
    <td width="706" height="102" valign="top"><h1 align="center">Method
Detail</h1>
    </td>
  </tr>
  <tr>
    <td height="258" valign="top"><table width="99%" border="1">
      <!--DWLayoutTable-->
      <tr>
        <td width="22%"><div align="center"><u>Key</u></div></td>
        <td width="54%" colspan="2"><div
align="center"><u>Name</u></div></td>
        <td width="24%"><div align="center"><u>Type</u></div></td>
      </tr>
      <tr bgcolor="#FFFF66">
        <td height="12" align="left" valign="top"><?php echo
$row_methodfocus['methkey']; ?></td>
        <td height="12" colspan="2" align="left" valign="top"><?php echo
$row_methodfocus['methname']; ?></td>
        <td height="12" align="left" valign="top"><?php echo
$row_methodfocus['methtype']; ?></td>
      </tr>
      <tr>
        <td colspan="4"><div align="center">Description</div></td>
      </tr>
      <tr align="left" valign="top" bgcolor="#FFFF66">
        <td height="12" colspan="4"><div align="left"><?php echo
$row_methodfocus['methdescr']; ?></div></td>
      </tr>
      <tr>
        <td colspan="4"><div align="center">Purpose</div></td>
      </tr>
      <tr align="left" valign="top" bgcolor="#FFFF66">
        <td height="12" colspan="4"><?php echo
$row_methodfocus['methpurpose']; ?></td>

```

```

        </tr>
        <tr>
            <td colspan="4"><div align="center">Related to:</div></td>
        </tr>
        <tr align="left" valign="top" bgcolor="#FFFF66">
            <td height="12" colspan="4"><?php echo
$row_methodfocus['methreltdto']; ?></td>
        </tr>
        <tr>
            <td colspan="2"><div align="center">Advantages</div></td>
            <td colspan="2"><div align="center">Disadvantages</div></td>
        </tr>
        <tr bgcolor="#FFFF66">
            <td height="12" colspan="2" align="left" valign="top"><?php echo
$row_methodfocus['methadv']; ?></td>
            <td height="12" colspan="2"><?php echo
$row_methodfocus['methdisadv']; ?></td>
        </tr>
        <tr>
            <td colspan="4"></td>
        </tr>
    </table>
</td>
</tr>
<tr>
    <td height="29" valign="top">
        <p>
            <?php $linkstart = '<a href="methmodify.php?key='; $linkend = '">'; ?>
        ?>
            <?php echo $linkstart,$key,$linkend; ?>Modify Method</a></p>
        </tr>
        <tr>
            <td height="45" valign="top" bgcolor="#FF6633">
                <?php $linkstart = '<a href="methdelete.php?key='; $linkend = '">'; ?>
                Delete Method<br>
                Caution!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!! Method will be deleted as soon
                as you select this link!!!!!!!!!!!!!!!!!!!!!!!!!!!! </tr>
            <tr>
                <td height="24" valign="top">
                    <a href="methlist.php">Return to Methods
                    List</a>
                </tr>
    </table>
</body>
</html>
<?php
mysql_free_result($methodfocus);
?>

```

## Method Modify

### Modify Technique

Key	Name	Type
ab	A+B Price and time Qualifications process	<input type="text" value="select"/>
<b>Description</b>		
<p>This process requires the contractor provide a proposal that includes time as a component in the selection process of the low bidder for a project. The completion time forwarded within the contractors ?proposal? becomes the completion time for the project and the start time for liquidated damages. Incentives/disincentives are almost always used with this process. The disincentive is applied as a separate element in addition to liquidated damages. This bid process provides the ?best value? of cost and time for completion of work. An exemption to the normal bid process is required for this style of bidding.</p>		
<b>Purpose</b>		
<p>This bid method is used to allow the contractor propose on work based on its best work schedule and cost. When time becomes a cost element in the proposal process, the contractor must put an emphasis on reduction of float time to perform the work in the most efficient manner possible. The contractor with the shortest time along with the best price is selected for the work. After the contract is awarded, a second benefit is realized by ODOT in that the contractor must give this project priority over other work that is being performed by the contractor, in order to meet his completion date. This procurement method is used for most work categories.</p>		
<b>Related to</b>		
<p>This is similar to the intermediate completion date bid process with a fixed start date and where the contractor has control of the completion date. Incentives and disincentives are usually combined with this process.</p>		
<b>Advantages</b>	<b>Disadvantages</b>	
<p>Allows the contractor to select the best time to start a project based on weather, contractor resources and workload. Causes the project to take on a higher priority over other contractor work. Improves the pace for which a project is completed. Causes the contractor to estimating the job more efficiently reducing impacts to traffic and businesses. Tends to favor contractors that operate on a more efficient basis.</p>	<p>The exemption process can slightly increase the design costs for the project. The contractor has control over the completion time and may not be the shortest time for completion of the work. Unknowns to construction do have a negative impact on this process. The project first cost (bid proposal) may be slightly higher than the low dollar bid and the lowest bid may not be the successful based upon time. Owner still controls the start time but does not control the final completion time for the project.</p>	
<input type="button" value="Update Record"/>		

```

<?php require_once('../Connections/odottools.php'); ?>
<?php
function GetSQLValueString($theValue, $theType, $theDefinedValue = "",
$theNotDefinedValue = "")
{
    $theValue = (!get_magic_quotes_gpc()) ? addslashes($theValue) : $theValue;

    switch ($theType) {
        case "text":
            $theValue = ($theValue != "") ? "'" . $theValue . "'" : "NULL";
            break;
        case "long":
        case "int":
            $theValue = ($theValue != "") ? intval($theValue) : "NULL";
            break;
        case "double":
            $theValue = ($theValue != "") ? "'" . doubleval($theValue) . "'" :
"NULL";
            break;
        case "date":
            $theValue = ($theValue != "") ? "'" . $theValue . "'" : "NULL";
            break;
        case "defined":
            $theValue = ($theValue != "") ? $theDefinedValue : $theNotDefinedValue;
            break;
    }
    return $theValue;
}

$editFormAction = $HTTP_SERVER_VARS['PHP_SELF'];
if (isset($HTTP_SERVER_VARS['QUERY_STRING'])) {
    $editFormAction .= "?" . $HTTP_SERVER_VARS['QUERY_STRING'];
}

if ((isset($HTTP_POST_VARS["MM_update"])) && ($HTTP_POST_VARS["MM_update"] ==
"form1")) {
    $updateSQL = sprintf("UPDATE methods SET methname=%s, methtype=%s,
methdescr=%s, methpurpose=%s, methreltdto=%s, methadv=%s, methdisadv=%s WHERE
methkey=%s",

        GetSQLValueString($HTTP_POST_VARS['methname'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['methtype'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['methdescr'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['methpurpose'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['methreltdto'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['methadv'], "text"),
        GetSQLValueString($HTTP_POST_VARS['methdisadv'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['methkey'],
"text"));

    mysql_select_db($database_odottools, $odottools);
    $Result1 = mysql_query($updateSQL, $odottools) or die(mysql_error());
}

```

```

$updateGoTo = "methdetail.php";
if (isset($_HTTP_SERVER_VARS['QUERY_STRING'])) {
    $updateGoTo .= (strpos($updateGoTo, '?') ? "&" : "?");
    $updateGoTo .= $_HTTP_SERVER_VARS['QUERY_STRING'];
}
header(sprintf("Location: %s", $updateGoTo));
}

$colname_methodfocus = "1";
if (isset($_HTTP_GET_VARS['key'])) {
    $colname_methodfocus = (get_magic_quotes_gpc()) ? $_HTTP_GET_VARS['key'] :
addslashes($_HTTP_GET_VARS['key']);
}
mysql_select_db($database_odottools, $odottools);
$query_methodfocus = sprintf("SELECT * FROM methods WHERE methkey = '%s'",
$colname_methodfocus);
$result_methodfocus = mysql_query($query_methodfocus, $odottools) or
die(mysql_error());
$row_methodfocus = mysql_fetch_assoc($result_methodfocus);
$totalRows_methodfocus = mysql_num_rows($result_methodfocus);
?>

<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<html>
<head>
<title>Untitled Document</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
</head>

<body>

<table width="715" border="0" cellpadding="0" cellspacing="0">
  <!--DWLayoutTable-->
  <tr>
    <td width="789" height="56" valign="top"><h1 align="center">Modify
Method</h1></td>
  </tr>
  <tr>
    <td height="397" valign="top"><form method="post" name="form1"
action="<?php echo $editFormAction; ?>">
      <p>&nbsp;</p>
      <table width="614" border="1" align="left">
        <!--DWLayoutTable-->
        <tr valign="baseline">
          <td width="147" height="23" align="right" valign="top"
nowrap><div align="center"><u>Key</u></div></td>
          <td colspan="2" valign="top"><div
align="center"><u>Name</u></div></td>
          <td colspan="2" valign="top"><div
align="center"><u>Type</u></div>
          </td>
        </tr>
        <tr valign="baseline">
          <td height="26" valign="top"><?php echo
$row_methodfocus['methkey']; ?></td>

```



```

        <td colspan="2" valign="top"><input type="text" name="methname"
value="<?php echo $row_methodfocus['methname']; ?>" size="60"></td>
        <td colspan="2" valign="top"><input type="text" name="methtype"
value="<?php echo $row_methodfocus['methtype']; ?>" size="8">
        </td>
    </tr>
    <tr valign="baseline">
        <td height="23" colspan="5" valign="top"> <div
align="center">Description</div>
        </td>
    </tr>
    <tr valign="baseline">
        <td height="74" colspan="5" valign="top"><textarea
name="methdescr" cols="85"><?php echo $row_methodfocus['methdescr'];
?></textarea>
        </td>
    </tr>
    <tr valign="baseline">
        <td height="23" colspan="5" valign="top">Purpose</td>
    </tr>
    <tr valign="baseline">
        <td height="74" colspan="5" valign="top"> <textarea
name="methpurpose" cols="85"><?php echo $row_methodfocus['methpurpose'];
?></textarea>
        </td>
    </tr>
    <tr valign="baseline">
        <td height="23" colspan="5" valign="top">Related to</td>
    </tr>
    <tr valign="baseline">
        <td height="74" colspan="5" valign="top"><textarea
name="methreltdto" cols="85"><?php echo $row_methodfocus['methreltdto'];
?></textarea>
        </td>
    </tr>
    <tr valign="baseline">
        <td height="23" colspan="2" valign="top">Advantages</td>
        <td colspan="3" valign="top">Disadvantages</td>
    </tr>
    <tr valign="baseline">
        <td height="74" colspan="2" valign="top"><textarea name="methadv"
cols="43"><?php echo $row_methodfocus['methadv']; ?></textarea>
        </td>
        <td colspan="3" valign="top"><textarea name="methdisadv"
cols="43"><?php echo $row_methodfocus['methdisadv']; ?></textarea>
        </td>
    </tr>
    <tr valign="baseline">
        <td height="28" colspan="4" valign="top"><div align="center">
            <input name="submit" type="submit" value="Update Record">
        </div>
        </td>
        <td width="4">&nbsp;</td>
    </tr>
    <tr>
        <td height="5"></td>
        <td width="142"></td>
    </tr>

```

