

Evaluation of Project Delivery Methods

DETAILS

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AUTHORS

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TABLE OF CONTENTS

LIST OF FIGURES	vi
LIST OF TABLES	vii
AUTHOR ACKNOWLEDGMENTS	ix
EXECUTIVE SUMMARY	1
CHAPTER 1 - OVERVIEW	3
Introduction	3
Research Plan and the Work Accomplished	3
Organization of the Report	9
CHAPTER 2 – BACKGROUND AND DEFINITIONS	10
Distinguishing Characteristics of Transit Projects	10
Evolution of Current Alternative Delivery Methods in Transit Projects	11
Definitions of the Delivery Methods	12
Statutory Authorization of Delivery Methods in Various States	19
Existing Selection Approaches of Project Delivery Methods	19
Timing of Project Delivery Method Selection	21
CHAPTER 3 – CASE STUDY PROJECTS	23
Background	23
Case Study Collection Methodology	24
Case Study Matrix	25
Case 1 — TREX	27
Case 2 — Weber County Commuter Rail	32
Case 3 — University Line	37
Case 4 — Medical Center Extension	41
Case 5 — Greenbush Commuter Rail	46
Case 6 — Hudson Bergen Light Rail	51
Case 7 — Silver Line Project	56
Case 8 — Portland Mall Light Rail	61
Case 9 — I-205 Light Rail Extension	66
CHAPTER 4 – FINDINGS AND LESSONS LEARNED	71
Introduction	71
Project Identification Data	71
Project Scope Data	71
Project Financial and Schedule Data	71
Project Delivery Method Decision Rationale	73
Project Issue Data	75
Project Risk Analysis Process Data	77
Project Procurement Process Data	78
Project Quality Management Data	82

MAJOR FINDINGS	82
LESSONS LEARNED	83
RECOMMENDATION FOR IMPLEMENTATION	83
CHAPTER 5 – ADVANTAGES/DISADVANTAGES OF EACH DELIVERY METHOD	85
Introduction.....	85
Purpose.....	85
Project-Level Issues	85
Agency-Level Issues.....	91
Public Policy/Regulatory Issues	97
Life-Cycle Issues	101
Other Issues.....	104
Conclusion.....	106
CHAPTER 6 – TIER 1 – ANALYTICAL DELIVERY DECISION APPROACH.....	107
Introduction.....	107
Step 1. Create Project Description.....	109
Step 2. Define Project Goals	111
Step 3. Review Go/No-Go Decision Points	114
Step 4. Review Project Delivery Method Advantages and Disadvantages	117
Step 5. Choose the Most Appropriate Project Delivery Method.....	146
Step 6. Document Results	149
Conclusions	149
CHAPTER 7 – TIER 2 – WEIGHTED-MATRIX DELIVERY DECISION APPROACH	150
Introduction.....	150
Step 1. Define Selection Factors.....	152
Step 2. Weight Selection Factors	154
Step 3. Score Project Delivery Methods	155
Step 4. Choose the Most Appropriate Project Delivery Method.....	159
Step 5. Document Results	159
Conclusions	160
CHAPTER 8 – TIER 3 – RISK-BASED APPROACH.....	161
Introduction.....	161
Qualitative Approach.....	163
Quantitative Approach.....	165
Summary.....	168
CHAPTER 9 – EVALUATION OF PROJECT DELIVERY METHOD DECISION TOOL... 169	169
Final Validation of PDM Multi-Tier Decision Tool.....	170
CHAPTER 10 – SUMMARY.....	173
APPENDIX A - REFERENCES	175
APPENDIX B – ANNOTATED BIBLIOGRAPHY.....	181
APPENDIX C – LEGALITY OF ALTERNATIVE DELIVERY METHODS	198
APPENDIX D – INTERVIEW BLANK FORM.....	207
APPENDIX E – PROJECT DELIVERY METHOD SELECTION SYSTEM ASSESSMENT	
QUESTIONNAIRE	230

LIST OF FIGURES

Figure 1-1 - Overview of the Research Plan.....	4
Figure 2-1 - Design-Bid-Build.....	14
Figure 2-2 - Construction Manager-at-Risk.....	16
Figure 2-3 - Design-Build.....	18
Figure 6-1 - Tier 1 Selection Process Overview.....	108
Figure 6-2 - Project Description Example.....	111
Figure 6-3 - Go/No-Go Decision Points.....	115
Figure 7-1 - Tier 2 Selection Process Overview.....	151
Figure 7-2 - Tier 2 Selection Factor Development.....	153
Figure 7-3 – Example Listing of Selection Factors.....	154
Figure 7-4 - Example of Weighted Ranking for Selection Factors.....	155
Figure 7-5 - Example of Weighted Ranking for Project Goals and Critical Issues.....	159
Figure 8-1 - Overview of the Risk-based Qualitative and Quantitative Approaches.....	162
Figure 8-2 - Distribution of Project Costs.....	162
Figure 8-4 - Risk Analysis Outcome as an Input to PDM Selection.....	165
Figure 8-5 - Overview of the Quantitative Approach.....	167
Figure 9-1 - Project Delivery Decision Tool Final Internal and External Validation Flow Chart	170

LIST OF TABLES

Table 1-1 - Transit Projects Interviewed	5
Table 1-2 - Pertinent Issue Critique Matrix	6
Table 2-1 - The Timing of PDM Selection	22
Table 3-1 - Summary of Case Study Projects	24
Table 3-2 - Case Study Project Issues	28
Table 3-3 - Procurement Phase Summary	29
Table 3-4 - Design Phase Summary	30
Table 3-5 - Construction Phase Summary	30
Table 3-6 - Case Study Project Issues	33
Table 3-7 - Procurement Phase Summary	34
Table 3-8 - Design Phase Summary	35
Table 3-9 - Construction Phase Summary	35
Table 3-10 - Case Study Project Issues	38
Table 3-11 - Procurement Phase Summary	39
Table 3-12 - Design Phase Summary	39
Table 3-13 - Construction Phase Summary	40
Table 3-14 - Case Study Project Issues	42
Table 3-15 - Procurement Phase Summary	43
Table 3-16 - Design Phase Summary	44
Table 3-17 - Construction Phase Summary	44
Table 3-18 - Case Study Project Issues	48
Table 3-19 - Procurement Phase Summary	49
Table 3-20 - Design Phase Summary	49
Table 3-21 - Construction Phase Summary	49
Table 3-22 - Case Study Project Issues	52
Table 3-23 - Procurement Phase Summary	54
Table 3-24 - Design Phase Summary	54
Table 3-25 - Construction Phase Summary	55
Table 3-26 - Case Study Project Issues	57
Table 3-27 - Procurement Phase Summary	58
Table 3-28 - Design Phase Summary	59
Table 3-29 - Construction Phase Summary	59
Table 3-30 - Case Study Project Issues	62
Table 3-31 - Procurement Phase Summary	63
Table 3-32 - Design Phase Summary	64
Table 3-33 - Construction Phase Summary	64
Table 3-34 - Case Study Project Issues	67
Table 3-35 - Procurement Phase Summary	68
Table 3-36 - Design Phase Summary	69
Table 3-37 - Construction Phase Summary	69
Table 4-1 - Procurement Phase Solicitation Document Content	78
Table 4-2 - Procurement Phase Proposal Information	78
Table 4-3 - Design Phase Responsibilities	79
Table 4-4 - Construction Phase Responsibilities	80

Table 6-1 - Examples of Generic Project Goals	112
Table 6-2 - Examples of Project Goals	113
Table 6-3 - Go/No-Go Issue Summary	114
Table 6-4 - Go/No-Go Summary Form	117
Table 6-5 - Project Size Advantages/Disadvantage Summary	119
Table 6-6 - Cost Advantages/Disadvantage Summary	121
Table 6-7 - Schedule Advantages/Disadvantage Summary	122
Table 6-8 - Risk Management Advantages/Disadvantages Summary	123
Table 6-9 - Risk Allocation Advantages/Disadvantages Summary	124
Table 6-10 - LEED Certification Advantages/Disadvantages Summary	125
Table 6-11 - Agency Experience Advantages/Disadvantages Summary	127
Table 6-12 - Staff Required Advantages/Disadvantages Summary	128
Table 6-13 - Staff Capability Advantages/Disadvantages Summary	129
Table 6-14 - Agency Goals and Objectives Advantages/Disadvantages Summary	130
Table 6-15 - Agency Control of Project Advantages/Disadvantages Summary	131
Table 6-16 - Third Party Agreement Advantages/Disadvantages Summary	133
Table 6-17 - Competition Advantages/ Disadvantages Summary	134
Table 6-18 - DBE Impacts Advantages/Disadvantages Summary	135
Table 6-19 - Labor Unions Advantages/Disadvantages Summary	136
Table 6-20 - Fed/State/Local Laws Advantages/ Disadvantages Summary	137
Table 6-21 - FTA/EPA Regulations Advantages/Disadvantages Summary	138
Table 6-22 - Stakeholder/Community Input Advantages/Disadvantages Summary	139
Table 6-23 - Life-Cycle Costs Advantages/Disadvantages Summary	140
Table 6-24 - Maintainability Advantages/Disadvantages Summary	141
Table 6-25 - Sustainable Design Goals Advantages/Disadvantages Summary	143
Table 6-26 - Sustainable Construction Goals Advantages/Disadvantages Summary	144
Table 6-27 - Construction Claims Advantages/Disadvantages Summary	145
Table 6-28 - Adversarial Relationship Advantages/Disadvantages Summary	146
Table 6-29 - Project Delivery Method Advantage/Disadvantage Summary	148
Table 7-1 - Project Delivery Scoring Scale (adapted from Saaty 1990).....	156
Table 7-2 - Weighted-Matrix Template	157
Table 8-1 - Example of Risk Allocation Matrix	164

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ABSTRACT

This research documents the benefits and disadvantages of various project delivery methods for capital transit projects and provides guidelines for selecting the most appropriate delivery method for a specific project. Project delivery methods considered are Design-Bid-Build (DBB), Construction Manager at Risk (CMR), Design-Build (DB), and Design-Build-Operate-Maintain (DBOM). The results of several extensive interviews with directors of transit projects throughout the United States are reported. A three-tiered project delivery selection framework is developed that can help the owners of transit projects to evaluate pros and cons of each delivery method and select the most appropriate for their project. Tier 1 is a qualitative approach that allows the user to document advantages and disadvantages of each competing delivery method. The user can then review the results of this analysis and select the best delivery method. If at the conclusion of this analysis, still a clear option does not emerge, the user can move to Tier 2. Tier 2 is a weighted matrix approach that allows the user to quantify the effectiveness of competing delivery methods and select the approach that receives the highest score. The third Tier uses principles of risk analysis to evaluate delivery methods. Regardless of how many tiers an agency uses to arrive at a project delivery method selection decision, the framework forces the decision-makers to document their logic as they proceed through the process. This aspect will prove especially helpful as agencies can use these documented decisions in future projects.

EXECUTIVE SUMMARY

Objective

The objective of this research was to conduct a comprehensive study of the benefits and disadvantages of various project delivery methods for transit projects and to develop guidelines for selecting the most appropriate delivery method for a specific project. A variety of project delivery methods is available to the developers of public projects in the United States. While the traditional design-bid-build remains the most common method for project delivery, there is considerable interest on the part of transportation agencies in alternative forms of project delivery and their potential benefits. The outcome of this research is culminated in a guidebook that can be used by transit agencies for choosing the best delivery method for their projects. The guidebook is an easy-to-use document that is prepared using the most up-to-date literature on the topic and the experience of several transit project directors that were interviewed for this purpose. It is recommended that transit agencies use industry professionals from outside the agency to facilitate the implementation of this methodology. The use of such professionals will ensure that the appropriate expertise and experience is incorporated into the process.

The *project delivery method* is the process by which a construction project is comprehensively designed and constructed for an owner including project scope definition, organization of designers, constructors and various consultants, sequencing of design and construction operations, execution of design and construction, and closeout and start-up. With the rapid change in procurement laws, public agencies now share the ability of their private sector counterparts to acquire construction services via alternative project delivery methods, such as construction management, design-build, and other hybrid systems. In some instances some of these methods, such as design-build may include operations and maintenance as well as multi-year warranties in the contract.

Research Methodology

The approach in developing the project delivery method selection framework was to review and analyze relevant literature on project delivery methods and previous work in developing decision support systems for project delivery selection. In addition, an extensive questionnaire was developed for a face-to-face structured interview with several transit agencies. The authors traveled to five selected project sites across the United States, interviewed project directors, and collected data on nine major transit projects. The results of the interviews were then analyzed and summarized in great detail. Transit agencies' concerns, practices, limitations, and goals were studied and the effect of these factors on the choice of delivery method was studied. Based on the outcome of the literature search and the structured interviews, a set of *pertinent issues* were identified and studied. These pertinent issues were factors that were thought to have profound effect on the choice of project delivery method. These factors in turn were used to develop the project delivery method selection framework described in this guidebook.

Selection System Framework

The selection of the project delivery method is a decision that is based on a multitude of factors. In this effort, these factors are called *pertinent issues* and have been categorized according to the following: project-level issues, agency-level issues, public policy/regulatory issues, life cycle issues, and other issues. The research team has identified and verified these pertinent issues through literature search, extensive interviews with various transit agencies across the United States, and discussions among project team and the project oversight panel. Based on these pertinent issues, the team has developed a 3-tiered project delivery selection system that consists of the following tiers:

- Tier 1 – Analytical Approach
- Tier 2 – Weighted Matrix Approach
- Tier 3 – Optimal Risk-based Approach

The Tier 1 Analytical Approach provides a framework for agencies to define project goals and examine the advantages and disadvantages of each delivery method within the context of these goals. The motivation for this approach is to help agencies understand project delivery method attributes and to determine if their specific project goals align with the attributes of a particular delivery method. The Tier 1 approach also provides a “go/no go” review to determine if one or more project delivery methods should be excluded from the examination. At the completion of Tier 1, the agency may not have a single, clear and logical choice for a project delivery method. If this is the case, the agency will be advised to move to the Tier 2 selection process with the best delivery method options and create a more detailed analysis to select the final project delivery method.

The Tier 2 Weighted-Matrix Approach provides a means for the agency to further examine and document a project delivery decision for an individual project. In case an obvious choice was not found in the Tier 1 Analytical Approach, the Tier 2 approach provides the agency with a process to select a delivery method by prioritizing project objectives and selecting the delivery method that best aligns with these objectives. In tier 2 the user concentrates on a few key parameters that affect the choice of project delivery method, assign appropriate weights to each parameter and calculate a score for each competing delivery method. The process of selecting each parameter and assigning the proper weight is described in sufficient detail.

The Tier 3 Optimal Risk-based Approach will leverage the current cutting-edge risk-based cost estimating methods that have emerged in transit and highway agencies in the past few years. It is expected that the delivery method decision be made by completing the tiers 1 and 2. Tier 3 will only be applied when a decision is not apparent after completing Tiers 1 and 2, and when a formal risk management process for the project is already in place. It is important to note that the level of effort involved in using Tier 3 (especially the quantitative approach) is considerably larger than either Tier 1 or Tier 2.

Regardless of how many tiers an agency uses to arrive at a project delivery method selection decision, the framework forces the decision-makers to document their logic as they proceed through the process. This aspect will prove especially helpful as agencies can use these documented decisions in future projects. It is the authors’ belief that the guidebook, which was the main deliverable of this research, is a comprehensive resource for helping transit agencies to select the most appropriate project delivery method and to document their decision in a concise and easy to understand format.

CHAPTER 1 - OVERVIEW

Introduction

The objective of this research effort is to develop a guidebook to help transit agencies evaluate and choose the most appropriate project delivery method for their projects. The *project delivery method* (PDM) is the process by which a construction project is comprehensively designed and constructed for an owner including project scope definition, organization of designers, constructors and various consultants, sequencing of design and construction operations, execution of design and construction, and closeout and start-up. In some cases, the project delivery method may encompass operation and maintenance. Currently available project delivery methods have moved far beyond the traditional design-bid-build method. With the rapid change in procurement laws, public agencies now share the ability of their private sector counterparts to acquire construction services via alternative project delivery methods, such as construction management, design-build, and other hybrid systems which can include maintenance, operations, and/or warranties.

This chapter presents the organization of this research report. The chapter will then review the steps envisaged in the original proposal and summarize the work accomplished during this effort. Another major deliverable of this effort is the Guidebook that is prepared separately but contains many parts of this final report. Specifically, Chapters 2, 5, 6, 7, and 8 of this final report are repeated in the guidebook. The guidebook was designed with the objective of developing an easy-to-use and practical tool for transit agencies to help them choose the most appropriate project delivery method (PDM). The guidebook is the deliverable that is going to be used by the practitioners. This final report on the other hand, while containing the essential elements of the guidebook, is prepared with the aim of demonstrating the research approach, the interview data and statistics, and the validation process used for testing the system.