```

        <td width="248"></td>
        <td width="39"></td>
        <td></td>
    </tr>
</table>
<input type="hidden" name="MM_update" value="form1">
<input type="hidden" name="methkey" value="<?php echo
$row_methodfocus['methkey']; ?>">
</form>
<p>&nbsp;</p></td>
</tr>
</table>
</body>
</html>
<?php
mysql_free_result($methodfocus);
?>

```

## Method Delete

This section was not implemented.

## Characteristic by Method—Method Choice

### Technique List

Please select a method. The next page will allow you to select an attribute to rate for the technique chosen.

Key	Type	Name
<a href="#">ab</a>	select	A+B Price and time Qualifications process
<a href="#">gc</a>	struct	BASE General Contractor form of team structure
<a href="#">bot</a>	struct	Build operate transfer (or Public Private Partners
<a href="#">ls</a>	select	BASE Lump-sum (hard bid, low-bid) selection proces
<a href="#">cmar</a>	struct	construction management at risk
<a href="#">db</a>	struct	design-build
<a href="#">test</a>	a	a
<a href="#">qo</a>	select	Qualifications-only selection process
<a href="#">aq</a>	select	A+Q Price and Qualifications selection process

Records 1 to 9 of 9

[Management Home Page](#)

```

<?php require_once('../Connections/odottools.php'); ?>
<?php
$currentPage = $HTTP_SERVER_VARS["PHP_SELF"];

$maxRows_methodsall = 10;
$pageNum_methodsall = 0;
if (isset($HTTP_GET_VARS['pageNum_methodsall'])) {

```

```

    $pageNum_methodsall = $HTTP_GET_VARS['pageNum_methodsall'];
}
$startRow_methodsall = $pageNum_methodsall * $maxRows_methodsall;

mysql_select_db($database_odottools, $odottools);
$query_methodsall = "SELECT * FROM methods";
$query_limit_methodsall = sprintf("%s LIMIT %d, %d", $query_methodsall,
$startRow_methodsall, $maxRows_methodsall);
$methodsall = mysql_query($query_limit_methodsall, $odottools) or
die(mysql_error());
$row_methodsall = mysql_fetch_assoc($methodsall);

if (isset($HTTP_GET_VARS['totalRows_methodsall'])) {
    $totalRows_methodsall = $HTTP_GET_VARS['totalRows_methodsall'];
} else {
    $all_methodsall = mysql_query($query_methodsall);
    $totalRows_methodsall = mysql_num_rows($all_methodsall);
}
$totalPages_methodsall = ceil($totalRows_methodsall/$maxRows_methodsall)-1;

$queryString_methodsall = "";
if (!empty($HTTP_SERVER_VARS['QUERY_STRING'])) {
    $params = explode("&", $HTTP_SERVER_VARS['QUERY_STRING']);
    $newParams = array();
    foreach ($params as $param) {
        if (strpos($param, "pageNum_methodsall") == false &&
            strpos($param, "totalRows_methodsall") == false) {
            array_push($newParams, $param);
        }
    }
    if (count($newParams) != 0) {
        $queryString_methodsall = "&" . implode("&", $newParams);
    }
}
$queryString_methodsall = sprintf("&totalRows_methodsall=%d%s",
$totalRows_methodsall, $queryString_methodsall);
?>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<html>
<head>
<title>Methods List</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
</head>

<body>

<table width="715" border="0" cellpadding="0" cellspacing="0">
    <!--DWLayoutDefaultTable-->
    <tr>
        <td height="43" colspan="2" valign="top"><h1 align="center">Methods
List</h1></td>
    </tr>
    <tr>
        <td height="52" colspan="2" valign="top">Please select a method. The next
page will allow you to select a characteristic to rate for the method
chosen.</td>
    </tr>

```

```

<tr>
  <td height="73" colspan="2" valign="top"><table width="100%" border="1">
    <tr>
      <td width="9%"> <div align="center">Key</div></td>
      <td width="8%"> <div align="center">Type</div></td>
      <td width="83%"> <div align="center">Name</div></td>
    </tr>
    <?php do { ?>
      <tr>
        <td>
          <?php $linkstart = '<a href="charlistmethdetail.php?key=';
$linkend = '>'; ?>
          <?php echo
$linkstart,$row_methodsall['methkey'],$linkend,$row_methodsall['methkey'];
?></a></td>
          <td bgcolor="#FFFF66"><?php echo $row_methodsall['methtype'];
?></td>
          <td bgcolor="#FFFF66"><?php echo $row_methodsall['methname'];
?></td>
        </tr>
        <?php } while ($row_methodsall = mysql_fetch_assoc($methodsall)); ?>
      </table></td>
    </tr>
    <tr>
      <td width="585" height="76" valign="top"><div align="center">&nbsp;
Records
      <?php echo ($startRow_methodsall + 1) ?> to <?php echo
min($startRow_methodsall + $maxRows_methodsall, $totalRows_methodsall) ?> of
<?php echo $totalRows_methodsall ?> </div>
      <table border="0" width="50%" align="center">
        <tr>
          <td width="23%" align="center"> <?php if ($pageNum_methodsall > 0)
{ // Show if not first page ?>
            <a href="<?php printf("../%25s?pageNum_methodsall=%25d%25s",
$currentPage, 0, $queryString_methodsall); ?>">First</a>
            <?php } // Show if not first page ?> </td>
          <td width="31%" align="center"> <?php if ($pageNum_methodsall > 0)
{ // Show if not first page ?>
            <a href="<?php printf("../%25s?pageNum_methodsall=%25d%25s",
$currentPage, max(0, $pageNum_methodsall - 1), $queryString_methodsall);
?>">Previous</a>
            <?php } // Show if not first page ?> </td>
          <td width="23%" align="center"> <?php if ($pageNum_methodsall <
$totalPages_methodsall) { // Show if not last page ?>
            <a href="<?php printf("../%25s?pageNum_methodsall=%25d%25s",
$currentPage, min($totalPages_methodsall, $pageNum_methodsall + 1),
$queryString_methodsall); ?>">Next</a>
            <?php } // Show if not last page ?> </td>
          <td width="23%" align="center"> <?php if ($pageNum_methodsall <
$totalPages_methodsall) { // Show if not last page ?>
            <a href="<?php printf("../%25s?pageNum_methodsall=%25d%25s",
$currentPage, $totalPages_methodsall, $queryString_methodsall); ?>">Last</a>
            <?php } // Show if not last page ?> </td>
        </tr>
      </table></td>
      <td width="130">&nbsp;</td>
    </tr>

```

```

<tr>
  <td height="25" colspan="2" valign="top"><a
href=" ../managementhome.htm">Management
  Home Page</a></td>
</tr>
<tr>
  <td height="68">&nbsp;</td>
  <td>&nbsp;</td>
</tr>
</table>
</body>
</html>
<?php
mysql_free_result($methodsall);
?>

```

## Characteristic by Method Matrix

### Attributes by Technique

Choose an attribute below that you would like to rate for this technique.

Key	Name	Type
ab	A+B Price and time Qualifications process	select
Description		
This process requires the contractor provide a proposal that includes time as a component in the selection process of the low bidder for a project. The completion time forwarded within the contractors ?proposal? becomes the completion time for the project and the start time for liquidated damages. Incentives/disincentives are almost always used with this process. The disincentive is applied as a separate element in addition to liquidated damages. This bid process provides the ?best value? of cost and time for completion of work. An exemption to the normal bid process is required for this style of bidding.		

Key	Name	Type	01	02	03	04	05	06	07	08	09	10
pol	Political sensitivity	external	4	4	4	4	4	4	4	4	4	4
safe	Public safety	external	4	4	4	3	3	3	2	2	1	1
row	Right-of-Way	external	4	4	3	3	2	2	1	0	0	-1
util	Utility interference	external	4	4	4	3	3	2	2	1	-1	-2
trfk	Traffic volume	external	4	4	4	4	4	4	4	4	4	4
dsgn	design complexity	internal	1	1	2	2	3	3	3	4	4	4
staf	ODOT staffing level	internal	4	4	4	4	4	4	4	4	4	4
size	Project size	internal	1	1	1	2	2	3	3	4	4	4

Records 1 to 8 of 8

[Return to Techniques List](#)

```

<?php require_once(' ../Connections/odottools.php'); ?>
<?php
$currentPage = $HTTP_SERVER_VARS["PHP_SELF"];

$key = $_GET['mkey'];
$key = $mkey;
$colname_methodfocus = "1";
if (isset($HTTP_GET_VARS['mkey'])) {

```

```

    $colname_methodfocus = (get_magic_quotes_gpc()) ? $HTTP_GET_VARS['mkey'] :
addslashes($HTTP_GET_VARS['mkey']);
}
mysql_select_db($database_odottools, $odottools);
$query_methodfocus = sprintf("SELECT * FROM methods WHERE methkey = '%s'",
$colname_methodfocus);
$methodfocus = mysql_query($query_methodfocus, $odottools) or
die(mysql_error());
$row_methodfocus = mysql_fetch_assoc($methodfocus);
$totalRows_methodfocus = mysql_num_rows($methodfocus);
?>
<?php
$maxRows_characteristicsall = 10;
$pageNum_characteristicsall = 0;
if (isset($HTTP_GET_VARS['pageNum_characteristicsall'])) {
    $pageNum_characteristicsall = $HTTP_GET_VARS['pageNum_characteristicsall'];
}
$startRow_characteristicsall = $pageNum_characteristicsall *
$maxRows_characteristicsall;

mysql_select_db($database_odottools, $odottools);
$query_characteristicsall = "SELECT * FROM characteristics ORDER BY chartype
ASC";
$query_limit_characteristicsall = sprintf("%s LIMIT %d, %d",
$query_characteristicsall, $startRow_characteristicsall,
$maxRows_characteristicsall);
$characteristicsall = mysql_query($query_limit_characteristicsall,
$odottools) or die(mysql_error());
$row_characteristicsall = mysql_fetch_assoc($characteristicsall);

if (isset($HTTP_GET_VARS['totalRows_characteristicsall'])) {
    $totalRows_characteristicsall =
$HTTP_GET_VARS['totalRows_characteristicsall'];
} else {
    $all_characteristicsall = mysql_query($query_characteristicsall);
    $totalRows_characteristicsall = mysql_num_rows($all_characteristicsall);
}
$totalPages_characteristicsall =
ceil($totalRows_characteristicsall/$maxRows_characteristicsall)-1;
?>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<html>
<head>
<title>Method Detail</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
</head>

<body>

<table width="749" border="0" cellpadding="0" cellspacing="0">
  <!--DWLayoutTable-->
  <tr>
    <td height="41" colspan="2" valign="top"><h1
align="center">Characteristics
    by Method</h1></td>
    <td width="1"></td>
  </tr>

```

```
|  |  |  |  |  |  |  | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Choose a characteristic below that you would like to rate for this method.</td>  <table width="99%" border="1"> <!--DWLayoutTable--> |  |  |  | | --- | --- | --- | | <?php echo $row_methodfocus['methkey']; ?></td>  <?php echo $row_methodfocus['methname']; ?></td>  <?php echo $row_methodfocus['methtype']; ?></td> </tr> $row_methodfocus['methdescr']; ?></div></td> </tr> </table></td> &nbsp; <table border="1"> = '&mkey='; $linkend = '>'; ?> <?php echo $linkstart,$row_characteristicsall['charkey'],$linkmid,$key,$linkend,$row_cha racteristicsall['charkey']; ?></a> | | | | | | |

```

```

<td><?php echo $row_characteristicsall['charname']; ?></td>
<td><?php echo $row_characteristicsall['chartype']; ?></td>
<?php
    $ckey = $row_characteristicsall['charkey'];
    $cmkey = $ckey.$mkey;
    $cmkey_charmethfocus = "";
    if (isset($cmkey))
    {
        $cmkey_charmethfocus = (get_magic_quotes_gpc()) ? $cmkey
: addslashes($cmkey);
    }
    mysql_select_db($database_odottools, $odottools);
    $query_charmethfocus = sprintf("SELECT * FROM charmeth
WHERE charmethkey = '%s'", $cmkey_charmethfocus);
    $charmethfocus = mysql_query($query_charmethfocus,
$odottools) or die(mysql_error());
    $row_charmethfocus = mysql_fetch_assoc($charmethfocus);
    $totalRows_charmethfocus = mysql_num_rows($charmethfocus);

$queryString_characteristicsall = "";
if (!empty($_HTTP_SERVER_VARS['QUERY_STRING'])) {
    $params = explode("&", $_HTTP_SERVER_VARS['QUERY_STRING']);
    $newParams = array();
    foreach ($params as $param) {
        if (strpos($param, "pageNum_characteristicsall") == false &&
            strpos($param, "totalRows_characteristicsall") == false) {
            array_push($newParams, $param);
        }
    }
    if (count($newParams) != 0) {
        $queryString_characteristicsall = "&" . implode("&", $newParams);
    }
}
$queryString_characteristicsall =
sprintf("&totalRows_characteristicsall=%d%s", $totalRows_characteristicsall,
$queryString_characteristicsall);
?>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval01']; ?></div></td>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval02']; ?></div></td>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval03']; ?></div></td>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval04']; ?></div></td>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval05']; ?></div></td>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval06']; ?></div></td>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval07']; ?></div></td>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval08']; ?></div></td>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval09']; ?></div></td>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval10']; ?></div></td>

```



```

        </tr>
        <?php } while ($row_characteristicsall =
mysql_fetch_assoc($characteristicsall)); ?>
        </table></td>
        <td>&nbsp;</td>
    </tr>
    <tr>
        <td height="24" colspan="3" valign="top">&nbsp;<?php echo
($startRow_characteristicsall + 1) ?> to <?php echo
min($startRow_characteristicsall + $maxRows_characteristicsall,
$totalRows_characteristicsall) ?> of <?php echo $totalRows_characteristicsall
?> </tr>
    <tr>
        <td height="26" colspan="3" valign="top">&nbsp;<?php
        <table border="0" width="50%" align="center">
            <tr>
                <td width="23%" align="center">
                    <?php if ($pageNum_characteristicsall > 0) { // Show if not first
page ?>
                        <a href="<?php printf("%s?pageNum_characteristicsall=%d%s",
$currentPage, 0, $queryString_characteristicsall); ?>">First</a>
                    <?php } // Show if not first page ?>
                </td>
                <td width="31%" align="center">
                    <?php if ($pageNum_characteristicsall > 0) { // Show if not first
page ?>
                        <a href="<?php printf("%s?pageNum_characteristicsall=%d%s",
$currentPage, max(0, $pageNum_characteristicsall - 1),
$queryString_characteristicsall); ?>">Previous</a>
                    <?php } // Show if not first page ?>
                </td>
                <td width="23%" align="center">
                    <?php if ($pageNum_characteristicsall <
$totalPages_characteristicsall) { // Show if not last page ?>
                        <a href="<?php printf("%s?pageNum_characteristicsall=%d%s",
$currentPage, min($totalPages_characteristicsall, $pageNum_characteristicsall
+ 1), $queryString_characteristicsall); ?>">Next</a>
                    <?php } // Show if not last page ?>
                </td>
                <td width="23%" align="center">
                    <?php if ($pageNum_characteristicsall <
$totalPages_characteristicsall) { // Show if not last page ?>
                        <a href="<?php printf("%s?pageNum_characteristicsall=%d%s",
$currentPage, $totalPages_characteristicsall,
$queryString_characteristicsall); ?>">Last</a>
                    <?php } // Show if not last page ?>
                </td>
            </tr>
        </table>
    </tr>
    <tr>
        <td width="1" height="24">&nbsp;<?php
        <td colspan="2" valign="top"> <a href="charmethmlist.php">Return to Methods
List</a>
    </tr>
    <tr>
        <td height="1"></td>

```

```

        <td width="822"></td>
        <td></td>
    </tr>
</table>
</body>
</html>
<?php
mysql_free_result($methodfocus);

mysql_free_result($characteristicsall);
?>

```

## Characteristic by Method Rating

### Rating Attributes by Technique

Key	Technique	Type							
ab	A+B Price and time Qualifications process	select							
<u>Description</u> This process requires the contractor provide a proposal that includes time as a component in the selection process of the low bidder for a project. The completion time forwarded within the contractors ?proposal? becomes the completion time for the project and the start time for liquidated damages. Incentives/disincentives are almost always used with this process. The disincentive is applied as a separate element in addition to liquidated damages. This bid process provides the ?best value? of cost and time for completion of work. An exemption to the normal bid process is required for this style of bidding.									
Key	Attribute	Type							
pol	Political sensitivity	external							
<u>Description</u> Politically sensitive project; may include general public, media, or legislative, gubernatorial focus									
<u>Scoring range</u>									
<u>Value=01</u>	<u>Value=05</u>	<u>Value=10</u>							
Project has little impact to public or environment	Visible project that has general impact to public or environment; any public comment has been resolved	Highly controversial project that has a significant public or environmental impact and for which controversy continues. Strong public, media, and legislative/ gubernatorial focus exists.							
Score the timeliness effectiveness of the above technique under the following values of the above attribute (see key above). A score of "-10" = potential delay of 50% or more of the project schedule; "0" = no effect on the project timeliness; "10" = potential project acceleration of 50% or more of the project schedule:									
01	02	03	04	05	06	07	08	09	10
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="button" value="Update Record"/>									

[Return to Attributes by Technique list](#)

```

<?php require_once('../Connections/odottools.php'); ?>
<?php
$currentPage = $HTTP_SERVER_VARS["PHP_SELF"];

$key = $_GET['mkey'];
$key = $key;
$colname_methodfocus = "1";
if (isset($HTTP_GET_VARS['mkey'])) {
    $colname_methodfocus = (get_magic_quotes_gpc()) ? $HTTP_GET_VARS['mkey'] :
    addslashes($HTTP_GET_VARS['mkey']);
}

```

```

}
mysql_select_db($database_odottools, $odottools);
$query_methodfocus = sprintf("SELECT * FROM methods WHERE methkey = '%s'",
$colname_methodfocus);
$methodfocus = mysql_query($query_methodfocus, $odottools) or
die(mysql_error());
$row_methodfocus = mysql_fetch_assoc($methodfocus);
$totalRows_methodfocus = mysql_num_rows($methodfocus);
?>
<?php
$maxRows_characteristicsall = 10;
$pageNum_characteristicsall = 0;
if (isset($_HTTP_GET_VARS['pageNum_characteristicsall'])) {
    $pageNum_characteristicsall = $_HTTP_GET_VARS['pageNum_characteristicsall'];
}
$startRow_characteristicsall = $pageNum_characteristicsall *
$maxRows_characteristicsall;

mysql_select_db($database_odottools, $odottools);
$query_characteristicsall = "SELECT * FROM characteristics ORDER BY chartype
ASC";
$query_limit_characteristicsall = sprintf("%s LIMIT %d, %d",
$query_characteristicsall, $startRow_characteristicsall,
$maxRows_characteristicsall);
$characteristicsall = mysql_query($query_limit_characteristicsall,
$odottools) or die(mysql_error());
$row_characteristicsall = mysql_fetch_assoc($characteristicsall);

if (isset($_HTTP_GET_VARS['totalRows_characteristicsall'])) {
    $totalRows_characteristicsall =
$_HTTP_GET_VARS['totalRows_characteristicsall'];
} else {
    $all_characteristicsall = mysql_query($query_characteristicsall);
    $totalRows_characteristicsall = mysql_num_rows($all_characteristicsall);
}
$totalPages_characteristicsall =
ceil($totalRows_characteristicsall/$maxRows_characteristicsall)-1;
?>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<html>
<head>
<title>Method Detail</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
</head>

<body>

<table width="749" border="0" cellpadding="0" cellspacing="0">
  <!--DWLayoutTable-->
  <tr>
    <td height="41" colspan="2" valign="top"><h1
align="center">Characteristics
    by Method</h1></td>
    <td width="1"></td>
  </tr>
<tr>

```

```

        <td height="61" colspan="2" valign="top">Choose a characteristic below
that you would
        like to rate for this method.</td>
    </td></td>
</tr>
<tr>
    <td height="104" colspan="2" valign="top"><table width="99%" border="1">
        <!--DWLayoutTable-->
        <tr>
            <td width="151"><div align="center"><u>Key</u></div></td>
            <td width="373"><div align="center"><u>Name</u></div></td>
            <td width="162"><div align="center"><u>Type</u></div></td>
        </tr>
        <tr bgcolor="#FFFF66">
            <td height="12" align="left" valign="top"><?php echo
$row_methodfocus['methkey']; ?></td>
            <td height="12" align="left" valign="top"><?php echo
$row_methodfocus['methname']; ?></td>
            <td height="12" align="left" valign="top"><?php echo
$row_methodfocus['methtype']; ?></td>
        </tr>
        <tr>
            <td colspan="3"><div align="center">Description</div></td>
        </tr>
        <tr align="left" valign="top" bgcolor="#FFFF66">
            <td height="12" colspan="3"> <div align="left"><?php echo
$row_methodfocus['methdescr']; ?></div></td>
        </tr>
    </table></td>
</td></td>
</tr>
<tr>
    <td height="90" colspan="2" valign="top">&nbsp; <table border="1">
        <tr>
            <td width="10">Key</td>
            <td width="128">Name</td>
            <td width="30">Type</td>
            <td width="7"><div align="right">01</div></td>
            <td width="7"><div align="right">02</div></td>
            <td width="7"><div align="right">03</div></td>
            <td width="7"><div align="right">04</div></td>
            <td width="7"><div align="right">05</div></td>
            <td width="7"><div align="right">06</div></td>
            <td width="7"><div align="right">07</div></td>
            <td width="7"><div align="right">08</div></td>
            <td width="7"><div align="right">09</div></td>
            <td width="7"><div align="right">10</div></td>
        </tr>
        <?php do { ?>
        <tr>
            <td>
                <?php $linkstart = '<a href="charmethrating.php?ckey='; $linkmid
= '&mkey='; $linkend = '>'; ?>
                <?php echo
$linkstart,$row_characteristicsall['charkey'],$linkmid,$key,$linkend,$row_cha
racteristicsall['charkey']; ?></a>
                <td><?php echo $row_characteristicsall['charname']; ?></td>

```

```

<td><?php echo $row_characteristicsall['chartype']; ?></td>
<?php
    $ckey = $row_characteristicsall['charkey'];
    $cmkey = $ckey.$mkey;
    $cmkey_charmethfocus = "%";
    if (isset($cmkey))
    {
        $cmkey_charmethfocus = (get_magic_quotes_gpc()) ? $cmkey
: addslashes($cmkey);
    }
    mysql_select_db($database_odottools, $odottools);
    $query_charmethfocus = sprintf("SELECT * FROM charmeth
WHERE charmethkey = '%s'", $cmkey_charmethfocus);
    $charmethfocus = mysql_query($query_charmethfocus,
$odottools) or die(mysql_error());
    $row_charmethfocus = mysql_fetch_assoc($charmethfocus);
    $totalRows_charmethfocus = mysql_num_rows($charmethfocus);