Research Plan and the Work Accomplished

Figure 1.1 depicts an overview of the research plan as envisaged in the proposal. This plan closely follows the tasks identified in the RFP. Task descriptions below come from the TCRP Request for Proposal and are followed by a brief description of the work accomplished.

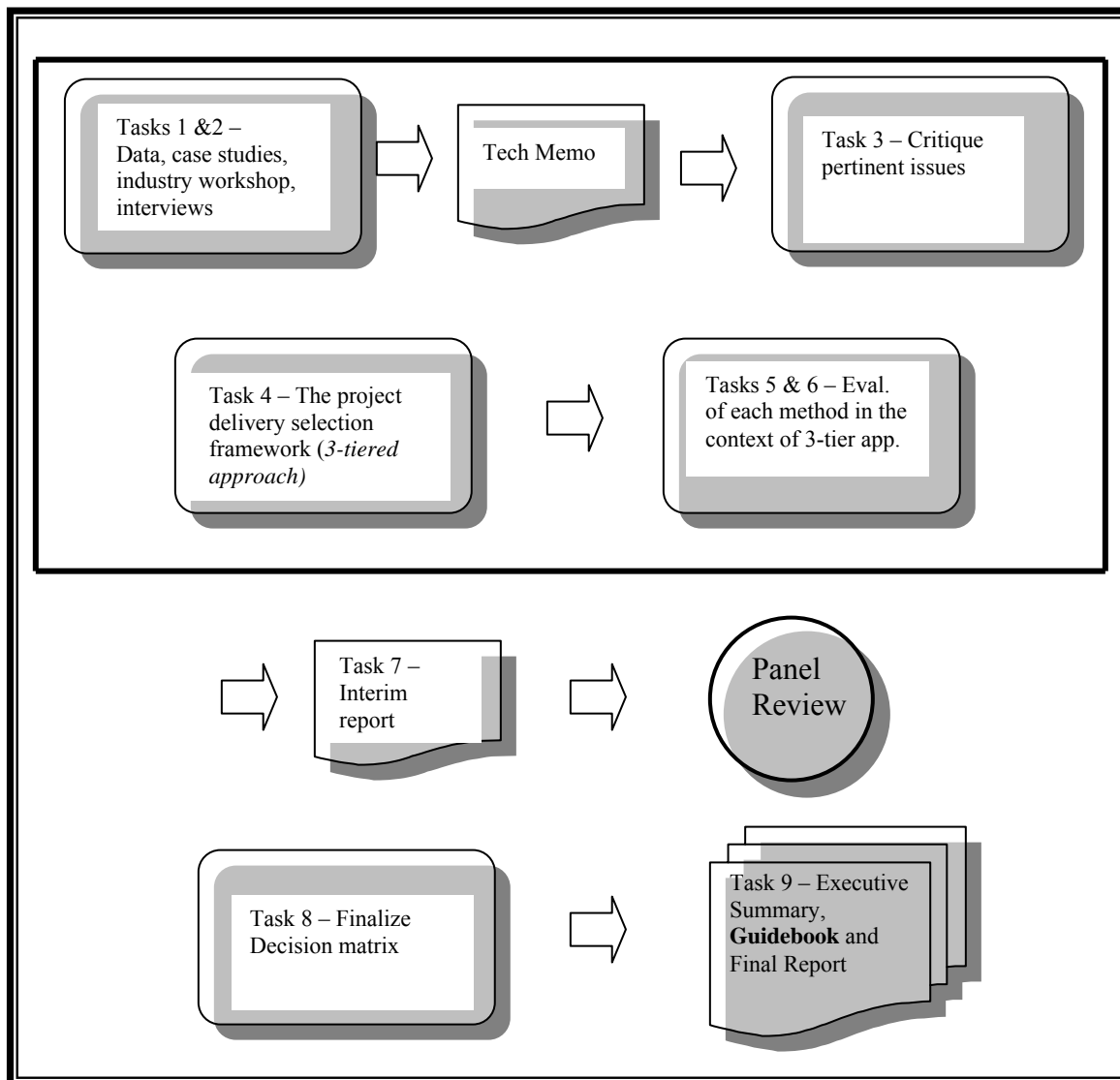


Figure 1-1 - Overview of the Research Plan

Task 1. Collect and review relevant literature, case studies, research findings, and other appropriate material, inside and outside of the transit industry.

The team conducted a thorough literature search on the material relevant to project delivery methods, public transportation especially transit projects, and decision support systems. References cited in this report are presented in Appendix A. Appendix B, the bibliography, contains the sources that are relevant to this research. Many of the sources in the bibliography are annotated to facilitate the literature evaluation by the reader of this report. The results of this task's literature review have been used in Tasks 2 and 3 to confirm findings from the structured interviews and identify trends in the pro/con analysis.

Task 2. Identify agencies, suppliers, and individuals with experience in using the various project delivery and contracting methods. Prepare a plan for in-depth interviews that includes a list of proposed interviewees, a draft summary of pertinent interview issues, and an interview guide for project panel review and approval. Conduct in-depth interviews with those entities approved by the project panel. Produce a technical memorandum describing the findings and lessons learned.

Based on the results of the literature review, the research team began to identify its case studies. The team was able to identify and gain access to information on nine projects worth more than \$3.0 billion that represent the cross-section of delivery methods and are located across the United States (Table 1.1). The researchers used a rigorous structured interview methodology to develop three extensive questionnaires (for DBB, CMR, and DB projects) and submitted a sample to panel for comments. A copy of the questionnaire is presented in Appendix D. In each case the team members traveled to the transit agency and interviewed the project director and other appropriate personnel including the project's contractor in some cases. The results of these structured interviews were reported in the Technical Memorandum that was envisaged in the original proposal. These results were corroborated with a workshop that was organized and conducted by the project team in Minneapolis as part of the DBIA Transportation conference in April 2007. Workshop participants represented owners, contractors, consultants, and attorneys. An important outcome of this task and the feedback from the workshop was the decision to focus the remainder of the research on four distinct project delivery methods: DBB, CMR, DB, and DBOM.

Table 1-1 - Transit Projects Interviewed

Case #	Project	Agency/Location	Project Delivery Method
1	T-REX (Southeast Corridor Light Rail)	Regional Transportation District/ Denver, CO	Design-Build
2	Weber County Commuter Rail	Utah Transit Agency/ Salt Lake City to Ogden, UT	CM-at-Risk
3	University Line	Utah Transit Agency/ Salt Lake City, UT	Design- Build
4	Medical Center Extension	Utah Transit Agency/ Salt Lake City, UT	Design- Build
5	Greenbush Commuter Rail	Massachusetts Bay Transportation Authority/ Boston, MA	Design- Build
6	Hudson Bergen Light Rail	New Jersey Transit Authority/ Hudson, NJ	Design- Build-Operate-Maintain
7	Silver Line Project	Massachusetts Bay Transportation Authority/ Boston, MA	Design-Bid-Build Multi-Prime
8	Portland Mall Project	TriMet/ Portland OR	CM-at-Risk
9	I-205 Light Rail Extension Project	TriMet/ Portland OR	Design- Build

A detailed report of these interviews is presented in two chapters in this report. Chapter 3 provides detailed statistics and qualitative data on all the interviewed projects. Chapter 4 presents a set of conclusions and lessons learned from the interviews and literature search. These lessons learned were later used in developing the 3-tier project delivery selection system.

Task 3. Describe and critique pertinent issues related to each project delivery method in terms of its application to transit in the United States. As a separate effort, describe and critique pertinent issues related to contracting out operations and maintenance when the transit agency has determined to do so in the context of new construction projects.

The original proposal contained a proposed listing of pertinent issues related to each project delivery method (Table 1.2). This list was augmented as a result of literature search and interviews. Each issue in this revised list was carefully evaluated and critiqued in relation to the four main project delivery methods, *i.e.*, DBB, CMR, DB, DBOM. A concise set of advantages/disadvantages for each of these critical issues is included in this report in Chapter 5. These pertinent issues became the cornerstone of the project delivery selection system developed in this research project.

Table 1-2 - Pertinent Issue Critique Matrix

Issue Type	Project Delivery Method	DBB		CMR		DB		DB w/OM	
		Pro	Con	Pro	Con	Pro	Con	Pro	Con
Project-level Issues	<ul style="list-style-type: none"> • Project Size • Risk management • Risk allocation • Schedule • Cost • LEED certification • Other 								
Agency-level Issues	<ul style="list-style-type: none"> • Agency experience • Staffing required • Staff capability • Agency goals & objectives • Agency control of project • Third party agreements • Other 								

Issue Type	Project Delivery Method	DBB		CMR		DB		DB w/OM	
		Pro	Con	Pro	Con	Pro	Con	Pro	Con
Public Policy/Regulatory Issues	<ul style="list-style-type: none"> • Competition • DBE/small business impact • Labor • Fed/State/Local laws • FTA/EPA regs. • Stakeholder/community input • Other 								
Life Cycle Issues	<ul style="list-style-type: none"> • Life cycle cost • Maintainability • Sustainable design goals • Sustainable construction • Other 								
Other Issues	<ul style="list-style-type: none"> • Construction Claims • Adversarial relationships • Other 								

Task 4. *Develop a framework and methodology for analyzing the advantages and disadvantages of the project delivery methods--both with and without contracting for operations and maintenance--for use by transit agencies in evaluating and selecting options.*

Task 5. *Using the framework developed in Task 4, document, evaluate, and compare the merits of each respective type of project delivery and contracting method, discussing the advantages and disadvantages of each.*

The team's approach in developing the selection system was such that Tasks 4 and 5 were accomplished simultaneously. Comparing and evaluating the merits of each type of project delivery (Task 5) was indeed part of the methodology's framework (Task 4). The research team developed a three-tiered approach to the framework solution, which was based on existing industry standards and the new research being conducted in this study:

- Tier 1 – Analytical Approach
- Tier 2 – Weighted Matrix Approach
- Tier 3 – Optimal Risk Allocation Approach

The Tier 1 Analytical Approach provides a framework for agencies to define project goals and examine the advantages and disadvantages of each delivery method within the context of these

goals. The motivation for this approach is to help agencies understand project delivery method attributes and to determine if their specific project goals align with the attributes of a particular delivery method. The Tier 1 approach also provides a “go/no go” review to determine if one or more project delivery methods should be excluded from the examination.

At the completion of Tier 1, the agency may not have a single, clear and logical choice for a project delivery method. If this is the case, the agency will be advised to move to the Tier 2 selection process with the best delivery method options and create a more detailed analysis to select the final project delivery method. The first tier is designed as a simple and straightforward selection method. Any owner, no matter what their level of experience with alternative project delivery methods, will be able to use this tier.

The Tier 2 Weighted-Matrix Approach provides a means for the agency to further examine and document a project delivery decision for an individual project. In case an obvious choice was not found in the Tier 1 Analytical Approach, the Tier 2 approach provides the agency with a process to select a delivery method by prioritizing project objectives and selecting the delivery method that best aligns with these objectives. The Tier 2 Weighted-Matrix Approach is founded upon successful delivery decision tools developed by academics and professionals over the past 20 years. In tier 2 the user concentrates on a few key parameters that affect the choice of project delivery method, assign appropriate weights to each parameter and calculate a score for each competing delivery method.

The Tier 3 Optimal Risk-based Approach will leverage the current cutting-edge risk-based cost estimating methods that have emerged in transit and highway agencies in the past few years. The user should first complete Tier 1 and Tier 2. The risk-based approach as proposed here consists of two phases. The first phase is a qualitative approach consisting of developing a risk allocation matrix that clearly portrays owner’s risk under competing delivery methods. By reviewing these risks, the agency will have an opportunity to decide if a specific delivery method is superior. If this analysis cannot provide a definitive answer to the delivery selection question, then a quantitative approach should be considered. The quantitative approach emphasizes the effect of the Project Delivery Method on project cost and schedule. It is expected that most of the times the delivery method decision can be made by completing the first two tiers. It is important to note that the level of effort involved in using Tier 3 (especially the quantitative approach) is considerably larger than either Tier 1 or Tier 2.

Task 6. Using the framework developed in Task 4, discuss and analyze the impacts, advantages, and disadvantages of including operations and maintenance in the project delivery contract.

During the interviews it became apparent that while including operation and maintenance with DBB or CMR is theoretically feasible, none of the agencies are using this option. Further it seemed unlikely that transit agencies were going to attach operations and maintenance to DBB or CMR contracts in the foreseeable future. This observation was corroborated during our transit workshop as part of the DBIA conference in Minneapolis. Because of this, it was decided to concentrate on DBB, CMR, DB, and DBOM for the guidebook. This change in the original scope was approved by the project’s panel. As a result, this effort considered the impacts, advantages, and disadvantages of including operations and maintenance in the context of the DBOM delivery method.

Task 7. *Prepare an interim report documenting the results of Tasks 1 through 6. The interim report shall also contain a detailed outline of the guidebook.*

The interim report was submitted and approved by the project panel.

Task 8. *Based on the results of Tasks 1 through 7, develop a decision matrix at the macro level to guide decision makers on selecting the most appropriate project delivery and contracting method(s) in various transit environments.*

Based on the framework developed in Task 4 and the results of tasks 3, 5, and 6 the team finalized the development of the *project delivery selection system* in this task. An important component of this task was the evaluation and testing of the system by a select number of subject experts.

Task 9. *Prepare the guidebook, a stand-alone executive summary, and a final report documenting the entire research effort.*

Organization of the Report

This final report is divided into ten chapters and five appendices. The first chapter (the current chapter) provided an overview of the work accomplished in this research project. Chapter 2 will present the results of the literature search by identifying distinguishing characteristics of transit projects, providing clear definitions of various delivery methods, and identifying the appropriate point in time when various delivery methods can be adopted. Chapter 3 will provide an extensive description of the case study projects and the structured interviews. Chapter 4 provides summary results and lessons learned from the interviews and literature search. Chapter 5 describes pertinent issues affecting the choice of project delivery method and the advantages/disadvantages of each project delivery method based on a pro/con analysis of each issue in connection with the delivery method. Chapters 6, 7 and 8 describe the project delivery selection framework for the proposed three tiers. Chapter 9 describes the validation process and a summary of research can be found in the last chapter.

Appendix A contains a reference list. Appendix B is an annotated bibliography, a comprehensive collection of useful and relevant resources that should benefit the serious researcher in the area of project delivery methods. Appendix C presents a review of the research regarding the legal authority for public entities to utilize alternative project delivery methods in various states. In Appendix D a sample questionnaire is presented that was used in interviewing project directors. The last appendix (Appendix E) shows the assessment questionnaire used by the research team in evaluating the decision system developed in this research.

CHAPTER 2 – BACKGROUND AND DEFINITIONS

Distinguishing Characteristics of Transit Projects

Several types of project delivery methods are currently available to the owners of publicly funded transportation projects in the United States. An important decision, especially in the case of large complicated transportation projects, is to select the most appropriate project delivery method for a specific project. Contractual relations, contemporary laws and regulations, owner's perception of risks, awarding mechanisms and the method of payment all contribute to project delivery method selection. This document in no way advocates one project delivery method over another. In fact, it is the expressed purpose of this effort to assist transit agencies in making the right project delivery method decision. In the subsequent paragraphs, alternative project delivery methods will be compared to traditional design-bid-build (DBB) project delivery, which functions as the benchmark against which all other methods should be compared. The literature has found that the use of alternative project delivery can accrue benefits for owners. However, that is usually across a population of projects rather than on an individual basis. Thus, the reporting of benefits found in the literature should not be misconstrued as advocating one project delivery method over another. All project delivery methods have yielded both success and failure. Selecting the wrong project delivery method is often a significant driver of project failure. Therefore, the reader should accept the facts reported in this document as evidence that a given project delivery method can be used successfully on a specific set of projects, not as a declaration that any method is inherently superior to all others.

Before embarking on describing various delivery methods it is important to observe the distinguishing features of major transit projects compared to other transportation projects. Transit projects are larger projects, usually in excess of \$100 million. These projects, especially projects with fixed guideway system, usually consist of at least two large contracts: civil and systems. The nature of these contracts and the specialization required is such that usually two different entities deliver these contracts. This makes the coordination between these players of paramount importance to project success. Generally, in DBB projects the owner hires a construction manager (This construction manager (CM) is a representative of the owner, i.e., Agency CM, as opposed to the CM-at-risk) to coordinate these two separate contracts and manage their work. In design-build (DB) projects, the design-builder often subcontracts to separate systems and civil contractors or forms a joint venture with them. Another feature of transit projects is that they are usually built in major urban population centers. This increases the complexity of dealing with various stakeholders. The ability of various delivery methods in dealing with project stakeholders then becomes a major decision criterion.

Whenever a commuter rail project is considered, a freight line may be in the mix where the owner will have to share the line with *temporal* separation or *track* separation. This makes coordination with the railroad company owning the freight line extremely important. Reaching agreements with the

railroad company and clarifying the details of the work and responsibilities of various parties cannot be overemphasized. The railroad company usually wants to do the track work with its own forces on a cost reimbursable basis and this puts all the risk on the owner. This also increases the constructor's risk because its work may be impacted by the railroad. This makes early involvement of the construction contractor very important to project success. Also, the railroad company tends to do the work at its own pace while considering project milestones; as a general rule, the agency does not enjoy the same degree of control that it exerts over the constructor with the railroad company.

Another distinguishing characteristic of transit is that typical projects may require multiple disciplines as well as incorporating a significant degree of architectural features that extend the project outside the scope of a normal engineered project and demand the involvement of design professionals from architecture, landscape architecture and interior design. The integration of “vertical” construction features such as parking structures and transit stations with the “horizontal” construction features such as track bed, bridges, and roadway elements creates a need for a comprehensive set of both design and construction services that is not normally found in transportation projects. Additionally, the need for transit agencies to integrate their facilities with other modes of transportation demands another comprehensive set of both design and construction service providers and requires a more flexible approach to design and construction than single mode transportation projects. These characteristics drive the need for a “toolbox” of project delivery methods that permits the transit agency to select the appropriate project delivery “tool” based on the technical demands of a given project.

Unlike some toll roads in the highway sector, transit projects are not usually money makers. So it is difficult to generate interest in potential public private partnerships. Financial institutions, while sometimes interested in supporting toll road and bridge projects, are usually not interested in transit investment, although that may change in the future.

Finally, federal support for transit projects, often crucial for bringing the project into reality, depends on specific steps not similar to other transportation projects. The Federal Transit Administration (FTA) plays an important role in this process. Various transit agencies compete for federal dollars by preparing specific reports to the FTA. Depending on the rating that a project receives, it may be permitted to move into the next development stage. The owner agency needs to meet certain requirements to advance from planning to final design, and finally into construction. If during various phases of project development, and as project scope becomes more accurate, the rating of the project falls below the required threshold, there is a possibility that the project may be discontinued. The burden is on the owner agency to ensure that the project remains viable and meets the federal requirements.

Evolution of Current Alternative Delivery Methods in Transit Projects

Public procurement law has historically limited public agencies to only use design-bid-build (DBB) construction project delivery. The wide range of options for project delivery methods that are available today is a relatively recent development for publicly funded transit projects in the United States. The shaping of the public procurement laws leading to the traditional DBB project delivery method, in part can be traced to the Brooks Act. Enacted in 1972, the Brooks Act (Public Law 92-582) states that design services on federally funded projects in the United States (US) should only be procured on the basis of qualifications. Alternatively, numerous laws and statutes throughout the US

have limited the procurement of constructors to the lowest responsible, responsive bidder. The combination of these two procurement practices has helped solidify the proliferation of DBB in the public sector. This method has been the traditional project delivery method in transportation projects until the introduction of DB and design-build-operate-maintain (DBOM) in the Intermodal Surface Transportation Efficiency Act of 1991¹. Another step was taken in 1996 when the Federal Acquisition Reform Act explicitly authorized the use of DB for federal projects. After that, the Transportation Equity Act for the 21st Century, Public Law 105-178 (TEA-21) allowed the state departments of transportation (DOTs) to award DB contracts if the enabling state-level legislation was in force (TEA-21 1998). Subsequent to the successful experience of using DB in several projects, many states passed new legislation and codes to allow alternative project delivery methods, i.e. DB and Construction Manager-at-Risk (CMR). Adding the responsibility of operation and maintenance to DB projects expanded to another delivery method called DBOM. The difference between delivery methods, the unique characteristics of each project, and the vast variety of parameters affecting the project delivery method selection, has made the decision complicated for many owners. The purpose of this guidebook is to facilitate decision-making by clarifying the differences between the delivery methods and proposing a structured decision-making approach which incorporates all the pertinent parameters.

Definitions of the Delivery Methods

Since the early 1980s, owners of construction projects have been putting greater pressure on the architecture/engineering/construction (A/E/C) industry to improve quality, reduce cost, and more importantly compress the period it takes from concept to completion for all manner of public and private facilities. As a result, both owners and industry have experimented with various forms of project delivery with varying degrees of success. The adoption of alternative project delivery methods has added to the challenge of selecting the method most appropriate to the owner's needs and desires as well as the project's technical requirements. As a result, this document provides a set of standard project delivery definitions as a basis for communicating the technical requirements for bringing a new project from the owner's concept to operation and final decommissioning of the project.

Project delivery method is a term used to refer to all the contractual relations, roles and responsibilities of the entities involved in a project. The Texas DOT defines project delivery method as follows: "A project delivery method equates to a procurement approach and defines the relationships, roles and responsibilities of project team members and sequences of activities required to complete a project. A contracting approach is a specific procedure used under the large umbrella of a procurement method to provide techniques for bidding, managing and specifying a project." (Walewski *et al* 2001) The AGC (2004) defines project delivery method as "the comprehensive process of assigning the contractual responsibilities for designing and constructing a project. A delivery method identifies the primary parties taking contractual responsibility for the performance of the work." *Thus, the different project delivery methods are distinguished by the way the contracts between the owner, the designer, and the builder are formed and the technical relationships between each party within those contracts.*

¹In 1992 the FTA announced the initiation of a *Turnkey Demonstration Program* (Federal Register Vol. 57, No. 157, 8/13/92) and later selected five projects for DB implementation. These projects were Los Angeles Union Station Intermodal Terminal, Baltimore Light Rail Transit, San Juan Tren Urbano, Bay Area Rapid Transit in San Francisco, Hudson-Bergen LRT.

The Construction Industry Institute (CII) maintains that there are really only three fundamental project delivery methods: DBB, DB, and CMR (Project Delivery Methods 1997). While there are a multitude of various names for project delivery methods throughout the industry, CII is essentially correct. Therefore, this report will focus its information in those three categories.

The AGC also distinguishes between the *delivery method* and the *management method*. The management method “is the mechanics by which construction is administered and supervised” (AGC 2004). This function is either retained by the owner agency or is outsourced. An example of outsourcing the management process is to hire an Agency CM to represent the owner’s interests during design and construction. Theoretically any management method may be used with any delivery method. As an example, the owner may hire an Agency CM to manage a DBB, DB, or even a CMR project.

The definitions and a brief explanation with a graphic displaying the contractual relationships are included below to assist the reader in putting the contents of this report into proper context. Note that the lines of communication shown in the figures represent the ability to exchange information through the use of formal and informal requests for information between various entities in the project.

Design-Bid-Build (DBB)

DBB is the traditional project delivery method in which an owner retains a designer to furnish complete design services and then advertises and awards the separate construction contract based on the designer’s completed construction documents. The owner is responsible for the details of design and warrants the quality of the construction design documents to the construction contractor.

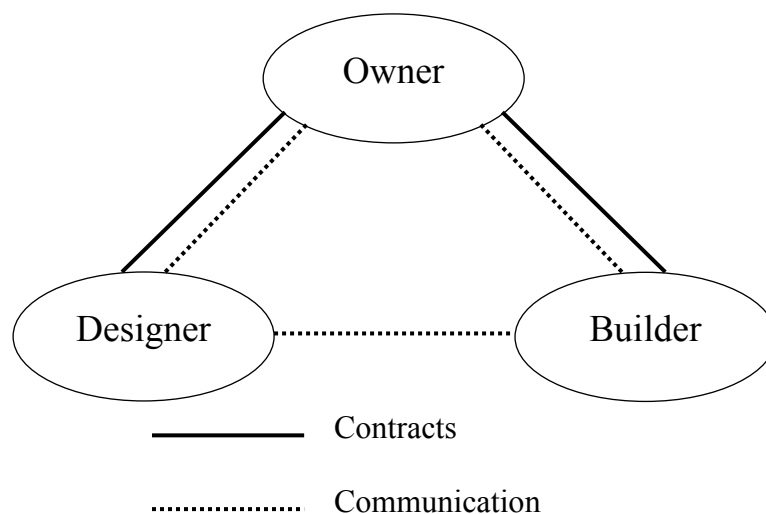


Figure 2-1 - Design-Bid-Build²

Figure 2.1 shows that the owner is squarely situated between the designer and the builder in the project delivery process. In DBB, the owner “owns” the details of design during construction and as a result, is financially liable for the cost of any design errors or omissions encountered in construction, called the “Spearin Doctrine” (Mitchell, 1999). The construction phase of DBB projects is generally awarded on a low bid basis. There is no incentive for the builder to minimize the cost of change orders in this delivery method. In fact, there can be quite the opposite effect. A builder who has submitted a low bid may need to look to post-award changes as a means to enhance profit on the project after bidding the lowest possible margin to win the project. One author states that the defining characteristics of DBB are as follows (Bearup et al 2007):

- There are separate contracts for design and construction.
- Contractor selection is based entirely on cost.
- Design documents are 100% complete.

Despite the above definitions, DBB projects can also be awarded on a negotiated basis and a best-value basis (Scott et al 2006), although in transit projects this usually will require FTA approval and frequently violates local laws. In both cases, the probability that the project will be awarded to a builder who has submitted a mistakenly low bid is reduced. Additionally, the motivation of the builder in both cases is to complete the project in a manner that will get it invited back to do the next negotiated contract or that will reflect well in the next best-value selection. Regardless of the award method, DBB is distinguished by less builder input to the design than DB or CMR. Thus, the owner must rely on the designer or agency CM (and not the builder) for constructability review if there is any at all. However, in this method the owner has full control over the details of design which may be a requirement for some complex projects.

² Figures adapted from American Institute of Architects, California Council (1996). *Handbook on Project Delivery. Sacramento*. American Institute of Architects, California Council, Sacramento, CA.

DBB is also characterized by the greatest amount of familiarity in both the design and construction areas. All qualified designers are able to compete for the design without restriction. Additionally, all constructors who are able to furnish the requisite bonding and meet any agency pre-qualification criteria are also able to compete without constraint. Design sub-consultants and construction trade subcontractors are also able to compete with minimal restrictions. Finally, as DBB is normally viewed as the traditional project delivery method in the US, it is both well-understood and well-accepted by both owners and members of the design and construction industries.

Construction Manager-at-Risk (CMR) or Construction Manager/General Contractor (CM/GC)

CMR projects are characterized by a contract between an owner and a construction manager who will be at risk for the final cost and time of construction. In this agreement, the owner authorizes the construction manager to handle the construction phase and give inputs during the design development. The idea of CMR is to furnish professional management of all phases of a project life to an owner whose organization may not have those capabilities (North Carolina 2005). Typically, CMR contracts contain a provision in which the CMR stipulates a guaranteed maximum price (GMP) above which the owner is not liable for payment. Often these contracts include incentive clauses in which the CMR and owner can share any cost savings realized below the GMP. Some states, like Oklahoma, take the GMP and convert it to a firm-fixed price contract and administer the construction as if it were a traditional DBB project thereafter (AIA 2005). CMR contracts can contain provisions for the CMR to handle some aspects of design, but generally, the owner retains the traditional responsibility by keeping a separate design contract and furnishing the CMR with a full set of plans and specifications upon which all construction subcontracts are based as seen in Figure 2.2. The CMR will usually be paid for furnishing preconstruction services such as cost engineering, constructability review, and development of subcontractor bid packages. According to AGC (2004) the defining characteristics of the CMR are the followings:

- The designer and the CMR hold separate contracts with the owner.
- The CMR is chosen based on criteria other than just the lowest construction cost, such as qualifications and past performance.

Additional defining characteristics are:

- “The CMR contracts directly with trades and takes on ‘performance risk’ (cost and schedule commitments)
- Schedule allows for overlapping design and construction
- Owner procures preconstruction services from the CMR
- Owner expects the CMR to provide guaranteed maximum price (GMP) and to commit to delivery schedule” (Bearup et al 2007)
- “Transparency is enhanced, because all costs and fees are in the open, which diminishes adversarial relationships between components working on the project, while at the same time eliminating bid shopping” (AIA 2005).

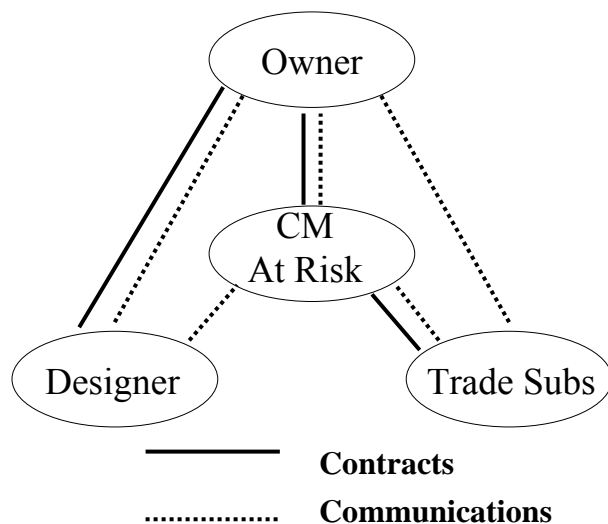


Figure 2-2 - Construction Manager-at-Risk

Constructability and speed of implementation are the major reasons an owner would select the CMR method (3DI 2005). Additionally, CMR greatly facilitates phased construction if that is a requirement for given project. Unlike DBB, CMR brings the builder into the design process at a stage where definitive input can have a positive impact on the project. “The CM[R] becomes a collaborative member of the project team. Preconstruction services include budgeting, cost estimating, scheduling, constructability reviews and value engineering studies.” (3DI 2005). In CMR, the construction manager essentially becomes the general contractor at the time the guaranteed maximum price is established. While some experts attempt to distinguish between CMR and Construction Manager/General Contractor (CM/GC) due to perceived levels of risk, many agencies use these terms more or less interchangeably³. The CMR can and is expected to provide realistic project cost estimates early in the project life cycle. It is anticipated that after a certain amount of design is complete and the project is sufficiently defined, the owner will enter into a contract with the CMR for providing construction services. Many states reserve the right to go out for bid if they think that the CMR’s price is not competitive (Minchin *et al* 2007)⁴. The timing of GMP negotiations varies among different agencies. In many cases, at least 60% of design is completed before a GMP is established. In some cases, the design is carried to 80-90% before a GMP can be effectively negotiated with the CMR. This depends on project complexity, agency rules and external conditions such as inflation and level of competition expected among subcontractors. In general, the CMR may feel that committing to a GMP while all the details of design are not defined, may put undue risks upon him. Also, some agency rules may hamper early GMP

³ According to AGC (2004) there has been some confusion about terms CM-at-risk and CM/GC because of the assumption that the phrase at-risk connotes cost guarantee. Even if there are no cost guarantees, the CM is still at-risk because the CMR holds the trade contracts (warranting the performance of the work). Because of this, some users choose to avoid the debate over the term risk and instead use the term CM/GC (p.8).

⁴ There are two types of CM arrangements, namely *Agency CM* and *CM-at-risk*. Our emphasis in this work is CM-at-risk. Agency CM is not a project delivery method as the CM is not contractually responsible for delivering the project. Its role is purely consultative and is usually not at risk for the cost and schedule of building the project.

negotiations. As an example, if the agency insists on requiring a fully open competition for hiring of subcontractors, then negotiating an early GMP may be more difficult because some subcontractors may be reluctant to give their prices without a 100% complete design. This in turn makes the CMR hesitant to provide a reasonable GMP fearing he may lose money if the subcontract bids come in too high.

As the design selection process virtually mirrors the same process in DBB, implementing CMR does not inherently restrict competition among designers and design subconsultants (AIA 2005). Owners occasionally require the designer in a CMR project to have previous CMR experience, which may result in fewer qualified proposers, but only if the owner chooses to do so. As the constructor is selected on a basis of qualifications and past performance and must also have the capability to perform preconstruction services, CMR project delivery can constrain competition to those constructors that have previous CMR experience. Most public CMR laws require competitively bidding out the construction trade subcontract work packages. The central idea of CMR is to get the advantage of price competition in the sub packages combined with the qualifications-based selection of the GC as CMR. One author puts it this way: “To ensure a positive relationship, C&S engages in a number of practices to involve and benefit our clients. We are responsible for complete bid documents, pre-bid meetings, and a fair and competitive bid process. We share the results of all bids with the owner for review and final selection” (C&S 2005). Hence competition is not restricted at that level by CMR.