$queryString_characteristicsall = "";
if (!empty($_SERVER_VARS['QUERY_STRING'])) {
    $params = explode("&", $_SERVER_VARS['QUERY_STRING']);
    $newParams = array();
    foreach ($params as $param) {
        if (strpos($param, "pageNum_characteristicsall") == false &&
            strpos($param, "totalRows_characteristicsall") == false) {
            array_push($newParams, $param);
        }
    }
    if (count($newParams) != 0) {
        $queryString_characteristicsall = "&" . implode("&", $newParams);
    }
}
$queryString_characteristicsall =
sprintf("&totalRows_characteristicsall=%d%s", $totalRows_characteristicsall,
$queryString_characteristicsall);
?>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval01']; ?></div></td>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval02']; ?></div></td>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval03']; ?></div></td>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval04']; ?></div></td>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval05']; ?></div></td>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval06']; ?></div></td>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval07']; ?></div></td>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval08']; ?></div></td>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval09']; ?></div></td>
<td bgcolor="#FFFF00"><div align="right"><?php echo
$row_charmethfocus['charmethval10']; ?></div></td>
</tr>

```

```

        <?php } while ($row_characteristicsall =
mysql_fetch_assoc($characteristicsall)); ?>
        </table></td>
        <td>&nbsp;</td>
    </tr>
    <tr>
        <td height="24" colspan="3" valign="top">&nbsp;<?php echo
($startRow_characteristicsall + 1) ?> to <?php echo
min($startRow_characteristicsall + $maxRows_characteristicsall,
$totalRows_characteristicsall) ?> of <?php echo $totalRows_characteristicsall
?> </tr>
    <tr>
        <td height="26" colspan="3" valign="top">&nbsp;<?php
        <table border="0" width="50%" align="center">
            <tr>
                <td width="23%" align="center">
                    <?php if ($pageNum_characteristicsall > 0) { // Show if not first
page ?>
                        <a href="<?php printf("%s?pageNum_characteristicsall=%d%s",
$currentPage, 0, $queryString_characteristicsall); ?>">First</a>
                    <?php } // Show if not first page ?>
                </td>
                <td width="31%" align="center">
                    <?php if ($pageNum_characteristicsall > 0) { // Show if not first
page ?>
                        <a href="<?php printf("%s?pageNum_characteristicsall=%d%s",
$currentPage, max(0, $pageNum_characteristicsall - 1),
$queryString_characteristicsall); ?>">Previous</a>
                    <?php } // Show if not first page ?>
                </td>
                <td width="23%" align="center">
                    <?php if ($pageNum_characteristicsall <
$totalPages_characteristicsall) { // Show if not last page ?>
                        <a href="<?php printf("%s?pageNum_characteristicsall=%d%s",
$currentPage, min($totalPages_characteristicsall, $pageNum_characteristicsall
+ 1), $queryString_characteristicsall); ?>">Next</a>
                    <?php } // Show if not last page ?>
                </td>
                <td width="23%" align="center">
                    <?php if ($pageNum_characteristicsall <
$totalPages_characteristicsall) { // Show if not last page ?>
                        <a href="<?php printf("%s?pageNum_characteristicsall=%d%s",
$currentPage, $totalPages_characteristicsall,
$queryString_characteristicsall); ?>">Last</a>
                    <?php } // Show if not last page ?>
                </td>
            </tr>
        </table>
    </tr>
    <tr>
        <td width="1" height="24">&nbsp;<?php
    <td colspan="2" valign="top"> <a href="charmethmlist.php">Return to Methods
List</a>
    </tr>
    <tr>
        <td height="1"></td>
        <td width="822"></td>

```

```
        <td></td>
    </tr>
</table>
</body>
</html>
<?php
mysql_free_result($methodfocus);

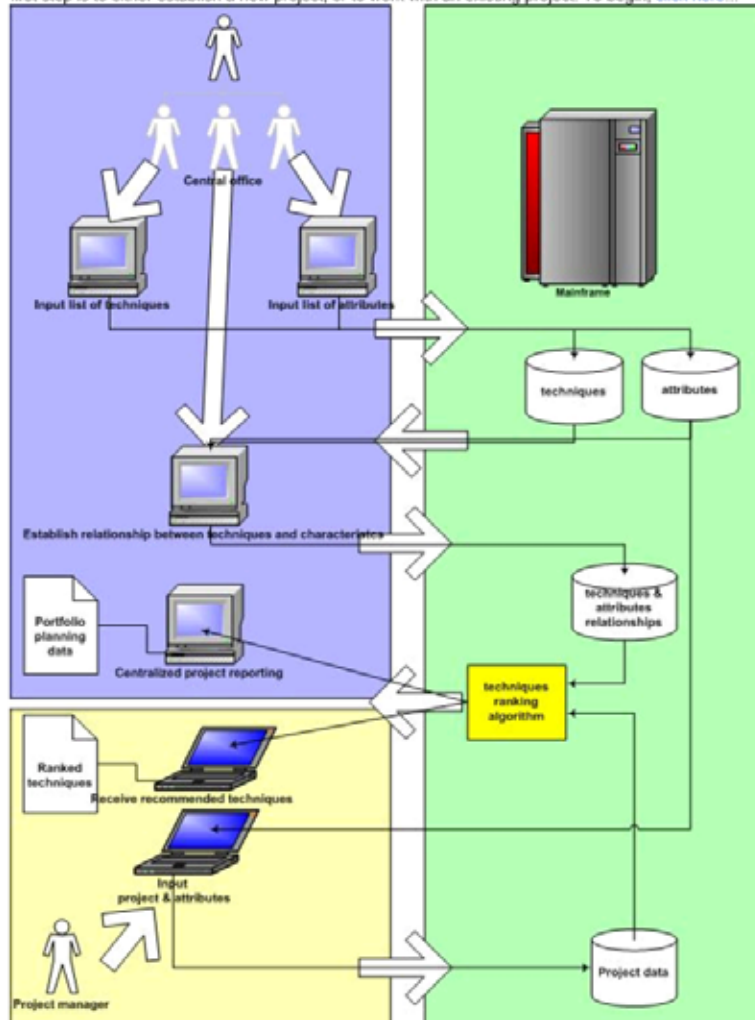
mysql_free_result($characteristicsall);
?>
```

## Project Section Home

### Project List

From this page, you may enter information about your project, and based on that information, obtain recommendations of project delivery techniques that may help the timely delivery of your project. The first step is to either establish a new project, or to work with an existing project. To begin, [click here...](#)

[Return to TST Home Page](#)



If you are interested in working with a project that has not been established in the system, please [Add a Project Here](#) and then return to this page. If your project is already logged into the system, then choose one of the following options:

- The "Proj Link" selection (below) allows you to review and/or modify details about the project;
- The "Attrib Link" selection allows you to assess the attributes for the project and obtain recommendations of delivery techniques

Proj Link	Attrib link	projnum	projname
<a href="#">test</a>	<a href="#">test</a>	010102	Historic Bridge Replacement
<a href="#">tst1</a>	<a href="#">tst1</a>	020202	Riedl Avenue
<a href="#">tst3</a>	<a href="#">tst3</a>	06003	Van Buren Bridge Replacement
<a href="#">tst4</a>	<a href="#">tst4</a>	080228	Latest test project
<a href="#">1234</a>	<a href="#">1234</a>	5555	test project #1
<a href="#">ex00</a>	<a href="#">ex00</a>	Example 00	Very complicated project
<a href="#">ex01</a>	<a href="#">ex01</a>	003	very simple pavement overlay

Records 1 to 7 of 7

[Return to TST Home Page](#)



```

<?php require_once('../Connections/odottools.php'); ?>
<?php
$currentPage = $HTTP_SERVER_VARS["PHP_SELF"];

$maxRows_projectsall = 10;
$pageNum_projectsall = 0;
if (isset($HTTP_GET_VARS['pageNum_projectsall'])) {
    $pageNum_projectsall = $HTTP_GET_VARS['pageNum_projectsall'];
}
$startRow_projectsall = $pageNum_projectsall * $maxRows_projectsall;

mysql_select_db($database_odottools, $odottools);
$query_projectsall = "SELECT * FROM projects";
$query_limit_projectsall = sprintf("%s LIMIT %d, %d", $query_projectsall,
    $startRow_projectsall, $maxRows_projectsall);
$projectsall = mysql_query($query_limit_projectsall, $odottools) or
    die(mysql_error());
$row_projectsall = mysql_fetch_assoc($projectsall);

if (isset($HTTP_GET_VARS['totalRows_projectsall'])) {
    $totalRows_projectsall = $HTTP_GET_VARS['totalRows_projectsall'];
} else {
    $all_projectsall = mysql_query($query_projectsall);
    $totalRows_projectsall = mysql_num_rows($all_projectsall);
}
$totalPages_projectsall = ceil($totalRows_projectsall/$maxRows_projectsall)-
1;

$queryString_projectsall = "";
if (!empty($HTTP_SERVER_VARS['QUERY_STRING'])) {
    $params = explode("&", $HTTP_SERVER_VARS['QUERY_STRING']);
    $newParams = array();
    foreach ($params as $param) {
        if (strpos($param, "pageNum_projectsall") == false &&
            strpos($param, "totalRows_projectsall") == false) {
            array_push($newParams, $param);
        }
    }
    if (count($newParams) != 0) {
        $queryString_projectsall = "&" . implode("&", $newParams);
    }
}
$queryString_projectsall = sprintf("&totalRows_projectsall=%d%s",
    $totalRows_projectsall, $queryString_projectsall);
?>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<html>
<head>
<title>Project List</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
</head>

<body>

<table width="720" border="0" cellpadding="0" cellspacing="0">

```

```

<!--DWLayoutTable-->
|  |  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| <h1 align="center">Project List</h1></td> | |
| From this page, you may enter information about your project, and based on that information, obtain recommendations of project delivery methods that may help the timely delivery of your project. The first step is to either establish a new project, or to work with an existing project. To begin, <a href="#projectsectionanchor">click here</a>...</td> |  |  | | --- | --- | | <div align="right">Return to <a href=" ../index.htm">MSeT Home Page</a></div></td> | | | </td> | | | <p><a name="projectsectionanchor"></a>If you are interested in working with a project that has not been established in the system, please <a href="projadd.php">Add a Project Here</a> and then return to this page. If your project is already logged into the system, then choose one of the following options:</p> | | | <ul> <li>The &quot;Proj Link&quot; selection (below) allows you to review and/or modify details about the project;</li> <li>The &quot;Attrib Link&quot; selection allows you to assess the characteristics for the project and obtain recommendations of delivery methods</li> </ul></td> | | | &nbsp;   |                                                                                                                                                                                                                                                      |  |  |  |             |  |  |  |         |  |  |  |          |  |  |  |                                                                                                                                                                             |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|-------------|--|--|--|---------|--|--|--|----------|--|--|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--| | Proj Link                                                                                                                                                                                                                                            |  |  |  | Attrib link |  |  |  | projnum |  |  |  | projname |  |  |  |                                                                                                                                                                             |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | <?php do { ?> <tr> <td colspan="16"> &lt;?php \$linkstart = '&lt;a href="projdetail.php?pkey='; \$linkend = '&gt;'; ?&gt; &lt;?php echo \$linkstart,\$row_projectsall['projkey'],\$linkend,\$row_projectsall['projkey']; ?&gt;&lt;/a&gt; </td> </tr> |  |  |  |             |  |  |  |         |  |  |  |          |  |  |  | <?php \$linkstart = '<a href="projdetail.php?pkey='; \$linkend = '>'; ?> <?php echo \$linkstart,\$row_projectsall['projkey'],\$linkend,\$row_projectsall['projkey']; ?></a> |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | <?php \$linkstart = '<a href="projdetail.php?pkey='; \$linkend = '>'; ?> <?php echo \$linkstart,\$row_projectsall['projkey'],\$linkend,\$row_projectsall['projkey']; ?></a>                                                                          |  |  |  |             |  |  |  |         |  |  |  |          |  |  |  |                                                                                                                                                                             |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | | | |

```

```

                <?php $linkstart = '<a
href="../../../Proj_Char/projcharlist.php?pkey='; $linkend = '>'; ?>
                <?php echo
$linkstart,$row_projectsall['projkey'],$linkend,$row_projectsall['projkey'];
?></a>                </td>
                <td bgcolor="#FFFF66"><?php echo $row_projectsall['projnum'];
?></td>
                <td bgcolor="#FFFF66"><?php echo $row_projectsall['projname'];
?></td>
            </tr>
            <?php } while ($row_projectsall = mysql_fetch_assoc($projectsall));
?>
        </table>        </td>
    </tr>
    <tr>
        <td height="27" colspan="2" valign="top">&nbsp; Records <?php echo
($startRow_projectsall + 1) ?> to <?php echo min($startRow_projectsall +
$maxRows_projectsall, $totalRows_projectsall) ?> of <?php echo
$totalRows_projectsall ?> </td>
    </tr>
    <tr>
        <td height="57" colspan="2" valign="top">&nbsp;
        <table border="0" width="50%" align="center">
            <tr>
                <td width="23%" align="center">
                    <?php if ($pageNum_projectsall > 0) { // Show if not first page
?>
                    <a href="<?php printf("%s?pageNum_projectsall=%d%s",
$currentPage, 0, $queryString_projectsall); ?>">First</a>
                    <?php } // Show if not first page ?>                </td>
                <td width="31%" align="center">
                    <?php if ($pageNum_projectsall > 0) { // Show if not first page
?>
                    <a href="<?php printf("%s?pageNum_projectsall=%d%s",
$currentPage, max(0, $pageNum_projectsall - 1), $queryString_projectsall);
?>">Previous</a>
                    <?php } // Show if not first page ?>                </td>
                <td width="23%" align="center">
                    <?php if ($pageNum_projectsall < $totalPages_projectsall) { //
Show if not last page ?>
                    <a href="<?php printf("%s?pageNum_projectsall=%d%s",
$currentPage, min($totalPages_projectsall, $pageNum_projectsall + 1),
$queryString_projectsall); ?>">Next</a>
                    <?php } // Show if not last page ?>                </td>
                <td width="23%" align="center">
                    <?php if ($pageNum_projectsall < $totalPages_projectsall) { //
Show if not last page ?>
                    <a href="<?php printf("%s?pageNum_projectsall=%d%s",
$currentPage, $totalPages_projectsall, $queryString_projectsall);
?>">Last</a>
                    <?php } // Show if not last page ?>                </td>
            </tr>
        </table>        </td>
    </tr>
    <tr>
        <td height="19" colspan="2" valign="top">
            <p>&nbsp;</p>        </td>

```

```

        </tr>
        <tr>
            <td height="36" colspan="2" valign="top">Return to <a
href="../../index.htm">MSet
            Home Page</a></td>
        </tr>
    </table>
</body>
</html>
<?php
mysql_free_result($projectsall);
?>

```

## Project Add

### Add a project

Key (4 Number  
char's)

Name:

Description

Stage:

[Return to Project List](#)

```

/* Program to add projects - projadd.php */
<?php require_once('../../Connections/odottools.php'); ?>
<?php
function GetSQLValueString($theValue, $theType, $theDefinedValue = "",
$theNotDefinedValue = "")
{
    $theValue = (!get_magic_quotes_gpc()) ? addslashes($theValue) : $theValue;

    switch ($theType) {
        case "text":

```

```

        $theValue = ($theValue != "") ? "'" . $theValue . "'" : "NULL";
        break;
    case "long":
    case "int":
        $theValue = ($theValue != "") ? intval($theValue) : "NULL";
        break;
    case "double":
        $theValue = ($theValue != "") ? "'" . doubleval($theValue) . "'" :
"NULL";
        break;
    case "date":
        $theValue = ($theValue != "") ? "'" . $theValue . "'" : "NULL";
        break;
    case "defined":
        $theValue = ($theValue != "") ? $theDefinedValue : $theNotDefinedValue;
        break;
    }
    return $theValue;
}

$editFormAction = $HTTP_SERVER_VARS['PHP_SELF'];
if (isset($HTTP_SERVER_VARS['QUERY_STRING'])) {
    $editFormAction .= "?" . $HTTP_SERVER_VARS['QUERY_STRING'];
}

if ((isset($HTTP_POST_VARS["MM_insert"])) && ($HTTP_POST_VARS["MM_insert"] ==
"form2")) {
    $insertSQL = sprintf("INSERT INTO projects (projkey, projnum, projname,
projdescr, projstage) VALUES (%s, %s, %s, %s, %s)",
        GetSQLValueString($HTTP_POST_VARS['projkey'], "text"),
        GetSQLValueString($HTTP_POST_VARS['projnum'], "text"),
        GetSQLValueString($HTTP_POST_VARS['projname'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['projdescr'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['projstage'],
"text"));

    mysql_select_db($database_odottools, $odottools);
    $Result1 = mysql_query($insertSQL, $odottools) or die(mysql_error());

    require_once('../Population/populateprojchar.php');

    $insertGoTo = "projlist.php";
    if (isset($HTTP_SERVER_VARS['QUERY_STRING'])) {
        $insertGoTo .= (strpos($insertGoTo, '?')) ? "&" : "?";
        $insertGoTo .= $HTTP_SERVER_VARS['QUERY_STRING'];
    }
    header(sprintf("Location: %s", $insertGoTo));
}
?>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<html>
<head>
<title>Add a Project</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
</head>

```

```

<body>

<table width="715" border="0" cellpadding="0" cellspacing="0">
  <!--DWLayoutTable-->
  <tr>
    <td width="715" height="45" valign="top"><h1 align="center">Add a
project</h1></td>
  </tr>
  <tr>
    <td height="290" valign="top"><form name="form1" method="post" action="">

      </form>
      <form method="post" name="form2" action="<?php echo $editFormAction;
?>">
        <table align="center">
          <!--DWLayoutTable-->
          <tr valign="baseline">
            <td width="49" height="21" align="right" nowrap>Key (4
char's)</td>
            <td width="104">Number</td>
            <td width="245">Name:</td>
          </tr>
          <tr valign="baseline">
            <td height="24" valign="top"><input type="text" name="projkey"
value="" size="6">
            </td>
            <td valign="top"><input type="text" name="projnum" value=""
size="15">
            </td>
            <td valign="top"><input type="text" name="projname" value=""
size="50">
            </td>
          </tr>
          <tr valign="baseline">
            <td height="24" colspan="3" valign="top"><div
align="center">Description</div></td>
          </tr>
          <tr valign="baseline">
            <td height="24" colspan="3" valign="top"><textarea
name="projdescr" cols="80" rows="3"></textarea>
            </td>
          </tr>
          <tr valign="baseline">
            <td height="24" colspan="3" align="right" valign="top"
nowrap><div align="left">Stage:</div></td>
          </tr>
          <tr valign="baseline">
            <td height="24" colspan="3" valign="top"><input type="text"
name="projstage" value="" size="15">
            </td>
          </tr>
          <tr valign="baseline">
            <td height="26" colspan="3" valign="top"><input type="submit"
value="Insert Record">
            </td>
          </tr>
        </table>
      </form>
    </td>
  </tr>

```

```

        </table>
        <input type="hidden" name="MM_insert" value="form2">
    </form>
    </td>
</tr>
<tr>
    <td height="27" valign="top"><!--DWLayoutEmptyCell-->&nbsp;  </td>
</tr>
<tr>
    <td height="63" valign="top">Return to <a href="projlist.php">Project
    List</a></td>
</tr>
<tr>
    <td height="1"></td>
</tr>
</table>
</body>
</html>
<?php
mysql_free_result($projectsall);
?>

```

## Project Detail/Modify

Key	Number	Name
test	010102	Historic Bridge Replacement
Description		
<div>Remove historic bridge and replace with more economical one</div>		
Stage		
<div>PE</div>		
<div>Update Record</div>		

[Return to Project List](#)

```
<?php require_once('../Connections/odottools.php'); ?>
<?php
function GetSQLValueString($theValue, $theType, $theDefinedValue = "",
$theNotDefinedValue = "")
{
    $theValue = (!get_magic_quotes_gpc()) ? addslashes($theValue) : $theValue;

    switch ($theType) {
        case "text":
            $theValue = ($theValue != "") ? "'" . $theValue . "'" : "NULL";
            break;
        case "long":
        case "int":
            $theValue = ($theValue != "") ? intval($theValue) : "NULL";
            break;
        case "double":
```



```

        $theValue = ($theValue != "") ? "'" . doubleval($theValue) . "'" :
"NULL";
        break;
    case "date":
        $theValue = ($theValue != "") ? "'" . $theValue . "'" : "NULL";
        break;
    case "defined":
        $theValue = ($theValue != "") ? $theDefinedValue : $theNotDefinedValue;
        break;
    }
    return $theValue;
}

$editFormAction = $HTTP_SERVER_VARS['PHP_SELF'];
if (isset($HTTP_SERVER_VARS['QUERY_STRING'])) {
    $editFormAction .= "?" . $HTTP_SERVER_VARS['QUERY_STRING'];
}

if ((isset($HTTP_POST_VARS["MM_update"])) && ($HTTP_POST_VARS["MM_update"] ==
"form1")) {
    $updateSQL = sprintf("UPDATE projects SET projnum=%s, projname=%s,
projdescr=%s, projstage=%s WHERE projkey=%s",
        GetSQLValueString($HTTP_POST_VARS['projnum'], "text"),
        GetSQLValueString($HTTP_POST_VARS['projname'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['projdescr'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['projstage'],
"text"),
        GetSQLValueString($HTTP_POST_VARS['projkey'],
"text"));

    mysql_select_db($database_odottools, $odottools);
    $Result1 = mysql_query($updateSQL, $odottools) or die(mysql_error());

    $updateGoTo = "projdetail.php";
    if (isset($HTTP_SERVER_VARS['QUERY_STRING'])) {
        $updateGoTo .= (strpos($updateGoTo, '?')) ? "&" : "?";
        $updateGoTo .= $HTTP_SERVER_VARS['QUERY_STRING'];
    }
    header(sprintf("Location: %s", $updateGoTo));
}

$pkey_projectfocus = "%";
if (isset($HTTP_GET_VARS['pkey'])) {
    $pkey_projectfocus = (get_magic_quotes_gpc()) ? $HTTP_GET_VARS['pkey'] :
addslashes($HTTP_GET_VARS['pkey']);
}
mysql_select_db($database_odottools, $odottools);
$query_projectfocus = sprintf("SELECT * FROM projects WHERE projkey = '%s'",
$pkey_projectfocus);
$projectfocus = mysql_query($query_projectfocus, $odottools) or
die(mysql_error());
$row_projectfocus = mysql_fetch_assoc($projectfocus);
$totalRows_projectfocus = mysql_num_rows($projectfocus);
?>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">

```

```

<html>
<head>
<title>Display Project</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
</head>