Design-Build (DB)

Design-Build is a project delivery method in which the owner procures both design and construction services in the same contract from a single, legal entity referred to as the design-builder. A variety of methods exist for selecting the design-build constructor. The more common methods are the one-step and the two-step process. The one-step process provides for competitive evaluation of technical proposals, with the contract award decision based on best value to the owner agency. The best value is based on a combination of technical merit and price. The two-step process separates the technical proposal from the price. The method typically uses request for qualifications (RFQ)/request for proposal (RFP) procedures rather than the DBB invitation for bids procedures. There are a number of variations on the DB process, but all involve three major components. The owner develops an RFQ/RFP that describes essential project requirements in performance terms. Next is the evaluation of proposals, and finally, with evaluation complete, the owner must engage in some process that leads to contract award for both design and construction services. The DB entity is liable for all design and construction costs and normally, must provide a firm, fixed price in its proposal (El Wardani *et al.* 2006, Ibbs *et al.* 2003, Graham 2001).

Figure 2.3 clearly shows that the project’s chain of responsibility is considerably simplified from the owner’s standpoint. As in CMR, the builder has early constructability input to the design process. As the owner no longer owns the details of design, its relationship with the design-builder must be based on a strong degree of mutual professional trust (Beard *et al.* 2001). The design-builder literally controls this project delivery process. As a result, DB delivery method has proven to be highly successful in compressing the project delivery period (FHWA 2006) and as a result is often used for “fast-track” projects.

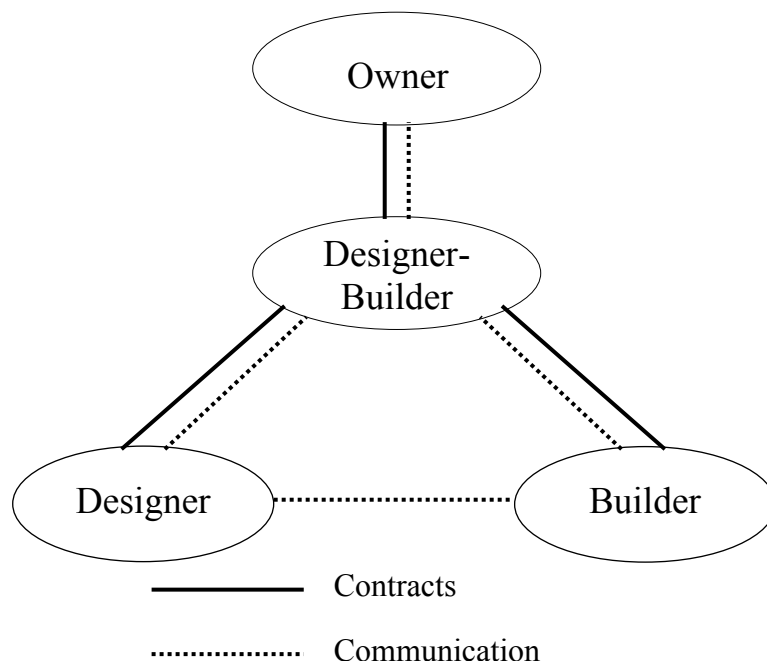


Figure 2-3 - Design-Build

Bearup et al (2007) state that the defining characteristics of DB are as follows:

- Single Point of Responsibility
- Schedule allows for overlapping design and construction
- The design-builder furnishes preconstruction services during the project design
- Owner expects the design-builder to provide a firm fixed price and to commit to delivery schedule

DB creates the greatest constraint on competition in that all parties to the DB contract are selected using qualifications and past performance as a major selection factor. As the owner transfers responsibility for all design and construction through the DB contract, it also loses the ability to foster competition between design subconsultants and construction trade subcontractors. There is typically no requirement to competitively bid for subcontract work packages and often the scale, complexity and speed at which DB projects are executed precludes firms with no DB experience from being able to participate. Additionally, as the contract is awarded before design is complete, DB can also create an unfavorable risk environment for subcontractors whose cost estimating systems lack the sophistication to be able to price work without completed construction documents.

There are many variations on the DB method. Design-build-operate-transfer, design-build-operate-own (sometimes called lease-back), design-build-operate-maintain, all require the DB contractor to remain with the project after construction is complete. Design-Build-Operate-Maintain (DBOM) is very similar to DB. However, the DBOM contractor assumes the operation and maintenance risks and is responsible to operate the new facility according to a set of regulations and codes for a determined duration (Wiss *et al* 2000, Kessler *et al* 2005).

Statutory Authorization of Delivery Methods in Various States

The traditional method of DBB has been used throughout the United States and state codes of all 50 states have given full authority to the transit agencies to use it in their projects. Alternative delivery methods do not have this clear statutory support. Some states do not allow transit entities to use them, some others have given one time authority for a special project, a group of states have put some limits on the application of alternative delivery methods and a few states require extra approval to be obtained by transit agencies in order to use alternative methods. Developing pilot programs is a common approach in some states for implementing previously unauthorized project delivery methods, particularly DB. In order to update information on the legal status of alternative project delivery methods in various states, a thorough literature search was conducted on the laws of all the 50 states. Several relevant *keywords* were electronically searched using LexisNexis search engine and all the state codes and statutes that deal with project delivery in transportation projects were examined. The results were then compared to the existing surveys of legal codes that are available in the literature (for example see Nossaman *et al* 2006; AIA Minnesota 2006). Our research shows that 37 states permit the use of DB in their transportation projects leaving 13 state agencies without the authority to do so. The application of CMR is not authorized in 31 states and only 14 states have fully authorized DOTs for use of this delivery method. Five states allow the use of CMR with some restrictions or after obtaining of extra approvals (Ghavamifar and Touran 2008). It should be noted that the laws governing the legality of alternative project delivery methods are evolving and because of this, giving any final conclusion is impossible. Also, while some state DOTs are permitted to use alternative delivery methods, it is not clear if those states' transit agencies are allowed to do that or not. The purpose of the literature search was to provide an overall picture of the status of legality of delivery methods for transportation projects in the United States at the time this report was prepared. Each public agency who is considering the use of a specific delivery method must check the legality of the method carefully.

FTA's requirements for third party contracting, described in Circular 4220.1E, are sufficiently flexible to allow the agencies to select their contractors through competitive bidding and/or competitive proposal/RFP (both price and other parameters considered). For the DBB the Circular allows the procurement of services through sealed bidding or competitive negotiations. For DB, the grantees must procure DB services through qualifications-based competitive proposal procedures. So it seems that if a specific state's laws allow an alternative project delivery method, the federal regulations will not prevent the agency of undertaking such procurement.

Existing Selection Approaches of Project Delivery Methods

Selection of the appropriate alternative project delivery method is a complex decision-making process. The decision should be made as early in the design phase as possible; preferably in the project scoping process and certainly before the final construction estimates of the projects are ready. The decision will occur when the owner still has little information about the outcome of the project and the project plans are not detailed enough to be reliable grounds for judgment about the project. In this environment, having a framework for decision-making is vital for transit projects. This framework should be simple, comprehensive, rational, and objective. The literature review of this research report shows that some experts have concentrated on this issue and have developed a list of criteria and some decision making frameworks (Gordon 1994, Konchar *et al* 1998, Debella *et al.* 2006, Mahdi *et al.* 2005, Ibbs *et al.* 2003, Oyeturji *et al.* 2006, Garvin 2003). Several of these

researchers have chosen some projects and have based the selection methodology on the characteristics of those projects.

One can roughly divide the relevant literature into two groups: (1) the papers and reports that compare the delivery methods based on the observed performance measurements, collected from a group of projects, and (2) the papers and reports that give a list of criteria and a framework for decision-making.

One of the best examples for the first group is a paper by Konchar *et al* (1998) in which a set of criteria is defined for a performance comparison of different delivery methods (i.e. DB, DBB and CMR) in 351 building projects. These criteria are mostly objective and measurable, like *cost growth*, *construction speed*, and *schedule growth*. Some criteria are also defined to incorporate the quality performance of the delivery methods, like *difficulty of facility start up*, *number and magnitude of call backs*, and *operation and maintenance costs*. Based on Konchar *et al* (1998), “when all other variables were held constant, the effects of project delivery system indicated design-build projects to be at least 5.2% less than design-bid-build projects and 12.6% less than construction management at risk projects on average in terms of cost growth.” The authors of the paper divided the projects into six different groups (such as light industrial, complex office, heavy industrial, *etc*) in order to get clearer trends in each group. Taking this into account, the paper does not have enough data to distinguish between the performances of different delivery methods in transit projects. However, two studies of DB versus DBB project performance in the federal building sector did make direct comparisons. The first compared 54 DBB projects to 34 DB projects and discovered that DB projects had 16.4% less cost growth and 19.0% less time growth than similar DBB projects. Another that looked at 110 Navy projects found that DB projects again performed better with 18.0% less cost growth and 60.0% less time growth (Allen *et al* 2002). Additionally, a recent NCHRP study of best value contracting (Scott *et al* 2006) also furnished direct comparison of transportation project performance between delivery methods. While that study did not include CMR projects, it did include DBB projects awarded on a best value basis which parallels the CMR delivery method. It found that DB projects had 4.7% less cost growth and 9.3% less time growth. Best value projects had 2.0% less cost growth and 18.5% less time growth. Others such as Debella *et al* (2006) and Ibbs *et al* (2003) have used a methodology similar to Konchar’s, but they have narrowed down the scope of their research either to special kinds of projects or fewer performance measures.

The papers and reports of the second group have focused on the decision-making process. These papers propose mechanisms for decision-making and define the necessary criteria and frameworks so that the most important project parameters are defined and used in the decision-making method. The frameworks are primarily intended to be simple, rational, and comprehensive. They range from basic flow chart methods (Gordon 1994) to more sophisticated processes based on methodologies such as multiple linear regression, the Analytical Hierarchy Process (AHP) (Mahdi & Al-Reshaid 2005), or Simple Multi Attribute Rating Technique with Swing weights (SMARTS) (Oyetunji and Anderson 2006).

Gordon (1994) created a procurement method selection model that uses a flowchart for selecting the best contracting method. Within the flowchart are a number of drivers that directs the owner’s attention to the most important issues in delivery method selection. A/E/C Training Technologies (2005) has developed a multimedia education compact disc and delivery selection tool. The tool integrates training on project delivery selection systems with a matrix-style decision framework that owners can complete to make an informed delivery selection. Skitmore and Marsden (1988)

presented a multi-attribute analysis technique and a discriminant method for selecting delivery methods. The multi-attribute method uses utility factors to evaluate the suitability of a delivery method with respect to a client's priority criteria. Kumaraswamy and Dissanayka (1996) propose a client advisory system with an expert system front end, which will gather project information and model the project profile to generate a list of delivery options. Finally, Oyetunji & Anderson (2006) use a SMARTS approach for delivery selection. The approach utilizes a matrix that has 20 criteria each with a given weight. The owner rates these criteria and goes through the required calculation that gives a single rank to each delivery method. The delivery method with the highest rank should be chosen for the project.

Based on both groups of the literature, one can find that the number of important parameters that affect the decisions early in the project can be divided into four groups: *project-related parameters*, *agency-related parameters*, *legal parameters* and *life-cycle issues*. Project-related parameters are those parameters that pertain to the duration, estimated cost, quality level, project risks, limits on schedule growth, project complexity, *etc.* Agency-related parameters mainly consist of the status of agency, the role of this project in the strategies of the agency and organization of the agency i.e. availability of funds, sophistication of the agency's employees, flexibility needs in construction phase, level of risk assumption, importance of preconstruction services, and quality level expectation. The legal parameters mainly cover the legal and contracting issues, such as statutory authority to use alternative project delivery methods, the level of competition in the market, permits needed for the project. Life-cycle issues cover the costs of maintaining and decommissioning the facility as well as the ability to minimize energy and environmental effects of the project.

In the parameters mentioned above, the ability to transfer risks of a project to other entities rather than the owner is a characteristic that is related to both the project and the owner agency. It shows the level of risk and uncertainty of the project and also the ability of the owner to assume the risks or transfer them (*risk-averse* or *risk-prone* agency). Delivery methods have different mechanisms for risk distribution among the entities involved. In summary, the existing body of knowledge in this area, along with specific information collected on transit projects during interviews, provides a solid foundation for developing a new selection system tailored to the needs of transit owners.

Timing of Project Delivery Method Selection

Transit projects, especially those that receive federal funds follow several steps during their development. These steps can be summarized as follows:

- Alternative Analysis – Draft Environmental Impact Statement (AA/DEIS)
- Final Environmental Impact Statement (FEIS)
- Full Funding Grant Agreement (FFGA)

The first two steps roughly coincide with conceptual design (5-15% of design effort) and preliminary engineering (PE) (25-30% of design effort). The timing of FFGA which represents the commitment of the federal government to fund the project depends on the project delivery method and can be at the end of PE or final design.

In selecting a project delivery method, the owner should realize that the window of opportunity will pass for some as the project moves to various stages of development. Table 2-1 maps project

delivery method selection decision against project development phase. It can be seen that selecting an alternative project delivery method should be done relatively early. Most of the benefits can be realized by engaging the constructor as soon as possible. The decision point for PDM selection should not be confused with the time that the constructor is engaged. As an example, an owner may decide to engage a DB contractor at the end of Preliminary Engineering or even later in order to clarify the scope and reduce the uncertainty. However, the owner should have decided on the type of delivery (for example DB) much earlier, so that the design documents can be properly developed considering the type of delivery method.

Table 2-1 – The Timing of PDM Selection

PDM	At the end of Conceptual Design	At the end of Prelim. Eng.	At the end of Final Design	Construction
DBB	■	■	□	
CMR	■	□	□	
DB	■	■		
DBOM	■	■		

■ Desirable

□ Feasible

CHAPTER 3 – CASE STUDY PROJECTS

Background

Based on the results of the literature review, the research team began its case study data collection. The team proposed to identify and analyze at least six projects from across the spectrum of project delivery methods. The team was able to identify and gain access to information on nine projects worth more than \$3.0 billion that represent the cross-section of delivery methods. In fact, the Silver Line project in Boston is a Design-Bid-Build/Multi-Prime project, which while it is not a different delivery method, was not a variation on DBB project delivery that was contemplated in the original proposal. Additionally, another enhancement to the original research plan was realized when the team was able to identify projects from more than one delivery method completed by the same agency. Thus, the depth and validity of the interviews were enhanced by permitting the interviewers to gain information that compared and contrasted the benefits and constraints of several delivery methods from a single source. Table 3.1 is a summary of the case study projects that were sampled for this research. One can see that the projects span from coast to coast and include two major metropolitan areas in the Rocky Mountain area as well.

Table 3-1 - Summary of Case Study Projects

Case #	Project	Agency/Location	Project Delivery Method	Project Contract Amount (Original/Actual)	Completion Date (Original/Actual)
1	T-REX (Southeast Corridor Light Rail)	Regional Transportation District/ Denver, CO	Design-Build	\$849/\$940* million *Scope added after award	7 yrs/ 5 yrs – 3 mos
2	Weber County Commuter Rail	Utah Transit Agency/ Salt Lake City to Ogden, UT	CM-at-Risk	\$196/\$241* million *Scope added after award	6 yrs/ 5 yrs-6 mos
3	University Line	Utah Transit Agency/ Salt Lake City, UT	Design-Build	\$124/118.5 million	2 yrs-2 mos/ 1 yr-5 mos
4	Medical Center Extension	Utah Transit Agency/ Salt Lake City, UT	Design-Build	\$95/89.4 million.	2 yrs-2 mos/ 1 yr-5 mos
5	Greenbush Commuter Rail	Massachusetts Bay Transportation Authority/ Boston, MA	Design-Build	\$252/\$300 million	3 yrs/ 5yrs* *Delay due to wetland permits
6	Hudson Bergen Light Rail	New Jersey Transit Authority/ Hudson, NJ	Design-Build-Operate-Maintain	\$554/\$611 million	6 yrs / 6yrs-2 mos
7	Silver Line Project	Massachusetts Bay Transportation Authority/ Boston, MA	Design-Bid-Build Multi-Prime	\$601/\$604.4 million	4 yrs/ 8yrs* *Delays due to Big Dig project
8	Portland Mall Project	TriMet/ Portland OR	CM-at-Risk	\$143.8/143.8 million	4 yrs/4yrs
9	I-205 Light Rail Extension Project	TriMet/ Portland OR	Design-Build	\$163.8/\$163.8 million	4 yrs/4yrs

Case Study Collection Methodology

The research team used the case study method described by Yin (1994) to furnish a rigorous methodology for collecting the data from the projects shown in Table 3.1. Yin maintains that planning the process of accessing and collecting data is essential preparation for efficiently and accurately collecting cogent information. Additionally, it is equally important to carefully select cases that can be compared directly with one another and also offer cross-sectional diversity. The selected sample fulfills this requirement in that there are five Design-Build (DB) projects from four different agencies and two Construction Manager-at-Risk (CMR) projects from two different agencies. The Design-Bid-Build (DBB)/Multi-Prime project is actually composed of a series of DBB projects undertaken by the same agency. It was chosen to permit the evaluation of this DBB-hybrid technique. The Design-Build-Operate-Maintain (DBOM) project is the only project for which there is no direct comparison. Nevertheless, its DB component can be reliably compared with the five other DB projects without loss of accuracy.