<body>

<table width="643" border="0" cellpadding="0" cellspacing="0">
  <!--DWLayoutTable-->
  <tr>
    <td width="643" height="356" valign="top"><form method="post"
name="form1" action="<?php echo $editFormAction; ?>">
      <p>&nbsp;</p>
      <table width="626" border="1" align="left">
        <!--DWLayoutTable-->
        <tr valign="baseline">
          <td width="71" height="23" align="right" valign="top" nowrap><div
align="left"><u>Key</u></div></td>
          <td width="110" valign="top"><div
align="left"><u>Number</u></div></td>
          <td width="408" valign="top"><div
align="left"><u>Name</u></div></td>
        </tr>
        <tr valign="baseline">
          <td height="26" colspan="1" valign="top"><?php echo
$row_projectfocus['projkey']; ?></td>
          <td valign="top"><input type="text" name="projnum" value="<?php
echo $row_projectfocus['projnum']; ?>" size="15">
          </td>
          <td valign="top"><input type="text" name="projname" value="<?php
echo $row_projectfocus['projname']; ?>" size="50">
          </td>
        </tr>
        <tr valign="baseline">
          <td height="23" colspan="3" valign="top"> <div
align="center">Description</div>
          </td>
        </tr>
        <tr valign="baseline">
          <td height="74" colspan="3" valign="top"><textarea
name="projdescr" cols="95"><?php echo $row_projectfocus['projdescr'];
?></textarea>
          </td>
        </tr>
        <tr valign="baseline">
          <td height="23" colspan="3" valign="top">Stage</td>
        </tr>
        <tr valign="baseline">
          <td height="74" colspan="3" valign="top"> <textarea
name="projstage" cols="95"><?php echo $row_projectfocus['projstage'];
?></textarea>
          </td>
        </tr>
        <tr valign="baseline">
          <td height="28" colspan="3" valign="top"><div align="center">
            <input name="submit" type="submit" value="Update Record">

```

```

        </div>
    </td>
</tr>
<tr valign="baseline">
    <td height="23" colspan="3" valign="top"><!--DWLayoutEmptyCell--
>&nbsp;</td>
</tr>
<tr valign="baseline">
    <td height="2"></td>
    <td></td>
    <td></td>
</tr>
</table>
<input type="hidden" name="MM_update" value="form1">
<input type="hidden" name="projkey" value="<?php echo
$row_projectfocus['projkey']; ?>">
</form>    <p>&nbsp;</p>
</td>
</tr>
<tr>
    <td height="26" valign="top">Return to <a href="projlist.php">Project
    List</a></td>
</tr>
<tr>
    <td height="3"></td>
</tr>
</table>
</body>
</html>
<?php
mysql_free_result($projectfocus);
?>

```

## Project Delete (Not Implemented)

This function was not implemented.

## Project Characteristic Profile

### Project Profile Definition (attributes scores)

#### Project Information

Key	Project Number	Project
test	010102	Historic Bridge Replacement

#### Project Profile

Key	Attribute	Description	Type	Score
pol	Political sensitivity	Politically sensitive project; may include general public, media, or legislative, gubernatorial focus	external	7
safe	Public safety	Characteristic may describe either direct safety concerns (such as increased likelihood of accidents), or secondary public safety issues (such as emergency route restrictions).	external	8
row	Right-of-Way	This attribute describes the state of issues surrounding rights-of-way necessary for the development of the project, including both permanent and temporary rights-of-way. The state of the rights-of-way include factors such as agreement status and timing.	external	5
util	Utility interference	This attribute describes a condition where significant third-party utilities exist that may require protection from damage or relocation.	external	5
trfk	Traffic volume	Higher score indicates higher amounts of traffic that will be affected by the construction	external	5
dsgn	design complexity	Design complexity indicates the nature of a project	internal	3
staf	ODOT staffing level	This attribute refers to the ODOT internal staffing resources available in relationship to the staffing needs of the project. Generally, this will also reflect the overall strain of the agency to undertake the total scope of work at hand for the agency.	internal	5
size	Project size	The size of the project as measured in terms of cost	internal	7

Records 1 to 8 of 8

[Retrieve list of prioritized methods](#)

[Return to project list](#)

```
<?php require_once('.../Connections/odottools.php'); ?>
```

```
<?php
$currentPage = $HTTP_SERVER_VARS["PHP_SELF"];

/*Build project focus recordset*/
$pkey = $_GET['pkey'];
echo "pkey=", $pkey;
$pkey_projectfocus = "%";
if (isset($_GET['pkey'])) {
    $pkey_projectfocus = (get_magic_quotes_gpc()) ? $_GET['pkey'] :
addslashes($_GET['pkey']);
}
mysql_select_db($database_odottools, $odottools);
$query_projectfocus = sprintf("SELECT * FROM projects WHERE projkey = '%s'",
$pkey_projectfocus);
$result_projectfocus = mysql_query($query_projectfocus, $odottools) or
die(mysql_error());
$row_projectfocus = mysql_fetch_assoc($result_projectfocus);
$totalRows_projectfocus = mysql_num_rows($result_projectfocus);
/* Build characteristic all recordset */
$maxRows_characteristicsall = 10;
$pageNum_characteristicsall = 0;
if (isset($HTTP_GET_VARS['pageNum_characteristicsall'])) {
    $pageNum_characteristicsall = $HTTP_GET_VARS['pageNum_characteristicsall'];
```

```

}
$startRow_characteristicsall = $pageNum_characteristicsall *
$maxRows_characteristicsall;

mysql_select_db($database_odottools, $odottools);
$query_characteristicsall = "SELECT * FROM characteristics ORDER BY
chartype";
$query_limit_characteristicsall = sprintf("%s LIMIT %d, %d",
$query_characteristicsall, $startRow_characteristicsall,
$maxRows_characteristicsall);
$characteristicsall = mysql_query($query_limit_characteristicsall,
$odottools) or die(mysql_error());
$row_characteristicsall = mysql_fetch_assoc($characteristicsall);

if (isset($HTTP_GET_VARS['totalRows_characteristicsall'])) {
    $totalRows_characteristicsall =
$HTTP_GET_VARS['totalRows_characteristicsall'];
} else {
    $all_characteristicsall = mysql_query($query_characteristicsall);
    $totalRows_characteristicsall = mysql_num_rows($all_characteristicsall);
}
$totalPages_characteristicsall =
ceil($totalRows_characteristicsall/$maxRows_characteristicsall)-1;
?>

<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">

<html>
<head>
<title>Untitled Document</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
</head>

<body>
<!--!Display project header-->
<table width="771" border="0" cellpadding="0" cellspacing="0">
  <!--DWLayoutTable-->
  <tr>
    <td height="36" colspan="3" valign="top"><h1 align="center">Project
Profile Definition<br>
(characteristics scores)</h1></td>
  </tr>
  <tr>
    <td height="19" colspan="2" valign="top"><p
align="center"><strong><u>Project Information</u></strong></p>
    <td width="1">&nbsp;</td>
  </tr>
  <tr>
    <td height="54" colspan="2" valign="top"><table width="100%"
border="1">
  <!--DWLayoutTable-->
  <tr>
    <td width="145" height="23" valign="top">Key</td>
    <td width="151" valign="top">Project Number</td>
    <td width="451" valign="top">Project</td>
  </tr>
  <tr>

```

```

        <td height="23" valign="top"><?php echo
$row_projectfocus['projkey']; ?></td>
        <td valign="top"><?php echo $row_projectfocus['projnum']; ?></td>
        <td valign="top"><?php echo $row_projectfocus['projname'];
?></td>
    </tr>
</table></td>
<td>&nbsp;</td>
</tr>
<!--!for all characteristics records-->
<!--!Display list of characteristics/scores-->
<tr>
    <td height="22" colspan="2" valign="top"><div
align="center"><u><strong>Project Profile</strong></u></div></td>
    <td>&nbsp;</td>
</tr>
<tr>
    <td height="92" colspan="2" valign="top"><table border="1">
        <tr>
            <td>Key</td>
            <td>Characteristic</td>
            <td>Description</td>
            <td>Type</td>
            <td>Score</td>
        </tr>
        <?php do { ?>
        <tr>
            <td>
                <!--make the characteristic key a hot link to the detail
scoring-->

                <?php echo $row_characteristicsall['charkey'];
                $ckey = $row_characteristicsall['charkey'];
                ?>
            </td>
            <td><?php echo $row_characteristicsall['charname']; ?></td>
            <td><?php echo $row_characteristicsall['chardescr']; ?></td>
            <td><?php echo $row_characteristicsall['chartype']; ?></td>
            <td>

                <?php
                /* Find proj/char record */
                $pckey = $pkey.$ckey;
                $pckey_projcharfocus = "%";
                if (isset($pckey)) {
                    $pckey_projcharfocus = (get_magic_quotes_gpc()) ?
$pckey : addslashes($pckey);
                }
                mysql_select_db($database_odottools, $odottools);
                $query_projcharfocus = sprintf("SELECT * FROM
projchar WHERE projcharkey = '%s'", $pckey_projcharfocus);
                $projcharfocus = mysql_query($query_projcharfocus,
$odottools) or die(mysql_error());
                $row_projcharfocus =
mysql_fetch_assoc($projcharfocus);
                $totalRows_projcharfocus =
mysql_num_rows($projcharfocus);

```

```

$queryString_characteristicsall = "";
if (!empty($HTTP_SERVER_VARS['QUERY_STRING'])) {
    $params = explode("&", $HTTP_SERVER_VARS['QUERY_STRING']);
    $newParams = array();
    foreach ($params as $param) {
        if (strpos($param, "pageNum_characteristicsall") == false &&
            strpos($param, "totalRows_characteristicsall") == false) {
            array_push($newParams, $param);
        }
    }
    if (count($newParams) != 0) {
        $queryString_characteristicsall = "&" . implode("&", $newParams);
    }
}
$queryString_characteristicsall =
sprintf("&totalRows_characteristicsall=%d&s", $totalRows_characteristicsall,
$queryString_characteristicsall);

/* if proj/char record doesn't exist */
if ($totalRows_projcharfocus == 0) {
    /* add a proj/char record with default of 5 */
    $insertSQL = sprintf("INSERT INTO projchar
(projcharkey, projcharprojkey, projcharcharkey) VALUES ('%s', '%s', '%s')",
$pkkey, $pkey, $ckey);
    echo $insertSQL;

    mysql_select_db($database_odottools,
$odottools);
    $Result1 = mysql_query($insertSQL, $odottools)
or die(mysql_error("Error on building new record"));
}
?>

<?php $linkstart = '<a href="projcharmodify.php?pkey=';
$linkmid = '&ckey='; $linkend = '">'; ?>
<?php echo
$linkstart,$pkey,$linkmid,$ckey,$linkend,$row_projcharfocus['projcharscore'];
?></a>

</td>
</tr>
<?php } while ($row_characteristicsall =
mysql_fetch_assoc($characteristicsall)); ?>
</table></td>
<td>&nbsp;</td>
</tr>
<tr>
<td height="19" colspan="2" valign="top">&nbsp;<?php echo
($startRow_characteristicsall + 1) ?> to <?php echo
min($startRow_characteristicsall + $maxRows_characteristicsall,
$totalRows_characteristicsall) ?> of <?php echo $totalRows_characteristicsall
?> </td>
<td>&nbsp;</td>
</tr>
<tr>
<td height="30" colspan="2" valign="top">&nbsp;<?php
<table border="0" width="50%" align="center">

```