While the collection of cases needs to cover the project delivery method spectrum in this research, it is “important that the participant pool remain relatively small” (Colorado State University, 2006). Although fewer cases can sometimes lead to unsubstantiated research conclusions based on the probability of atypical case selections, it provides a better opportunity to examine each case in detail without becoming too cumbersome. The sample used here appears to be representative for the various project delivery methods that do not involve post-construction operations and maintenance. DBOM is a delivery method that is not common to the US and therefore that post-construction aspects of the Hudson-Bergen project must be viewed as a single point of data and no attempt will be made to generalize observations and conclusions from that project in this report. Even for DBOM, we have identified two other major projects with New Jersey Transit⁵ that were used in the development of the Guidebook.

Determining quantitative data, rather than qualitative, is vital to prioritizing needed information. Quantitative data offers factual data that is not subjective, which creates greater viability to the research and potential conclusions. Although case studies have the ability to provide distinctive data that can expand analysis and future results, data points (objectives) sought using the case study should complement other applied research methods to strengthen the overall research (Yin 1994). Thus, to achieve this goal, the structured interviews used to methodically collect case study data included quantitative data points regarding scope, financial and schedule information on each project. This data allows the comparison of the projects on an objective basis and permits the trends identified from the qualitative data to be validated or refuted by the quantitative data. Table 2.1 summarizes the quantitative cost and schedule data and one can see that all but three of the projects either finished or are on track to finish ahead of schedule. The Hudson-Bergen project finished just two months late; given the size and complexity of this project, this was a remarkable achievement. Thanks to the structured interview methodology, the delays observed on the two projects with significant delays were explained as being caused by external factors and not attributable to the project delivery method. In the same vein, five of the projects experienced cost overruns. However, on two projects (T-REX and Weber County), cost growth was explained by the agency’s decision to add scope to the project after award. Thus, the evaluation of the project delivery method for those two was validated by the detailed explanation that was obtained via structured interview. These examples not only demonstrate the value of the selected data collection method but also lend authority to the trends and emerging conclusions that will be offered later in this report.

Case Study Matrix

The following section contains a standardized matrix which displays the salient information on each case study project in the same fashion to permit ease of understanding and comparison. The matrix consists of the following components:

1. Project identification data: Qualitative
2. Project scope data: Quantitative
3. Project financial and schedule data: Quantitative

⁵ The first phase of Hudson-Bergen Project with a cost of \$1.2m is one project where DBOM was used. Also, the South Jersey Light Rail, also known as “River Line” was another DBOM project that was built exclusively with state funds.

4. Project delivery method decision rationale: Qualitative
5. Project issue data: Qualitative
6. Project risk analysis process data: Qualitative
7. Project procurement process data: Quantitative
8. Quality management data: Qualitative

In addition to the data obtained using the structured interview questionnaire, detailed notes of the interviews were taken and used to furnish the basis for explanatory details on the standard questionnaire responses. Both the results of the questionnaire and the explanatory notes will be consolidated and assigned to an appendix in the final report of this research. As a whole, the interviews went very well with the minimum of inconsistencies. In all cases, the interviews were conducted with members of the agency's project delivery team for each project. In order to achieve this, the team had to track down two project managers who had retired. Thus, the information collected was received first hand.

Project scope data that was collected at the interview was validated by data obtained in the literature review which comprises Yin's "converging lines of information" and the "use of multiple sources." Multiple sources help alleviate lack of trust, increase viability, and frequently provide supplementary realms of thought and research that strengthens results. "Case studies are likely to be much more convincing and accurate if they are based on several different sources of information, following a corroborating mode" (Colorado State University, 2006). This goal was achieved in all cases.

The remainder of this section contains the specific case study data collected for each project displayed in the standard matrix format. The format is a synthesis of the structured interview questionnaire output in a manner that permits both comparison and contrast. The cases are grouped by agency with multiple projects from the same agency being listed consecutively in the order shown in Table 3.1.

Case 1 — TREX

Project Information

Project Name: Southeast Corridor Light Rail

Name of Agency: Regional Transportation District (a Public Transit Agency)

Location: Denver, Colorado

Delivery Method: Design-Build

Project Description

The new line expands the Regional Transportation District's (RTD) existing light rail system and extends light rail service along the southeast corridor of I-25 and I-225. An extensive bus feeder system makes it easy for people to get to and from the 13 new light rail stations. Bridges and underpasses provide pedestrian access to several of the stations. The Southeast Corridor Light Rail includes:

- 19 miles of completely grade-separated, double-track light rail to RTD's existing system
- Extension of light rail from the current station at I-25 and Broadway, along the west side of I-25 to Lincoln Avenue in Douglas County and in the median of I-225 to Parker Road in Aurora
- 13 light rail stations with park-n-Rides at 12 of the stations
- 6,000 parking spaces at park-n-Rides
- Unique functional public art elements at each of the 13 new stations
- 34 light rail vehicles to RTD's fleet
- New light rail maintenance facility where the fleet will be maintained, cleaned and inspected (already complete)
- A state-of-the-art communications system at a centralized control center for continuous monitoring and control of all rail operations

Project Financial and Schedule Information

Original Total Awarded Value of project: \$849 million

Final Total Awarded Value of project: \$940 million (note: RTD increased scope of work after award)

Project Schedule:

Initial Advertising: RFQ in March 2000

RFP Issued to Shortlist: November 2000

Contract Award: June 2001

Original Project Delivery Period: 7 years (June 2008)

Final Project Delivery Period: 5 years 3 months (September 2006)

Project Delivery Method Decision Rationale

Agency Project Delivery Experience

Design-Bid-Build: More than 10 projects

Construction Manager-at-Risk: 1 to 5 projects

Design-Build: 1 to 5 projects

Agency Project Delivery Decision-making Process: Top leadership decision making. The decision was made from the governor’s office and the top management of RTD and CDOT. This was a unique procurement in that aspect.

Reasons for Selecting Project Delivery Method (*most significant reason*)

Reduce/ compress/ accelerate project delivery period

Encourage innovation

Redistribute risk

Complex project requirements

Workforce-Related Reasons for Selecting Project Delivery Method

None

Table 3-2 - Case Study Project Issues

Issues	Project-level	Agency-level	Public Policy/ Regulatory	Life Cycle	Other
Considered a <i>Benefit</i> of the Chosen Delivery System to this Project	-Project Size -Risk management -Risk allocation -Schedule -Cost	-Staffing required -Agency goals & objectives	-Benefits & impacts -Fed/State/Local laws*	None	-Construction claims -Adversarial relationship between project participants
Remarks on Above Benefits			*New DB law had to be passed for the project	Life cycle issues did not enter into the decision	
Considered a <i>Constraint</i> of the Chosen Delivery System to this Project	None	-Agency experience* -Staff capability -Agency control of project -Third party agreement	-Competition* -DBE/small business impact Stakeholder/ community input	None	
Remarks on Above Constraints		*Agency had no previous DB experience	*Short list had three, but only two bidders submitted final proposals		
Summary Remarks	Many DB benefits were accrued including a significantly faster schedule, a reduction in claims and a partnering atmosphere. DB did create some issues on third party impacts during construction due to speed of the project. A lesson learned on stations was that design of the stations happened somewhat after the contract award and the local stakeholders did not get the degree of input that they might otherwise have.				

Case Study Project Risk Analysis Process

Formal Risk Analysis Areas: Contracting risk analysis done in conjunction with the project team and legal advisors.

Project Cost Estimate Uncertainty Analysis: None

Risk Identification Techniques Used: Brainstorming

Risk Assessment Techniques: Qualitative risk assessment only

Risk Management Techniques: Not used

Risk Technique used to Draft Contract: Risk matrix

*Case Study Project Procurement Process Summary***Table 3-3 - Procurement Phase Summary**

Required Elements of the Proposal	Evaluated for award decision	Remarks
Qualifications of the Project Manager	No	
Qualifications of the Designer-of-Record	Yes	
Past performance record on similar projects	Yes	
Proposed schedule	Yes	
Proposed schedule milestones	Yes	
Lump sum price	Yes	
Schedule of values	Yes	
Qualifications of the Project Quality Manager		Evaluated as part of quality plan
Qualifications of the Design Quality Manager		Evaluated as part of quality plan
Qualifications of the Construction Quality Manager		Evaluated as part of quality plan
Design quality management plan	Yes	
Construction quality assurance plan	Yes	
Construction quality control plan	Yes	
Independent quality assurance	Yes	
Outline specifications	No	

Technical Elements of the Solicitation Package (RFQ/RFP): Solicitation package included the following elements:

- Design criteria checklists
- Standard design details
- Standard guide specifications
- Construction testing matrix

Table 3-4 - Design Phase Summary

Responsibility allocation for design management tasks	Agency personnel	Design-builder's design staff	Design-builder's construction staff	Agency-hired consultant
Technical review of design deliverables	✓	✓	✓	✓
Checking of design calculations		✓		✓
Checking of design quantities			✓	
Acceptance of design deliverables	✓			✓
Review of specifications	✓	✓	✓	✓
Approval of construction documents	✓			✓
Approval of payments for design progress	✓			✓
Approval of post-award design QA/QC plans	✓			✓

Table 3-5 - Construction Phase Summary

Responsibility allocation for construction management tasks	Agency personnel	Design-builder's design staff	Design-builder's construction staff	Agency-hired consultant
Technical review of construction shop drawings		✓		✓
Technical review of construction material submittals*	✓	✓		✓
Review of construction schedule	✓			✓
Checking of pay quantities**	✓			✓
Routine construction inspection***	✓		✓	✓
Quality control testing			✓	✓
Establishment of horizontal and vertical control on site			✓	✓
Verification/acceptance testing****			✓	
Approval of progress payments for construction progress		✓		✓
Approval of construction post-award QA/QC plans		✓		✓
* DB QA Staff performed a pre-review of the submittals.				
**Paid based on progress of percent complete for each work item by work breakdown structure.				
*** Did not call it inspection, but rather called it auditing. QA/QC was with the contractor. Auditing only by the owner. DB Contractor also did do the bulk of the QA/QC inspection.				
****See previous note on routine construction inspection.				

Quality Management Summary

QA/QC Plans: Different from the ones used in traditional DBB projects:

- The design-builder is responsible for QA/QC and owner established an extensive quality oversight program audit system and a quality requirements database. All the requirements from the contract were in the database and documented a both conforming and nonconforming. The database consisted of approximately 5,000 items. One system encompassed both design and construction QA/QC.
- Minimum QA/QC plan content was specified. The design-builder had to be ISO 9000 certified within one year. Draft design and construction QA/QC plans were submitted in the DB proposal and these items were evaluated. These were two of the ten evaluation factors and made the proposers aware of the importance of quality management to the project

Use of mandated agency quality management plans: None. However, key personal were evaluated in submittals required by both the RFQ and RFP. Any replacements had to be approved. However, the philosophy was not to try to manage personnel, but rather examine processes and performance.

Case 2 — Weber County Commuter Rail

Project Information

Project Name: Weber County to Salt Lake City Commuter Rail Project

Name of Agency: Utah Transit Authority (a Public Transit Agency)

Location: Weber County, Utah (project extends from Ogden to Salt Lake City)

Delivery Method: Construction Manager-at-Risk (UTA uses the term CM/GC)

Project Description

The alignment begins in downtown Salt Lake City at the Inter-modal Hub and extends north along the Union Pacific Railroad (UPRR) right-of-way through Davis and Weber Counties, passing on new elevated structures over the Ogden Yard continuing north of Union Station in Ogden to Pleasant View, UT. There are presently three freight sidings (industry tracks) from the UPRR mainline track crossing the commuter rail tracks. Grade crossings and grade crossing protective devices for the commuter rail line are also being constructed or reconstructed as needed.

The Weber County Commuter Rail includes:

- 44 miles of new transitway using single track with sections of double track at key locations to provide bypass capability.
- 8 stations, including the Inter-modal Hub in Salt Lake City, which is being constructed under a different project.
- Plans to have the rail line connect to bus transit at all stations; the line will also connect to the TRAX Light Rail system, interstate bus service and Amtrak at the Salt Lake City Inter-modal Hub.
- All stations, including the downtown Salt Lake City Inter-modal Hub, are planned to include Park and Ride capabilities.
- Increased fleet to 11 locomotives and 35 passenger vehicles
- Upgrade of an existing maintenance facility and storage site at the former Union Pacific Diesel Maintenance Shop and Yard located in Salt Lake City immediately adjacent to the UPRR Main Line and the UTA-acquired right-of-way, to serve to maintain the Commuter Rail fleet.

Project Financial and Schedule Information

Original Total Awarded Value of project (CMR contract): \$196 million [Total project estimated budget \$541 million]

Final Total Awarded Value of project: \$241 million (note: UTA increased scope of work after award and includes \$550,000 Preconstruction Services fee for CM*) [Currently total project budget is \$611.6 million (FFGA)]

Project Schedule:

Preliminary design contract award: 2002

Initial Advertising: 2004

Final design contract award: 2005

Construction contract award: June 2005

Original Project Delivery Period: 6 years

Final Project Delivery Period: 5 years 6 months

Expected completion (revenue operation date): September 30, 2008

*Proposed preconstruction services fees ranged from \$550K (winner) to \$3.0 million

Project Delivery Method Decision Rationale

Agency Project Delivery Experience

- Design-Bid-Build: More than 10 projects; 11-25% of typical budget
- Construction Manager-at-Risk: 1 to 5 projects; >50% of typical budget
- Design-Build: 1 to 5 projects; 11-25% of typical budget

Agency Project Delivery Decision-making Process: Convened a workshop that evaluated each possible project delivery method against stated project goals. Conducted formal risk analysis based on input from both the design and construction communities.

Reasons for Selecting Project Delivery Method (*most significant reason*)

- Dealing with railroad safety requirements on shared/ adjacent ROW*
- Establish project budget at an early stage of design development #2
- Reduce/compress/accelerate project delivery period
- Get early construction contractor involvement
- Encourage innovation
- Facilitate Value Engineering
- Flexibility needs during construction phase

Workforce-Related Reasons for Selecting Project Delivery Method

Chose CMR to both augment existing staff and be able to decrease the size of the agency’s full-time staff.

Table 3-6 - Case Study Project Issues

Issues	Project-level	Agency-level	Public Policy/Regulatory	Life Cycle	Other
Considered a <i>Benefit</i> of the Chosen Delivery System to this Project	-Project Size -Risk management -Schedule -Cost -Stakeholder coordination*	-Agency experience -Staffing required -Staff capability -Agency goals & objectives -Agency control of project -Third party agreements -Other *	-Competition -DBE/small business impact -Benefits & impacts -Fed/State/Local laws* -Stakeholder/ community input	-Maintain-ability	-Construction claims* -Adversarial relationship between project participants
Remarks on Above Benefits	*Stake holder coordination a big benefit of CMR	* Expedites funding with FTA	*New DB law had to be passed for the project	Sustainability was not considered on this project	* “HUGE” benefit.....no claims on the project so far.

Considered a <i>Constraint</i> of the Chosen Delivery System to this Project	-Risk allocation		-Labor unions -FTA/EPA regulations.	None	
Remarks on Above Constraints					
Summary Remarks	Sustainability will be considered in the future projects. CMR project delivery would be judged as beneficial for future projects with sustainability requirements.				

Case Study Project Risk Analysis Process

Formal Risk Analysis Areas: Project Scope, Schedule, Cost and Contracting Risk

Project Cost Estimate Uncertainty Analysis: Yes

Risk Identification Techniques Used: Brainstorming, Scenario Planning, and Expert Interviews

Risk Assessment Techniques:

Qualitative risk assessment using expert panel with stakeholders included Evaluated project risks versus project goals

Quantitative risk assessment using Monte Carlo simulation and expected value analysis.

Risk Management Techniques: Risk register/charter, risk management plan, and risk mitigation plan.

Risk Technique used to Draft Contract: Risk mitigation plan used to draft special payment clauses to allocate risk for flagging during construction to comply with RR safety requirements, subcontractor payment, and unsuitable subgrade.

Case Study Project Procurement Process Summary

Table 3-7 - Procurement Phase Summary

Required Elements of the Proposal	Evaluated for award decision	Remarks
Qualifications of the Construction Quality Manager	Yes	
Past performance record on similar projects	Yes	

Technical Elements of the Solicitation Package (RFQ/RFP): Solicitation package included the following elements:

- Quality management roles and responsibilities

Table 3-8 - Design Phase Summary

Responsibility allocation for design management tasks	Agency personnel	Designer's design staff	CM pre-construction staff	Agency-hired consultant
Technical review of design deliverables	✓	✓	✓	
Checking of design calculations		✓		
Checking of design quantities		✓	✓	
Cost engineering reviews		✓		✓
Constructability reviews		✓	✓	
Acceptance of design deliverables	✓			
Review of specifications		✓	✓	
Approval of construction documents	✓			
Approval of payments for design progress	✓			✓
Approval of post-award design QA/QC plans	✓			✓

Table 3-9 - Construction Phase Summary

Responsibility allocation for construction management tasks	Agency personnel	Designer's design staff	CM construction staff	Agency-hired consultant
Technical review of construction shop drawings		✓		✓
Technical review of construction material submittals		✓		✓
Review of construction schedule	✓			✓
Checking of pay quantities	✓			✓
Routine construction inspection			✓	
Quality control testing			✓	
Establishment of horizontal and vertical control on site			✓	
Verification/acceptance testing			✓	✓
Approval of progress payments for construction progress	✓			✓
Approval of construction post-award QA/QC plans	✓			✓

Quality Management Summary

QA/QC Plans: Different than the ones used in traditional DBB projects. CMR manages the quality management program

Use of mandated agency quality management plans: UTA requires the CMR to develop and implement a plan that is in accordance with its standard QA/QC guidelines including a standard set of qualifications for the CMR's quality management staff. Also mandates the use of standard design details for system compatibility purposes.

Case 3 — University Line

Project Information

Project Name: University Line Light Rail Project
Name of Agency: Utah Transit Authority (a Public Transit Agency)
Location: Salt Lake City, Utah
Delivery Method: Design-Build

Project Description

The University line expanded the Regional Transportation District's existing TRAX light rail system that connected downtown Salt Lake City with the southern suburb of Sandy and extended light rail service Main Street with Rice Eccles Stadium at the University of Utah using existing right-of-way. The existing bus feeder system will make it easy for people to get to and from the 4 new light rail platforms. Bridges provide pedestrian access to several of the stations. The University Line Light Rail project includes:

- 2.3-mile overhead catenary branch line, connecting Main Street with Rice Eccles Stadium at the University of Utah.
- 4 light rail platforms
- Brought UTA's fleet to a total of 33 light rail vehicles.
- Furnished transit service for the 2002 Winter Olympics

Project Financial and Schedule Information

Original Total Awarded Value of project: \$124 million

Final Total Awarded Value of project: \$118.5 million

Project Schedule:

Preliminary Design Contract Awarded: 2000

DB Project Advertised: 2000

Contract Award: June 2001

Original Project Delivery Period: 2 years 2 months*

Final Project Delivery Period: 1 year 5 months*

*Combined time for this and Medical Center Extension Project

Project Delivery Method Decision Rationale

Agency Project Delivery Experience

Design-Bid-Build: More than 10 projects; 11-25% of typical budget

Construction Manager-at-Risk: 1 to 5 projects; >50% of typical budget

Design-Build: 1 to 5 projects; 11-25% of typical budget

Agency Project Delivery Decision-making Process: Convened a workshop that evaluated each possible project delivery method against stated project goals. Conducted formal risk analysis based on input from both the design and construction communities.

Reasons for Selecting Project Delivery Method (*most significant reason*)

Reduce/ compress/ accelerate project delivery period

Establish project budget at an early stage of design development

Get early construction contractor involvement

Encourage innovation

Facilitate Value Engineering

Flexibility needs during construction phase

Complex schedule that had to be done by the 2002 Winter Olympics

Workforce-Related Reasons for Selecting Project Delivery Method

Chose DB to both augment existing staff and be able to decrease the size of the agency’s full-time staff.

Table 3-10 - Case Study Project Issues

Issues	Project-level	Agency-level	Public Policy/ Regulatory	Life Cycle	Other
Considered a <i>Benefit</i> of the Chosen Delivery System to this Project	-Project Size -Risk management -Risk allocation -Schedule -Cost	-Staffing required -Staff capability -Agency goals & objectives	-Competition -DBE/small business impact -Stakeholder/ community input	None	-Construction claims -Adversarial relationship between project participants
Remarks on Above Benefits				Sustainability issues were not considered nor required	No construction claims on this project
Considered a <i>Constraint</i> of the Chosen Delivery System to this Project	None	-Agency experience* -Staff capability -Agency control of project -Third party agreement	-Fed/State/ Local laws* -Labor unions -FTA/EPA regulations.	None	None
Remarks on Above Constraints		*Agency had no previous DB experience	*New DB law had to be passed for the project		
Summary Remarks	Schedule considerations drove this project’s delivery method selection.				

Case Study Project Risk Analysis Process

Formal Risk Analysis Areas: Project Schedule

Project Cost Estimate Uncertainty Analysis: None

Risk Identification Techniques Used: Brainstorming, Scenario Planning, Expert Interviews

Risk Assessment Techniques: Qualitative risk assessment only; discussed schedule options and risks in detail

Risk Management Techniques: Risk register/charter, risk management plan, and risk mitigation plan.

Risk Technique used to Draft Contract: Risk assignment in contract, mainly clarifying those risks that the owner would retain.

*Case Study Project Procurement Process Summary***Table 3-11 - Procurement Phase Summary**

Required Elements of the Proposal	Evaluated for award decision	Remarks
Qualifications of the Project Manager	Yes	
Qualifications of the Designer-of-Record	Yes	
Past performance record on similar projects	Yes	
Proposed schedule	Yes	
Proposed schedule milestones	Yes	
Lump sum price	Yes	
Schedule of values	Yes	
Qualifications of the Project Quality Manager	Yes	
Qualifications of the Design Quality Manager	Yes	
Qualifications of the Construction Quality Manager	Yes	
Construction quality assurance plan	Yes	
Construction quality control plan	Yes	
Independent quality assurance	Yes	

Technical Elements of the Solicitation Package (RFQ/RFP): Solicitation package included the following elements:

- None listed on questionnaire

Table 3-12 - Design Phase Summary

Responsibility allocation for design management tasks	Agency personnel	Design-builder's design staff	Design-builder's construction staff	Agency-hired consultant
Technical review of design deliverables		✓		
Checking of design calculations		✓		
Checking of design quantities		✓		
Acceptance of design deliverables	✓			
Review of specifications		✓		

Approval of construction documents	✓	✓		
Approval of payments for design progress	✓			✓
Approval of post-award design QA/QC plans	✓			

Table 3-13 - Construction Phase Summary

Responsibility allocation for construction management tasks	Agency personnel	Design-builder's design staff	Design-builder's construction staff	Agency-hired consultant
Technical review of construction shop drawings		✓		
Technical review of construction material submittals		✓		
Review of construction schedule	✓		✓	✓
Checking of pay quantities				
Routine construction inspection			✓	✓
Quality control testing			✓	
Establishment of horizontal and vertical control on site			✓	
Verification/acceptance testing			✓	✓
Approval of progress payments for construction progress			✓	✓
Approval of construction post-award QA/QC plans	✓			

Quality Management Summary

QA/QC Plans: Different than the ones used in traditional DBB projects. The design-builder had more responsibility for QA/QC.

Use of mandated agency quality management plans: Required the design-builder to develop a QA/QC plan that followed the agency's published standard. Established a standard for the primary quality manager's qualifications.

Case 4 — Medical Center Extension

Project Information

Project Name: Medical Center Extension Light Rail Project
 Name of Agency: Utah Transit Authority (a Public Transit Agency)
 Location: Salt Lake City, Utah
 Delivery Method: Design-Build

Project Description

The Medical Center Extension line continued the expansion of the Regional Transportation District's existing TRAX light rail system that connected downtown Salt Lake City with the southern suburb of Sandy and extended light rail service to the University of Utah Health Sciences Center from Rice Eccles Stadium at the University of Utah using existing right-of-way. The existing bus feeder system will make it easy for people to get to and from the 3 new light rail stations. Bridges provide pedestrian access to several of the stations. Of particular interest in the design of the new extension was the priority given to transit in traffic management techniques to ensure high-quality service. Motorists will have to navigate through what is described as a "large roundabout" at the intersection of South Campus and Campus Center drives, a traffic feature already in operation for several months prior to the opening of the line. The roundabout, fortified with several gates, is cited by UTA officials as the only one in the country with trains running through it. The Medical Center Extension Light Rail consists of:

- 1.5-mile overhead catenary branch line, connecting Main Street with Rice Eccles Stadium at the University of Utah.
- 3 new light rail stations.

Project Financial and Schedule Information

Original Total Awarded Value of project: \$95 million
 Final Total Awarded Value of project: \$89.4 million
 Project Schedule:

Preliminary Design Contract Awarded: 2000
 DB Project Advertised: 2000
 Contract Award: June 2001
 Original Project Delivery Period: 2 years 2 months*
 Final Project Delivery Period: 1 year 5 months*
 *Combined time for this and University Line Project

Project Delivery Method Decision Rationale

Agency Project Delivery Experience

Design-Bid-Build: More than 10 projects; 11-25% of typical budget
 Construction Manager-at-Risk: 1 to 5 projects; >50% of typical budget
 Design-Build: 1 to 5 projects; 11-25% of typical budget

Agency Project Delivery Decision-making Process: Convened a workshop that evaluated each possible project delivery method against stated project goals. Conducted formal risk analysis based on input from both the design and construction communities.

Reasons for Selecting Project Delivery Method (*most significant reason*)

- Reduce/ compress/ accelerate project delivery period*
- Establish project budget at an early stage of design development
- Get early construction contractor involvement
- Encourage innovation
- Facilitate Value Engineering
- Flexibility needs during construction phase
- Complex schedule that had to be done by the 2002 Winter Olympics

Workforce-Related Reasons for Selecting Project Delivery Method

Chose DB to both augment existing staff and be able to decrease the size of the agency’s full-time staff.

Table 3-14 - Case Study Project Issues

Issues	Project-level	Agency-level	Public Policy/ Regulatory	Life Cycle	Other
Considered a <i>Benefit</i> of the Chosen Delivery System to this Project	-Project Size -Risk management -Risk allocation -Schedule -Cost	-Staffing required -Staff capability -Agency goals & objectives	-Competition -DBE/small business impact -Stakeholder/ community input	None	-Construction claims -Adversarial relationship between project participants
Remarks on Above Benefits				Sustainability issues were not considered nor required	No construction claims on this project
Considered a <i>Constraint</i> of the Chosen Delivery System to this Project	None	-Agency experience* -Staff capability -Agency control of project -Third party agreement	-Fed/State/ Local laws* -Labor unions -FTA/EPA regulations.	None	None
Remarks on Above Constraints		*Agency had no previous DB experience	*New DB law had to be passed for the project		
Summary Remarks	Schedule considerations drove this project’s delivery method decision.				

Case Study Project Risk Analysis Process

Formal Risk Analysis Areas: Project Schedule

Project Cost Estimate Uncertainty Analysis: None

Risk Identification Techniques Used: Brainstorming, Scenario Planning, Expert Interviews

Risk Assessment Techniques: Qualitative risk assessment only; discussed schedule options and risks in detail

Risk Management Techniques: Risk register/charter, risk management plan, and risk mitigation plan.

Risk Technique used to Draft Contract: Risk assignment in contract, mainly clarifying those risks that the owner would retain.

*Case Study Project Procurement Process Summary***Table 3-15 - Procurement Phase Summary**

Required Elements of the Proposal	Evaluated for award decision	Remarks
Qualifications of the Project Manager	Yes	
Qualifications of the Designer-of-Record	Yes	
Past performance record on similar projects	Yes	
Proposed schedule	Yes	
Proposed schedule milestones	Yes	
Lump sum price	Yes	
Schedule of values	Yes	
Qualifications of the Project Quality Manager	Yes	
Qualifications of the Design Quality Manager	Yes	
Qualifications of the Construction Quality Manager	Yes	
Construction quality assurance plan	Yes	
Construction quality control plan	Yes	
Independent quality assurance	Yes	

Technical Elements of the Solicitation Package (RFQ/RFP): Solicitation package included the following elements:

- None listed on questionnaire

Table 3-16 - Design Phase Summary

Responsibility allocation for design management tasks	Agency personnel	Design-builder's design staff	Design-builder's construction staff	Agency-hired consultant
Technical review of design deliverables		✓		
Checking of design calculations		✓		
Checking of design quantities		✓		
Acceptance of design deliverables	✓			
Review of specifications		✓		
Approval of construction documents	✓	✓		
Approval of payments for design progress	✓			✓
Approval of post-award design QA/QC plans	✓			

Table 3-17 - Construction Phase Summary

Responsibility allocation for construction management tasks	Agency personnel	Design-builder's design staff	Design-builder's construction staff	Agency-hired consultant
Technical review of construction shop drawings		✓		
Technical review of construction material submittals		✓		
Review of construction schedule	✓		✓	✓
Checking of pay quantities				
Routine construction inspection			✓	✓
Quality control testing			✓	
Establishment of horizontal and vertical control on site			✓	
Verification/acceptance testing			✓	✓
Approval of progress payments for construction progress			✓	✓
Approval of construction post-award QA/QC plans	✓			

Quality Management Summary

QA/QC Plans: Different than the ones used in traditional DBB projects. The design-builder has more responsibility for QA/QC

Use of mandated agency quality management plans: Required the design-builder to develop a QA/QC plan that followed the agency's published standard. Established a standard for the primary quality manager's qualifications.

Case 5 — Greenbush Commuter Rail

Project Information

Project Name: Greenbush Commuter Rail Project (Braintree to Scituate, Massachusetts)
 Name of Agency: Massachusetts Bay Transportation Authority (a Public Transit Agency)
 Location: Boston, Massachusetts
 Delivery Method: Design-Build

Project Description

Greenbush is the first Design-Build project undertaken by the Massachusetts Bay Transportation Authority (MBTA). The design-builder was given a conceptual design and was required to complete the design and furnish the construction according to performance based specification supplied by the owner. This commuter rail line “begins at the connection with the existing MBTA Old Colony Main Line at the Braintree Wye in East Braintree” and goes through the towns of Braintree, Weymouth, Hingham, Cohasset and Scituate in heavily settled area in Massachusetts.

Project experienced a two year delay (as-planned duration was 3 years while the actual duration is 5 years) due to Mass DEP Wetlands permits not being issued prior to design-build contract award. Another major delaying factor was property acquisition with respect to CSX (private railroad company) land.

The Greenbush Commuter Rail project will:

- Form 18 miles in a corridor of “former New Haven Railroad Greenbush Branch to the terminus in the Greenbush section of Scituate.”
- Build 7 new commuter rail stations.
- Provide approximately 3,000 parking spaces along the corridor.
- Be a “quiet zone”.
- Start operating in 2007 according to the schedule.

Project Financial and Schedule Information

Original Total Awarded Value of project (DB contract): \$252 million

Final Total Awarded Value of project (DB contract): \$300+ million; currently total project budget exceeds \$512 million.

Project Schedule:

Preliminary Design Contract Awarded: 2001

DB Project Advertised: 2002

Contract Award: June 2002

Original Project Delivery Period: 3 years

Final Project Delivery Period: 5 years*

*2 year delay due to wetlands permits and rising project costs.

Expected completion date: May 2007 (Actual completion date: September 2007)

*Project Delivery Method Decision Rationale***Agency Project Delivery Experience**

Design-Bid-Build: More than 10 projects; >50% of typical budget

Construction Manager-at-Risk: none

Design-Build: 1 to 5 projects; 11-25% of typical budget

Agency Project Delivery Decision-making Process: MBTA decided to aggressively press for early completion of this project. In their words: “Force the project along! We would have been designing forever with all the towns involved in this project.”