```

        <tr>
            <td width="23%" align="center">
                <?php if ($pageNum_characteristicsall > 0) { // Show if not
first page ?>
                    <a href="<?php printf("%s?pageNum_characteristicsall=%d%s",
$currentPage, 0, $queryString_characteristicsall); ?>">First</a>
                    <?php } // Show if not first page ?>
                </td>
                <td width="31%" align="center">
                    <?php if ($pageNum_characteristicsall > 0) { // Show if not
first page ?>
                        <a href="<?php printf("%s?pageNum_characteristicsall=%d%s",
$currentPage, max(0, $pageNum_characteristicsall - 1),
$queryString_characteristicsall); ?>">Previous</a>
                        <?php } // Show if not first page ?>
                    </td>
                    <td width="23%" align="center">
                        <?php if ($pageNum_characteristicsall <
$totalPages_characteristicsall) { // Show if not last page ?>
                            <a href="<?php printf("%s?pageNum_characteristicsall=%d%s",
$currentPage, min($totalPages_characteristicsall, $pageNum_characteristicsall
+ 1), $queryString_characteristicsall); ?>">Next</a>
                            <?php } // Show if not last page ?>
                        </td>
                        <td width="23%" align="center">
                            <?php if ($pageNum_characteristicsall <
$totalPages_characteristicsall) { // Show if not last page ?>
                                <a href="<?php printf("%s?pageNum_characteristicsall=%d%s",
$currentPage, $totalPages_characteristicsall,
$queryString_characteristicsall); ?>">Last</a>
                                <?php } // Show if not last page ?>
                            </td>
                        </tr>
                    </table></td>
                <td>&nbsp;</td>
            </tr>
            <tr>
                <td height="26" colspan="2" valign="top">
                    <?php
                        $linkstart = '<a href="../../../Projmeth/projmethcalculate.php?pkey=';
                        $linkend = '>Retrieve list of prioritized methods</a>';
                        echo $linkstart,$pkey,$linkend;?>
                    </td>
                <td>&nbsp;</td>
            </tr>
            <tr>
                <td width="1" height="41">&nbsp;</td>
                <td colspan="2" valign="top"><a
href="../../../ProjectSection/projlist.php">Return to project list</a></td>
            </tr>
            <tr>
                <td height="1"></td>
                <td width="769"></td>
            </tr>
        </table>
    </body>

```



```

</html>
<?php
mysql_free_result($projectfocus);

mysql_free_result($characteristicsall);

mysql_free_result($projcharfocus);
?>

```

## Project Characteristic Rating

# Project Attribute Rating

### Project

Key	Number	Name
test	010102	Historic Bridge Replacement

### Attribute

Key	Name	Description	Type
pol	Political sensitivity	Politically sensitive project; may include general public, media, or legislative, gubernatorial focus	external
Value 01		Value = 05	Value = 10
Project has little impact to public or environment		Visible project that has general impact to public or environment; any public comment has been resolved	Highly controversial project that has a significant public or environmental impact and for which controversy continues. Strong public, media, and legislative/ gubernatorial focus exists.

Projcharkey: testpol

Projcharscore:

```

<?php require_once('../Connections/odottools.php'); ?>
<?php
function GetSQLValueString($theValue, $theType, $theDefinedValue = "",
$theNotDefinedValue = "")
{
    $theValue = (!get_magic_quotes_gpc()) ? addslashes($theValue) : $theValue;

    switch ($theType) {
        case "text":
            $theValue = ($theValue != "") ? "'" . $theValue . "'" : "NULL";
            break;
        case "long":
        case "int":
            $theValue = ($theValue != "") ? intval($theValue) : "NULL";
            break;
        case "double":
            $theValue = ($theValue != "") ? "'" . doubleval($theValue) . "'" :
"NULL";

```

```

        break;
    case "date":
        $theValue = ($theValue != "") ? "'" . $theValue . "'" : "NULL";
        break;
    case "defined":
        $theValue = ($theValue != "") ? $theDefinedValue : $theNotDefinedValue;
        break;
    }
    return $theValue;
}

$editFormAction = $HTTP_SERVER_VARS['PHP_SELF'];
if (isset($HTTP_SERVER_VARS['QUERY_STRING'])) {
    $editFormAction .= "?" . $HTTP_SERVER_VARS['QUERY_STRING'];
}

if ((isset($HTTP_POST_VARS["MM_update"])) && ($HTTP_POST_VARS["MM_update"] ==
"form1")) {
    $updateSQL = sprintf("UPDATE projchar SET projcharscore=%s WHERE
projcharkey=%s",
                        GetSQLValueString($HTTP_POST_VARS['projcharscore'],
"int"),
                        GetSQLValueString($HTTP_POST_VARS['projcharkey'],
"text"));

    mysql_select_db($database_odottools, $odottools);
    $Result1 = mysql_query($updateSQL, $odottools) or die(mysql_error());

    $updateGoTo = "projcharlist.php?pkey=" .
$row_projcharfocus['projcharprojkey'] . "&ckey=" .
$row_projcharfocus['projcharcharkey'] . "";
    if (isset($HTTP_SERVER_VARS['QUERY_STRING'])) {
        $updateGoTo .= (strpos($updateGoTo, '?')) ? "&" : "?";
        $updateGoTo .= $HTTP_SERVER_VARS['QUERY_STRING'];
    }
    header(sprintf("Location: %s", $updateGoTo));
}

$pkey = $_GET['pkey'];
$ckey = $_GET['ckey'];
$pkkey = $pkey.$ckey;

$pkey_projectfocus = "$";
if (isset($_GET['pkey'])) {
    $pkey_projectfocus = (get_magic_quotes_gpc()) ? $_GET['pkey'] :
addslashes($_GET['pkey']);
}
mysql_select_db($database_odottools, $odottools);
$query_projectfocus = sprintf("SELECT * FROM projects WHERE projkey = '%s'",
$pkey_projectfocus);
$projectfocus = mysql_query($query_projectfocus, $odottools) or
die(mysql_error());
$row_projectfocus = mysql_fetch_assoc($projectfocus);
$totalRows_projectfocus = mysql_num_rows($projectfocus);

$ckey_characteristicfocus = "%";
if (isset($_GET['ckey'])) {

```

```

    $skey_characteristicfocus = (get_magic_quotes_gpc()) ? $_GET['ckey'] :
addslashes($_GET['ckey']);
}
mysql_select_db($database_odottools, $odottools);
$query_characteristicfocus = sprintf("SELECT * FROM characteristics WHERE
charkey = '%s'", $skey_characteristicfocus);
$characteristicfocus = mysql_query($query_characteristicfocus, $odottools) or
die(mysql_error());
$row_characteristicfocus = mysql_fetch_assoc($characteristicfocus);
$totalRows_characteristicfocus = mysql_num_rows($characteristicfocus);

$pckey_projcharfocus = "";
if (isset($pckey)) {
    $pckey_projcharfocus = (get_magic_quotes_gpc()) ? $pckey :
addslashes($pckey);
}
mysql_select_db($database_odottools, $odottools);
$query_projcharfocus = sprintf("SELECT * FROM projchar WHERE projcharkey =
'%s'", $pckey_projcharfocus);
$projcharfocus = mysql_query($query_projcharfocus, $odottools) or
die(mysql_error());
$row_projcharfocus = mysql_fetch_assoc($projcharfocus);
$totalRows_projcharfocus = mysql_num_rows($projcharfocus);
?>
<html>
<head>
<title>Project Characteristic Rating</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
</head>

<body>

<table width="787" border="0" cellpadding="0" cellspacing="0">
  <!--DWLayoutTable-->
  <tr>
    <td width="787" height="50" valign="top"><h1 align="center">Project
Characteristic Rating</h1>
    </td>
  </tr>
  <tr>
    <td height="56" valign="top"><h2>Project</h2>
    <table width="75%" border="1">
      <tr>
        <td>Key</td>
        <td>Number</td>
        <td>Name</td>
      </tr>
      <tr>
        <td><?php echo $row_projectfocus['projkey']; ?></td>
        <td><?php echo $row_projectfocus['projnum']; ?></td>
        <td><?php echo $row_projectfocus['projname']; ?></td>
      </tr>
    </table>
  </td>
  <tr>
    <td height="63" valign="top"><h2>Characteristic</h2>
    <table width="75%" border="1">

```



```
mysql_free_result($projcharfocus);

mysql_free_result($projectfocus);

mysql_free_result($characteristicfocus);
?>
```

## Project Method Rating

# Techniques rating results

Key	Number	
tst3	06003	
<b>Project</b>		
Van Buren Bridge Replacement		
<b>a Methods</b>	<b>Type</b>	<b>Score</b>
a	a	0
<b>select Methods</b>	<b>Type</b>	<b>Score</b>
A+B Price and time Qualifications process	select	3.125
A+Q Price and Qualifications selection process	select	1.375
Qualifications-only selection process	select	0.75
BASE Lump-sum (hard bid, low-bid) selection proces	select	0
<b>struct Methods</b>	<b>Type</b>	<b>Score</b>
design-build	struct	3.375
construction management at risk	struct	2.5
Build operate transfer (or Public Private Partners	struct	1.375
BASE General Contractor form of team structure	struct	0

Records 1 to 9 of 9

```
<?php require_once('.../Connections/odottools.php'); ?>
```

```
<?php
    $currentPage = $HTTP_SERVER_VARS["PHP_SELF"];

    $maxRows_projmethallscore = 10;
    $pageNum_projmethallscore = 0;
```

```

        if (isset($_HTTP_GET_VARS['pageNum_projmethallscore'])) {
            $pageNum_projmethallscore =
$_HTTP_GET_VARS['pageNum_projmethallscore'];
        }
        $startRow_projmethallscore = $pageNum_projmethallscore *
$maxRows_projmethallscore;

        /*Build project focus recordset*/
        $pkey = $_GET['pkey'];
        $pkey_projectfocus = "";
        //if (isset($_GET['pkey'])) {
        //    $pkey_projectfocus = (get_magic_quotes_gpc()) ? $_GET['pkey'] :
addslashes($_GET['pkey']);
        //}
        $pkey_projectfocus = $pkey;
        mysql_select_db($database_odottools, $odottools);
        $query_projectfocus = sprintf("SELECT * FROM projects WHERE projkey =
'%s'", $pkey_projectfocus);
        $projectfocus = mysql_query($query_projectfocus, $odottools) or
die(mysql_error("Couldn't open project database"));
        $row_projectfocus = mysql_fetch_assoc($projectfocus);
        $totalRows_projectfocus = mysql_num_rows($projectfocus);

?>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<html>
<head>
<title>Methods score calculation</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">

</head>

<body>

<table width="593" border="0" cellpadding="0" cellspacing="0">
  <!--DWLayoutTable-->
  <tr>
    <td height="40" colspan="2" valign="top">
      <h1 align="center">Methods rating results</h1>
    </td>
    <td width="1">&nbsp;</td>
    <td width="2">&nbsp;</td>
  </tr>
  <tr>
    <!--Project Header-->
    <td width="468" height="111" valign="top"><table width="100%" border="1">
      <!--DWLayoutTable-->
      <tr>
        <td width="148" height="23" valign="bottom"><div
align="center">Key</div></td>
        <td width="154" valign="bottom"><div
align="center">Number</div></td>
        <td width="147">&nbsp;</td>
      </tr>
      <tr>
        <td height="23" valign="top"><?php echo
$row_projectfocus['projkey']; ?></td>

```

```

        <td valign="top"><?php echo $row_projectfocus['projnum']; ?></td>
        <td>&nbsp;</td>
    </tr>
    <tr>
        <td height="30" colspan="3" valign="bottom"><h2
align="center">Project</h2>
        </td>
    </tr>
    <tr>
        <td height="23" colspan="3" valign="top"><?php echo
$row_projectfocus['projname']; ?></td>
    </tr>
</table>