Reasons for Selecting Project Delivery Method (*most significant reason*)

Reduce/ compress/ accelerate project delivery period

Establish project budget at an early stage of design development

Get early construction contractor involvement

Encourage innovation

Facilitate Value Engineering

Encourage price competition (bidding process)

Redistribute risk

Flexibility needs during construction phase

Workforce-Related Reasons for Selecting Project Delivery Method

No workforce issues were considered in the project delivery method decision.

Table 3-18 - Case Study Project Issues

Issues	Project-level	Agency-level	Public Policy/ Regulatory	Life Cycle	Other
Considered a <i>Benefit</i> of the Chosen Delivery System to this Project	-Risk management -Risk allocation*	-Agency goals & objectives		-Sustainable design/goals -Sustainable construction/goals	
Remarks on Above Benefits	*All risk was more or less transferred to contractor.				
Considered a <i>Constraint</i> of the Chosen Delivery System to this Project	None	-Agency experience* -Staff capability -Agency control of project -Third party agreement	-Fed/State/Local laws* -FTA/EPA regulations.*	None	-Construction claims* -Adversarial relationship between project participants** -Specs need to be more explicit
Remarks on Above Constraints		*Agency had no previous DB experience	*Lots of problems with State/Local laws and EPA regulations		*Contractor has put in a lot of claims, claiming “scope change.” ** Adversarial relationships existed, even within DB team
Summary Remarks	Lack of prescriptive specs has caused MBTA to not get exactly things that they wanted.				

*Case Study Project Risk Analysis Process***Formal Risk Analysis Areas:** None**Project Cost Estimate Uncertainty Analysis:** None**Risk Identification Techniques Used:** None**Risk Assessment Techniques:** None**Risk Management Techniques:** None**Risk Technique used to Draft Contract:** None

*Case Study Project Procurement Process Summary***Table 3-19 - Procurement Phase Summary**

Required Elements of the Proposal	Evaluated for award decision	Remarks
Qualifications of the Project Manager	Yes	
Qualifications of the Designer-of-Record	Yes	
Proposed schedule	Yes	
Lump sum price	Yes	
Schedule of values	Yes	
Qualifications of the Project Quality Manager	Yes	
Design submittals	Yes	

Technical Elements of the Solicitation Package (RFQ/RFP): Solicitation package included the following elements:

- Standard guide specifications

Table 3-20 - Design Phase Summary

Responsibility allocation for design management tasks	Agency personnel	Design-builder's design staff	Design-builder's construction staff	Agency-hired consultant
Technical review of design deliverables	✓	✓	✓	✓
Checking of design calculations		✓		
Checking of design quantities				
Acceptance of design deliverables			✓	
Review of specifications	✓		✓	✓
Approval of construction documents	✓		✓	✓
Approval of payments for design progress	✓		✓	
Approval of post-award design QA/QC plans	✓		✓	✓

Table 3-21 - Construction Phase Summary

Responsibility allocation for construction management tasks	Agency personnel	Design-builder's design staff	Design-builder's construction staff	Agency-hired consultant
Technical review of construction shop drawings		✓		
Technical review of construction material submittals		✓		
Review of construction				✓

schedule				
Checking of pay quantities	✓			
Routine construction inspection	✓		✓	
Quality control testing	✓		✓	
Establishment of horizontal and vertical control on site			✓	
Verification/acceptance testing	✓			✓
Approval of progress payments for construction progress	✓			
Approval of construction post-award QA/QC plans	✓			✓

Quality Management Summary

QA/QC Plans: Essentially the same as the ones used in traditional DBB projects.

Use of mandated agency quality management plans: Required the design-builder to develop a QA/QC plan that followed the agency's published standard.

Case 6 — Hudson Bergen Light Rail

Project Information

Project Name: Hudson Bergen Light Rail (HBLR) Minimum Operable Segment (MOS)2
Name of Agency: New Jersey Transit Authority (a Public Transit Agency)
Location: Hudson, New Jersey
Delivery Method: Design-Build-Operate-Maintain

Project Description

The Hudson-Bergen Light Rail Transit System (HBLRTS) is a 20.3-mile light rail project that connects the densely populated New Jersey's Hudson River waterfront communities. The project also supports significant economic development that continues to take place in the region. The HBLRTS is being built in three Minimum Operable Segments (MOS). The first Minimum Operable Segment (MOS1) runs from 34th Street in Bayonne to Hoboken Terminal. MOS2 runs from Hoboken Terminal to Tonnel Avenue in North Bergen, with an additional southern extension to 22nd St. in Bayonne. MOS3 will run from 22nd St. to 8th St. in Bayonne. Project budget/cost is as follows:

MOS1: \$992 million

MOS2: \$1.2 billion

MOS3: \$89 million

HBLRTS is funded by a combination of federal and state transportation funds. Construction of MOS1 and MOS2 is complete and operational. Design work for MOS3 is underway. Design work for MOS3 is scheduled for completion in January 2008.

The DBOM contract for the MOS 2 consisted of:

- Six miles of tracks including a 4100 foot tunnel with station access to street level 160 ft above the Hudson Bergen Light Rail.
- Seven new light rail stations.

Project Financial and Schedule Information

Original Total Awarded Value of project: \$554 million

Final Total Awarded Value of project: \$611 million

Project Schedule:

Preliminary Design Contract Awarded: 2000

DB Project Advertised: N/A; this was issued as a change order to the MOS1 DBOM contract

Contract Award: June 2001

Original Project Delivery Period: 6 years

Final Project Delivery Period: 6 year 2 months

Project Delivery Method Decision Rationale

Agency Project Delivery Experience

- Design-Bid-Build: More than 10 projects; >50% of typical budget
- Construction Manager-at-Risk: None
- Design-Build: 1 to 5 projects; <10% of typical budget
- Design-Build-Operate-Maintain: 1 to 5 projects; 26-50% of typical budget

Agency Project Delivery Decision-making Process: At the beginning the project was supposed to be a part of FTA turnkey demonstration but NJ transit decided not to do so. Another option was DBB. However, the agency felt that DBOM was an effective way to push the project through in the face of issues from various towns and third party stakeholders. If the project used the traditional DBB, there were many more stages where opposition from various parties could have delayed the project and possibly prevented its construction.

Reasons for Selecting Project Delivery Method (*most significant reason*)

- Reduce/ compress/ accelerate project delivery period*
- Establish project budget at an early stage of design development
- Get early construction contractor involvement
- Encourage innovation
- Redistribute risk
- Complex project requirements
- Reduce life cycle costs (by integrating operations and maintenance)
- Provide mechanism for follow-on operations and/or maintenance

Workforce-Related Reasons for Selecting Project Delivery Method

Chose DB to both augment existing staff and be able to decrease the size of the agency’s full-time staff.

Table 3-22 - Case Study Project Issues

Issues	Project-level	Agency-level	Public Policy/ Regulatory	Life Cycle	Other
Considered a <i>Benefit</i> of the Chosen Delivery System to this Project	-Project Size -Risk management -Risk allocation* -Schedule -Cost	-Staff capability -Agency goals & objectives	-DBE/small business impact*	-Life cycle cost Maintainability	-Construction claims*
Remarks on Above Benefits	*Fewer claims about differing site conditions.		* DBE goals in the RFP were achieved successfully. 50% subcontracting was mandated to ensure participation by local contractors.		*Fewer claims about differing site conditions. It can be great or terrible based on the characteristics of the contractor

Considered a <i>Constraint</i> of the Chosen Delivery System to this Project	None	-Staffing required* -Agency control of project** -Third party agreement***	-Competition* -Fed/State/ Local laws**	None	None
Remarks on Above Constraints		*Less staff employed because O&M was out sourced. The agency did not have a CM which proved to be a disadvantage. ** Agency had less control but that was not necessarily bad in this project. ***Third party agreements (real estate and utilities) were similar to ones used for DBB.	*Tying OM to DB reduces the # of bidders in general. There were 2 final bidders for this project. **Enough design should be done so that the owner can get the permits not the DB contractor. DBOM helped the project push through.		
Summary Remarks	Another advantage of DBOM was that at the time of the agreement between all the parties, the maximum level of contractual obligation is signed. In other words, all parties have obligated themselves not only for the construction but also for 15 years of O&M. This decreases the probability of facing barriers in different steps of project life cycle and facilitates the O&M specially because there is no need to ask for O&M budget annually.				

Case Study Project Risk Analysis Process

Formal Risk Analysis Areas: None

Project Cost Estimate Uncertainty Analysis: Yes

Risk Identification Techniques Used: Brainstorming, cost ranges were developed, but no modeling. Independent cost estimates were prepared by an outsider after the bids were opened.

Risk Assessment Techniques: None

Risk Management Techniques: Risk register/charter, risk management plan

Risk Technique used to Draft Contract: White papers were prepared and reviewed by industry who provided input.

Case Study Project Procurement Process Summary

Table 3-23 - Procurement Phase Summary

Required Elements of the Proposal	Evaluated for award decision	Remarks
Qualifications of the Project Manager	Yes	
Qualifications of the Designer-of-Record	Yes	
Past performance record on similar projects	Yes	
Proposed schedule	Yes	
Proposed schedule milestones	Yes	
Lump sum price	Yes	
Qualifications of the Design Quality Manager	Yes	
Qualifications of the Construction Quality Manager	Yes	
Construction quality assurance plan	Yes	
Construction quality control plan	Yes	
Independent quality assurance	No	With 15-year O&M contract, no need was felt.

Technical Elements of the Solicitation Package (RFQ/RFP): Solicitation package included the following elements:

- Design criteria checklists (*Manual of Design Criteria*)
- Standard design details
- Standard guide specifications

Table 3-24 - Design Phase Summary

Responsibility allocation for design management tasks	Agency personnel	Design-builder's design staff	Design-builder's construction staff	Agency-hired consultant
Technical review of design deliverables	✓	✓	✓	✓
Checking of design calculations	✓	✓		✓
Checking of design quantities	✓	✓	✓	
Acceptance of design deliverables	✓			✓
Review of specifications	✓	✓	✓	✓
Approval of construction documents	✓	✓	✓	✓
Approval of payments for design progress	✓			
Approval of post-award design QA/QC plans	✓			

Table 3-25 - Construction Phase Summary

Responsibility allocation for construction management tasks	Agency personnel	Design-builder's design staff	Design-builder's construction staff	Agency-hired consultant
Technical review of construction shop drawings	✓	✓	✓	✓
Technical review of construction material submittals	✓	✓	✓	✓
Review of construction schedule	✓			✓
Checking of pay quantities	✓		✓	✓
Routine construction inspection			✓	
Quality control testing	✓		✓	
Establishment of horizontal and vertical control on site			✓	
Verification/acceptance testing	✓	✓	✓	✓
Approval of progress payments for construction progress	✓			
Approval of construction post-award QA/QC plans	✓			

Quality Management Summary

QA/QC Plans: Similar to the ones used in traditional DBB projects.

Use of mandated agency quality management plans: specify what must be included in the design-builder's QA/QC plan.

Case 7 — Silver Line Project

Project Information

Project Name: Silver Line Busway/South Boston Piers Transitway Phase II.

Name of Agency: Massachusetts Bay Transportation Authority (a Public Transit Agency)

Location: Boston, Massachusetts

Delivery Method: Design-Bid-Build Multi-Prime with MBTA acting as its own CM

Project Description

This project is the second phase of a three-phase Bus Rapid Transit (BRT) system in Boston, MA. The first phase, completed in 2002, consists of at-grade dedicated lanes along Washington Street in downtown Boston with seven stations. Phase II is an underground BRT connecting the MBTA's rapid transit system at South Station to the South Boston Piers area. It consists of an underground tunnel and three stations, two of those, underground. Phase III is in planning stages and will be an extension of the Phase II tunnel.

The Phase II project utilized the NATM mined excavation and ground freezing and mini-piping support under historic buildings in downtown Boston including the Russia Wharf complex. There was also a cut-and-cover tunnel section. The Buses are electric and the tunnel is designed such that it can be converted into Light Rail Transit in the future. Part of the project was executed in coordination with the Central Artery/Tunnel (CA/T) highway project. The Silver Line project will:

- Provide dedicated lanes in downtown Boston
- Build 7 new bus transit stations at grade for the dedicated lane portion.
- Provide 1.5 mile two-way underground tunnel to South Boston Piers area
- Build 3 new stations for the South Boston Piers portion; 2 are underground.
- Include 32 dual mode hybrid diesel-electric buses
- Build a new vehicle maintenance facility.

Project Financial and Schedule Information

Original Total Awarded Value of project: \$601 million

Final Total Awarded Value of project: \$604.4 million

Project Schedule (NOTE: due to multi-prime DBB delivery, there were several design and construction packages. The dates shown below are for the program as a whole):

Preliminary Design Contract Awarded: 1993

First Design/Construction Project Advertised: 1996

Original Project Delivery Period: 4 years

Final Project Delivery Period: 8 years*

*delays due to attributed to coordination problems with the Central Artery/Tunnel (Big Dig) project. The budget was also amended during the project.

Project Delivery Method Decision Rationale

Agency Project Delivery Experience

Design-Bid-Build: More than 10 projects; >50% of typical budget
 Construction Manager-at-Risk: none
 Design-Build: 1 to 5 projects; 11-25% of typical budget

Agency Project Delivery Decision-making Process: Because of the regulations of the state of Massachusetts, the only delivery system available to MBTA was DBB at the time of Silverline. This was a multi-prime project and both the design and the construction of the project were divided to several parts. The MBTA personnel were in charge of coordination of these pieces. A consultant was retained as the master planner and master schedule developer of the project and remained on board during project execution. It should be mentioned that the owner supplied some long-lead items (these were major permanent equipment pieces such as large fans, *etc*) in this project. MBTA also did some of the quality control tests by its own employees

Reasons for Selecting Project Delivery Method (*most significant reason*)

The only method available at the time (alternative project delivery had not yet been authorized)

Workforce-Related Reasons for Selecting Project Delivery Method

No workforce issues were considered in the project delivery method decision.

Table 3-26 - Case Study Project Issues

Issues	Project-level	Agency-level	Public Policy/ Regulatory	Life Cycle	Other
Considered a <i>Benefit</i> of the Chosen Delivery System to this Project		-Agency experience -Agency goals & objectives -Agency control of project*	-DBE/small business impact -Labor Unions -Fed/State/Local laws -FTA/EPA regulations	-Life cycle costs* -Maintainability	
Remarks on Above Benefits	*All risk was more or less transferred to contractor.	*Benefit of DBB is giving a high level of control to the owner. This is not achieved in DB nor in CMR		*No sustainable development issues were seriously considered.	
Considered a <i>Constraint</i> of the Chosen Delivery System to this Project	-Schedule*	-Staffing required -Staff capability	-Competition*	None	-Construction claims -Adversarial relationship between project

					participants
Remarks on Above Constraints	*Schedule shortening was not a priority for this project. The deadline for revenues could be met by phasing the construction and dividing the project and using multiple primes.		* Timing was unfortunate as the CA/T Project was using all available talent in the area. Because of Big Dig everyone was busy, competition not high.		
Summary Remarks					

Case Study Project Risk Analysis Process

- Formal Risk Analysis Areas:** Only for the Russia Wharf, the most complex portion of project
- Project Cost Estimate Uncertainty Analysis:** None
- Risk Identification Techniques Used:** Brainstorming, scenario planning, and expert interviews (not conducted as formal processes)
- Risk Assessment Techniques:** None
- Risk Management Techniques:** None
- Risk Technique used to Draft Contract:** None

Case Study Project Procurement Process Summary

Table 3-27 - Procurement Phase Summary (NOTE: as DBB project, the next table applies only to the design contracts on this project)

Required Elements of the Design Proposal	Evaluated for award decision	Remarks
Qualifications of the Project Manager	Yes	
Qualifications of the Designer-of-Record	Yes	
Proposed schedule	Yes	
Proposed schedule milestones	Yes	
Qualifications of the Design Quality Manager		
Qualifications of the Construction Quality Manager	Yes	

Technical Elements of the Solicitation Package (RFQ/RFP)

None. MBTA has its own design groups that has electrical, mechanical, track, and signal subgroups.

Table 3-28 - Design Phase Summary

Responsibility allocation for design management tasks	Agency personnel	Agency-hired design consultant
Technical review of design deliverables	✓	✓
Checking of design calculations	✓	✓
Checking of design quantities	✓	
Acceptance of design deliverables	✓	
Review of specifications	✓	✓
Approval of construction documents	✓	
Approval of payments for design progress	✓	
Approval of post-award design QA/QC plans	✓	

Table 3-29 - Construction Phase Summary

Responsibility allocation for construction management tasks	Agency personnel	Designer's staff	Builder's construction staff	Agency-hired consultant
Technical review of construction shop drawings	✓	✓		
Technical review of construction material submittals	✓	✓		
Review of construction schedule	✓	✓		✓
Checking of pay quantities	✓			
Routine construction inspection	✓			
Quality control testing	✓		✓	
Establishment of horizontal and vertical control on site		✓		
Verification/acceptance testing	✓	✓		✓
Approval of progress payments for construction progress	✓			
Approval of construction post-award QA/QC plans	✓	✓		

Quality Management Summary

QA/QC Plans: These were a traditional DBB projects.