</td>
<td width="122">&nbsp;</td>
<td>&nbsp;</td>
<td></td>
</tr>
<tr>
    <td height="72" colspan="3" valign="top">
<?php
    /* Open methodsall recordset */
    mysql_select_db($database_odottools, $odottools);
    $query_methodsall = "SELECT * FROM methods";
    $methodsall = mysql_query($query_methodsall, $odottools) or
die(mysql_error());
    $row_methodsall = mysql_fetch_assoc($methodsall);
    $totalRows_methodsall = mysql_num_rows($methodsall);

    /*
    echo "totalRows_methodsall=", $totalRows_methodsall;
    echo "methkey=", $row_methodsall['methkey'], ";
row_methodsall=", $row_methodsall;
    */
?><?php
    require_once('projmethroutine.php');
    $mkey_projmethallscore = "%";
    if (isset($mkey))
    {
        $mkey_projmethallscore = (get_magic_quotes_gpc()) ? $mkey :
addslashes($mkey);
    }
    mysql_select_db($database_odottools, $odottools);
    $query_projmethallscore = sprintf("SELECT methods.methname,
methods.methtype, projmeth.projmethscore
                                FROM methods,
projmeth
                                WHERE
projmeth.projmethprojkey = '%s'
                                AND methods.methkey
= projmeth.projmethmethkey
                                ORDER BY
methods.methtype, projmeth.projmethscore DESC",
                                $pkey);
    $query_limit_projmethallscore = sprintf("%s LIMIT %d, %d",
$query_projmethallscore, $startRow_projmethallscore,
$maxRows_projmethallscore);

```

```

        $projmethallscore = mysql_query($query_limit_projmethallscore,
$odottools) or die(mysql_error());
        // print_r($query_limit_projmethallscore);
        $row_projmethallscore = mysql_fetch_assoc($projmethallscore);
        if (isset($HTTP_GET_VARS['totalRows_projmethallscore'])) {
            $totalRows_projmethallscore =
$HTTP_GET_VARS['totalRows_projmethallscore'];
        } else {
            $all_projmethallscore = mysql_query($query_projmethallscore);
            $totalRows_projmethallscore =
mysql_num_rows($all_projmethallscore);
        }
        $totalPages_projmethallscore =
ceil($totalRows_projmethallscore/$maxRows_projmethallscore)-1;
/* Control over pagination of methods score display */
        $queryString_projmethallscore = "";
        if (!empty($HTTP_SERVER_VARS['QUERY_STRING']))
        {
            $params = explode("&", $HTTP_SERVER_VARS['QUERY_STRING']);
            $newParams = array();
            foreach ($params as $param)
            {
                if (strpos($param, "pageNum_projmethallscore") == false &&
                    strpos($param, "totalRows_projmethallscore") ==
false)
                {
                    array_push($newParams, $param);
                }
            }
            if (count($newParams) != 0)
            {
                $queryString_projmethallscore = "&" . implode("&",
$newParams);
            }
        }
        $queryString_projmethallscore
        = sprintf("&totalRows_projmethallscore=%d%s",
            $totalRows_projmethallscore, $queryString_projmethallscore);
/* This commented-out section is old temporary display
do
{
    echo $row_projmethallscore ['methtype'],
        " - ", $row_projmethallscore ['methname'],
        " - ", $row_projmethallscore ['projmethscore'], "<br>";
} while ($row_projmethallscore = mysql_fetch_assoc($projmethallscore));
*/
?><table border="1">
    <?php
        $oldmethtype = '%';
        do {
            /* Print header for each change in method type */
            if ($oldmethtype != $row_projmethallscore['methtype'])
            {
                ?>
                <tr>
                    <td align="center"><?php echo
$row_projmethallscore['methtype'], " Methods";?></td>

```



```

        <td><h4 align="center">Type</h4></td>
        <td><h4 align="center">Score</h4></td>
    </tr>
    <?php
        $oldmethtype = $row_projmethallscore['methtype'];
    }
    /**/
    ?>
    <tr>
        <td><?php
            $linkstart = '<a
href="../../MethodsPages/methdetailonly.php?mkey=';
            $linkstart = $linkstart.$mkey.'" ' ';
            $linkmid = 'target="_blank">';
            $linkend = '</a>';
            echo $linkstart, $linkmid,
$row_projmethallscore['methname'],$linkend; ?>
        </td>

        <td><?php echo $row_projmethallscore['methtype']; ?></td>
        <td><?php echo $row_projmethallscore['projmethscore']; ?></td>
    </tr>
    <?php } while ($row_projmethallscore =
mysql_fetch_assoc($projmethallscore)); ?>
</table>
</td>
<td></td>
</tr>
<tr>
    <td height="43" colspan="3" valign="top">&nbsp; Records <?php echo
($startRow_projmethallscore + 1) ?> to <?php echo
min($startRow_projmethallscore + $maxRows_projmethallscore,
$totalRows_projmethallscore) ?> of <?php echo $totalRows_projmethallscore ?>
</td>
    <td></td>
</tr>
<tr>
    <td height="57" colspan="3" valign="top">&nbsp;
    <table border="0" width="50%" align="left">
        <tr>
            <td width="23%" align="left">
                <?php if ($pageNum_projmethallscore > 0) { // Show if not first
page ?>
                    <a href="<?php printf("%s?pageNum_projmethallscore=%d%s",
$currentPage, 0, $queryString_projmethallscore); ?>">First</a>
                    <?php } // Show if not first page ?>
                </td>
            <td width="31%" align="center">
                <?php if ($pageNum_projmethallscore > 0) { // Show if not first
page ?>
                    <a href="<?php printf("%s?pageNum_projmethallscore=%d%s",
$currentPage, max(0, $pageNum_projmethallscore - 1),
$queryString_projmethallscore); ?>">Previous</a>
                    <?php } // Show if not first page ?>
                </td>
            <td width="23%" align="center">

```

```

        <?php if ($pageNum_projmethallscore <
$totalPages_projmethallscore) { // Show if not last page ?>
        <a href="<?php printf("%s?pageNum_projmethallscore=%d%s",
$currentPage, min($totalPages_projmethallscore, $pageNum_projmethallscore +
1), $queryString_projmethallscore); ?>">Next</a>
        <?php } // Show if not last page ?>
        </td>
        <td width="23%" align="center">
        <?php if ($pageNum_projmethallscore <
$totalPages_projmethallscore) { // Show if not last page ?>
        <a href="<?php printf("%s?pageNum_projmethallscore=%d%s",
$currentPage, $totalPages_projmethallscore, $queryString_projmethallscore);
?>">Last</a>
        <?php } // Show if not last page ?>
        </td>
    </tr>
</table>
</td>
<td></td>
</tr>
<tr>
    <td height="29" colspan="2" valign="top"><!--return to projchar
assessment page-->
        <?php
        $linkstart = '<a href="../Proj_Char/projcharlist.php?pkey=';
        $linkend = '">Return to Project Characteristics Assessment</a>';
        echo $linkstart,$pkey,$linkend;
        ?>
        </td>
    <td>&nbsp;</td>
    <td></td>
</tr>
</table>
</body>
</html>
<?php
mysql_free_result($methodsall);
mysql_free_result($projcharfocus);
mysql_free_result($projmethallscore);
mysql_free_result($projmethall);
mysql_free_result($projectfocus);
mysql_free_result($charmethfocus);
?>
*****Calculation subroutine*****
<?php //for each method-->
do
{
    //set characterstic priority variable ('CPvar') to zero-->
    $cpvar = 0;
    $pmscore = 0;
    $mkey = $row_methodsall['methkey'];
    //echo "<br>","<br>","methkey= ", $mkey; // temporary tracing line
    mysql_select_db($database_odottools, $odottools);
    $query_charmethfocus = sprintf("SELECT * FROM charmeth WHERE
charmethmethkey = '%s'", $mkey);
    $charmethfocus = mysql_query($query_charmethfocus, $odottools) or
die(mysql_error());

```

```

$totalRows_charmethfocus = mysql_num_rows($charmethfocus);
//for each charmethfocus-->
while ($row_charmethfocus = mysql_fetch_assoc($charmethfocus))
{
    /* This is old code that is superceded
    //get hibound-->
    $hb = $row_charmethfocus['charmethhibound'];
    //get lobound-->
    $lb = $row_charmethfocus['charmethlobound'];
    /* echo $row_charmethfocus['charmethkey'], "hi & lo =
", $hb, ";", $lb; */
    // The following code has been added to reflect the new form of
calculation-->
    $charmethvalarray=array(1=>
    $row_charmethfocus['charmethval01'],
    $row_charmethfocus['charmethval02'],
    $row_charmethfocus['charmethval03'],
    $row_charmethfocus['charmethval04'],
    $row_charmethfocus['charmethval05'],
    $row_charmethfocus['charmethval06'],
    $row_charmethfocus['charmethval07'],
    $row_charmethfocus['charmethval08'],
    $row_charmethfocus['charmethval09'],
    $row_charmethfocus['charmethval10']);
    //get score-->
    $ckey = $row_charmethfocus['charmethcharkey'];
    //echo "<br>", $ckey;
    //print_r($charmethvalarray);
    $pckey = $pkey.$ckey;
    mysql_select_db($database_odottools, $odottools);
    $query_projcharfocus = sprintf("SELECT * FROM projchar WHERE
projcharkey = '%s'", $pckey);
    $projcharfocus = mysql_query($query_projcharfocus, $odottools)
or die(mysql_error());
    $row_projcharfocus = mysql_fetch_assoc($projcharfocus);
    $totalRows_projcharfocus = mysql_num_rows($projcharfocus);
    $x = $row_projcharfocus['projcharscore'];
    // echo "<br>", "assessment= ", $x, " "; /* */

    // The following section has been commented out and superceded-
->
    //calculate charmeth priority
    /*$hb = $hb + 0.5;
    $lb = $lb - 0.5;
    $cvar = abs((2/($hb-$lb)*$x)-(($hb+$lb)/($hb-$lb)));

    $cpvar = $cpvar + $cvar; */
    /* echo "cvar= ", $cvar, " "; */

```

```

        //next charmeth-->
    // End of superceded code <--

    // The following code replaces the superceded code -->
    // Calculate projmeth score -->
    $cmscore= $charmethvalarray [$x];
    // echo "; cmscore= ", $cmscore;
    $pmscore= $pmscore + $cmscore;
    //next charmeth-->
    // End of new replcement code <--
};
//calculate average score for projmeth-->
$pmscore= $pmscore / $totalRows_charmethfocus;
//write result to projmeth-->
    $pmkey = $pkey.$mkey;
    /* */
    //echo "<br>", "pkey=", $pkey, "; mkey=", $mkey, "; pmkey=", $pmkey, ";
pmscore=", $pmscore, " >>";
    /* */
    $insertSQL = sprintf("INSERT IGNORE INTO projmeth (projmethkey,
projmethprojkey, projmethmethkey, projmethscore)
                        VALUES ('%s', '%s', '%s', '%s')
                        ON DUPLICATE KEY UPDATE
projmethscore='%s'",
                        $pmkey, $pkey, $mkey, $pmscore, $pmscore);
    mysql_select_db($database_odottools, $odottools);
    $Result1 = mysql_query($insertSQL, $odottools) or die(mysql_error());
/*
//print projmethpriority-->
echo "</br>", $mkey, " score = ", $cpvar, "*****</br>";
*/
//next method-->
} while ($row_methodsall = mysql_fetch_assoc($methodsall));
?>

```

## **APPENDIX E: DATABASE STRUCTURE**



## APPENDIX E: DATABASE STRUCTURE

### Selection Tool Database Structure

The database for the testing model consists of six tables, structured as follows. The variables listed correspond to those variables noted in the code of the previous Appendix. The variables indicated here are generally a bare minimum of variables that would be required in a fully implemented system.