Use of mandated agency quality management plans: Required the design consultants and construction contractors to develop a QA/QC plan that followed the agency's published standard. Used standards agency specifications and details

Case 8 — Portland Mall Light Rail

Project Information

Project Name: Portland Mall Light Rail Project

Name of Agency: Tri-County Metropolitan Transportation District of Oregon (TriMet) (a Public Transit Agency)

Location: Portland, Oregon

Delivery Method: Construction Manager-at-Risk (Tri-Met uses the term CM/GC)

Project Description

The alignment loops the Portland Mall area from the Portland State University campus in the south to Union Station in the north. This project converts a bus transit mall to a multi-modal facility that incorporates the light rail, bus, auto lanes, and dedicated bicycle lanes. Grade crossings and grade crossing protective devices for the commuter rail line are also being constructed or reconstructed as needed.

The Portland Mall Light Rail Project will include:

- 2 miles of in-street light rail, plus additional lanes for buses, four auto pullouts for business delivery services and auto and bike access in left-side lanes separated by a rumble strip to ensure safe service.
- 14 stations and bus stops.
- Improvements to the Burnside intersections at 5th and 6th avenues will enhance traffic flow on these two streets.
- Revitalize the Mall for retail businesses, pedestrians, cyclists and autos by renovating the streetscape and adding amenities, art and upgraded shelters.
- 24 new light rail vehicles (with I-205 Extension project) (not part of the CM/GC contract).

Project Financial and Schedule Information

Original Total Awarded Value of project (CMR contract): \$143.8 million

Final Total Awarded Value of project: \$143.8 million (note: includes \$846,000 Preconstruction Services fee for CM)

Project Schedule:

Preliminary design contract award: 2004

Initial Advertising: May 2005

Final design contract award: October 2005

Construction contract award: June 2005

Original Project Delivery Period: 4 years

Final Project Delivery Period: 4 years

Expected completion (revenue operation date): September 30, 2009

Project Delivery Method Decision Rationale

Agency Project Delivery Experience

- Design-Bid-Build: More than 10 projects; 26-50% of typical budget
- Construction Manager-at-Risk: 6 to 10 projects; >50% of typical budget
- Design-Build: 1 to 5 projects; 26-50% of typical budget

Agency Project Delivery Decision-making Process: Developed a pro forma. Examined it and established public findings with regard to project complexity. Applied for and received a state exemption from low bid requirements. Input from internal sources only.

Reasons for Selecting Project Delivery Method (*most significant reason*)

- Complex project requirements*
- Establish project budget at an early stage of design development
- Get early construction contractor involvement
- Encourage innovation
- Facilitate Value Engineering
- Redistribute risk
- Flexibility needs during construction phase

Workforce-Related Reasons for Selecting Project Delivery Method

No workforce reasons were involved in the selection decision.

Table 3-30 - Case Study Project Issues

Issues	Project-level	Agency-level	Public Policy/ Regulatory	Life Cycle	Other
Considered a <i>Benefit</i> of the Chosen Delivery System to this Project	-Project Size -Risk management -Risk allocation -Schedule -Cost -Site*	-Agency experience -Staffing required -Agency goals & objectives -Agency control of project -Third party agreements*	-DBE/small business impact -Benefits & impacts -Stakeholder/community input	- Sustainable construction/goals*	-Construction claims* -Adversarial relationship between project participants
Remarks on Above Benefits	*Complex urban site coordination a big benefit	* TriMet does its own permits and ROW		*Sustainability was not considered on this project	* No claims on the project.
Considered a <i>Constraint</i> of the Chosen Delivery System to this Project	None	-Staff capability*	-Competition* -Fed/State/Local laws** -FTA/EPA regulations.	None	Lack of competition on self-performed work—track work.
Remarks on		*Lacked CMR	*Lack of		

Above Constraints		experience	competition on track-work **Need state waiver from low bid reg.		
Summary Remarks	Very satisfied with CMR project delivery. No reason to use DBB on future complex projects like this one.				

Case Study Project Risk Analysis Process

Formal Risk Analysis Areas: Schedule and Cost per FTA procedures

Project Cost Estimate Uncertainty Analysis: Yes

Risk Identification Techniques Used: Brainstorming, scenario planning, and influence diagramming. Also used Monte Carlo simulations.

Risk Assessment Techniques:

Qualitative risk assessment using FTA “Top-down” technique for cost categories with Beta factors supplied by FTA

Quantitative risk assessment using Monte Carlo simulation and expected value analysis.

Risk Management Techniques: Risk register/charter, risk management plan, and risk mitigation plan.

Risk Technique used to Draft Contract: Risk management plan used to draft “Commercial Risk Table” in contract that quantifies cost risk for each area and assigns the risk to either TriMet or the CMR.

Case Study Project Procurement Process Summary

Table 3-31 - Procurement Phase Summary

Required Elements of the Proposal	Evaluated for award decision	Remarks
Qualifications of the Project Quality Manager	Yes	
Qualifications of the Construction Quality Manager	Yes	
Past performance record on similar projects	Yes	
Design constructability review plan	Yes	
Design cost engineering review plan	Yes	
Construction quality management plan	Yes	
Construction quality control plan	Yes	

Technical Elements of the Solicitation Package (RFQ/RFP)

- Cost engineering review checklists
- Quality management roles and responsibilities

Table 3-32 - Design Phase Summary

Responsibility allocation for design management tasks	Agency personnel	Designer's design staff	CM pre-construction staff	Agency-hired consultant
Technical review of design deliverables	✓	✓	✓	
Checking of design calculations	✓	✓		
Checking of design quantities	✓	✓	✓	
Cost engineering reviews	✓	✓	✓	
Constructability reviews			✓	
Acceptance of design deliverables	✓	✓		
Review of specifications	✓	✓	✓	
Approval of construction documents	✓			
Approval of payments for design progress	✓			
Approval of post-award design QA/QC plans	✓			

Table 3-33 - Construction Phase Summary

Responsibility allocation for construction management tasks	Agency personnel	Designer's design staff	CM construction staff	Agency-hired consultant
Technical review of construction shop drawings	✓	✓		
Technical review of construction material submittals	✓	✓		
Review of construction schedule	✓			
Checking of pay quantities	✓			
Routine construction inspection	✓	✓	✓	
Quality control testing			✓	
Establishment of horizontal and vertical control on site		✓	✓	
Verification/acceptance testing	✓		✓	
Approval of progress payments for construction progress	✓			
Approval of construction post-award QA/QC plans	✓			

Quality Management Summary

QA/QC Plans: Same as ones used in traditional DBB projects.

Use of mandated agency quality management plans: TriMet requires the CMR to develop and implement a plan that is in accordance with its standard QA/QC guidelines. Also mandates the use of standard specifications and design details for system compatibility purposes.

Case 9 — I-205 Light Rail Extension

Project Information

Project Name: I-205 Light Rail Extension Project

Name of Agency: Tri-County Metropolitan Transportation District of Oregon (TriMet) (a Public Transit Agency)

Location: Portland, Oregon

Delivery Method: Design-Build

Project Description

The I-205 MAX Light Rail Extension Project connects Clackamas County, one of the region's fastest growing areas, with Portland State University (PSU), in conjunction with the Portland Mall Light Rail Project. The 8.3-mile light rail extension also is a critical element in the long-range transportation plan, positioning the region for future light rail extensions to Milwaukie, Vancouver and to the southwest. It will have eight new stations and five Park & Ride lots providing approximately 2,200 spaces. Station design and placement will enhance transit access by connecting MAX to bus service all along this corridor, including 10 bus lines at Clackamas Town Center. The line's design will emphasize rider and pedestrian safety. Extensive community input and support has made light rail the preferred transportation option along the I-205 corridor. The construction of the I-205 segment will take place largely along an existing transitway, which lends itself to a design-build construction approach. This allows the contractor to complete the design while the alignment is being built, making it faster and less expensive. The I-205 Light Rail Extension Project will include:

- 8.3 miles of light rail in existing transitway.
- 8 stations
- 5 Park & Ride lots.
- 24 new light rail vehicles (with Portland Mall project).

Project Financial and Schedule Information

Original Total Awarded Value of project (DB contract): \$163.8 million

Final Total Awarded Value of project: \$163.8 million

Project Schedule:

Preliminary design contract award: 2004

Initial Advertising: July 2005

Final design-build contract award: November 2005

Original Project Delivery Period: 4 years

Final Project Delivery Period: 4 years

Expected completion (revenue operation date): September 30, 2009

Project Delivery Method Decision Rationale

Agency Project Delivery Experience

- Design-Bid-Build: More than 10 projects; 26-50% of typical budget
- Construction Manager-at-Risk: 6 to 10 projects; >50% of typical budget
- Design-Build: 1 to 5 projects; 26-50% of typical budget

Agency Project Delivery Decision-making Process: Developed a pro forma. Examined it and established public findings with regard to project complexity. Applied for and received a state exemption from low bid requirements. Input from internal sources only.

Reasons for Selecting Project Delivery Method (*most significant reason*)

- Establish project budget at an early stage of design development*
- Reduce/compress/accelerate project schedule
- Get early construction contractor involvement
- Redistribute risk
- Complex project requirements

Workforce-Related Reasons for Selecting Project Delivery Method

No workforce reasons were involved in the selection decision.

Table 3-34 - Case Study Project Issues

Issues	Project-level	Agency-level	Public Policy/ Regulatory	Life Cycle	Other
Considered a <i>Benefit</i> of the Chosen Delivery System to this Project	-Project Size -Risk management -Risk allocation -Schedule -Cost	-Staffing required	-DBE/small business impact -Labor unions -Stakeholder/community input*	None	-Adversarial relationship between project participants
Remarks on Above Benefits			*Design-builder PM able to be involved	Sustainability issues were not considered nor required	No construction claims on this project so far
Considered a <i>Constraint</i> of the Chosen Delivery System to this Project	-LEED certification*	-Agency experience -Staff capability* -Agency control of project -Third party agreement	-Competition* -Fed/State/Local laws FTA/EPA regulations.	-Life cycle cost -Maintainability -Sustainable design/goals -Sustainable construction/goals	-Construction claims*
Remarks on Above Constraints	*Need to have greater scope definition to achieve LEED at an earlier time than this	*Difficult to train staff with no previous DB experience	*Fewer bidders	DB moves too fast to incorporate these in initial RFP	*Early pricing leaves owner exposed to potential claims for scope not

	DB project had				included in RFP
Summary Remarks	TriMet did not mandate a requirement for sustainability. Rather it asked for sustainable design and construction features to be proposed by the design-builder as a betterment.				

Case Study Project Risk Analysis Process

Formal Risk Analysis Areas: Schedule and Cost per FTA procedures

Project Cost Estimate Uncertainty Analysis: Yes

Risk Identification Techniques Used: Brainstorming, scenario planning, and influence diagramming. Also used Monte Carlo simulations.

Risk Assessment Techniques:

Qualitative risk assessment using FTA “Top-down” technique for cost categories with Beta factors supplied by FTA

Quantitative risk assessment using Monte Carlo simulation and expected value analysis.

Risk Management Techniques: Risk register/charter, risk management plan, and risk mitigation plan.

Risk Technique used to Draft Contract: Risk management plan used to draft “Commercial Risk Table” in contract that quantifies cost risk for each area and assigns the risk to either TriMet or the Design-builder.

Case Study Project Procurement Process Summary

Table 3-35 - Procurement Phase Summary

Required Elements of the Proposal	Evaluated for award decision	Remarks
Qualifications of the Project Manager	Yes	
Qualifications of the Designer-of-Record	Yes	
Past performance record on similar projects	Yes	
Proposed schedule	No	Schedule fixed by RFP
Proposed schedule milestones	No	
Lump sum price	No	Price competition was fixed fee with costs to be negotiated after award
Schedule of values	No	
Unit Prices	No	
Qualifications of the Project Quality Manager	Yes	
Qualifications of the Design Quality Manager	Yes	
Qualifications of the Construction Quality Manager	Yes	
Construction quality assurance plan	Yes	
Construction quality control plan	Yes	
Proposed sustainable design/construction	Yes	Sustainability treated as a betterment

Technical Elements of the Solicitation Package (RFQ/RFP)

Design criteria checklists

Standard design details

Standard guide specifications

Table 3-36 - Design Phase Summary

Responsibility allocation for design management tasks	Agency personnel	Design-builder's design staff	Design-builder's construction staff	Agency-hired consultant
Technical review of design deliverables	✓	✓	✓	
Checking of design calculations		✓		
Checking of design quantities	✓	✓	✓	
Acceptance of design deliverables	✓			
Review of specifications	✓	✓	✓	
Approval of construction documents	✓			
Approval of payments for design progress	✓			
Approval of post-award design QA/QC plans	✓			

Table 3-37 - Construction Phase Summary

Responsibility allocation for construction management tasks	Agency personnel	Design-builder's design staff	Design-builder's construction staff	Agency-hired consultant
Technical review of construction shop drawings	✓	✓		
Technical review of construction material submittals	✓	✓		
Review of construction schedule	✓			
Checking of pay quantities	✓			
Routine construction inspection	✓		✓	
Quality control testing			✓	
Establishment of horizontal and vertical control on site		✓	✓	
Verification/acceptance testing	✓		✓	
Approval of progress payments for construction progress	✓			
Approval of construction post-award QA/QC plans	✓			

Quality Management Summary

QA/QC Plans: Different than the ones used in traditional DBB projects. The design-builder has more responsibility for QA/QC

Use of mandated agency quality management plans: Required the design-builder to develop a QA/QC plan that followed the agency's published standard. Established a standard for the primary quality manager's qualifications.

CHAPTER 4 – FINDINGS AND LESSONS LEARNED

Introduction

This chapter explains some of the trends found in the case studies. The trends that are apparent will be explained in the same format as the case study project matrix. This permits the reader to easily cross-reference these trends and gain additional detail if so desired.

Project Identification Data

The trend that seems to be apparent in this section deals with the breadth of project delivery experience that was inherent to the respondents. Three (Colorado, Utah, and Oregon) of the five agencies that were interviewed had actual experience with DBB, CMR, and DB project delivery. The two east coast agencies had experience with DBB and DB. Only the New Jersey Transit Authority had experience with post-construction operations and maintenance. Thus, the conclusions drawn from qualitative data regarding the differences between the various project delivery systems can be considered authoritative in that the respondents have a strong experiential basis from which to derive the opinions that they expressed in the structured interviews.

Project Scope Data

All but one of the projects (Utah Medical Center) that were interviewed, were larger than \$100 million. Thus, these are megaprojects as defined in the literature.⁶ It appears from this data set that alternative project delivery seems to furnish a viable solution for delivering large transit projects. While the data set is not large enough to confirm it, this leads to an inference that alternative project delivery furnishes a means to complete large projects in a manner that does not require the agency to expand its internal workforce.

Project Financial and Schedule Data

This category contained the quantitative performance data of interest. While the goal of the case studies is not to attempt to link the project delivery method to financial and schedule performance (because of limited number of case studies), a number of project outcomes can be noted. When

⁶ See Memo of Major Project Guidance from FHWA Administrator J. Richard Capka to the Division administrators dated January 19, 2007 (<http://www.fhwa.dot.gov/programadmin/mega/011907.cfm> viewed February 21, 2007). See also the FHWA Major Projects web site (<http://www.fhwa.dot.gov/programadmin/mega/index.cfm> viewed February 21, 2007) and the FHWA Contract Administration web site for more information (<http://www.fhwa.dot.gov/programadmin/contracts/index.cfm> viewed February 21, 2007).

combined with the literature review regarding the financial and schedule performance of the delivery methods, these outcomes provided useful anecdotal evidence for the final guidebook.

The data regarding alternative project delivery's impact on project schedule is very definitive for this group of projects. Only one of the DB projects was completed behind its original schedule. When the two-year delay incurred on the Greenbush Commuter Rail project mostly due to wetland permits is taken into account, that project was delivered in the three-year period originally planned. Using Yin's principle of multiple sources in case study analysis (Yin 2003), one can combine this with the findings of a recent report to the US Congress by the Federal Highway Administration (FHWA) analyzing the performance of over 300 highway projects delivered using DB. That report recommends that the public agency not award the DB contract until all necessary permits and environmental clearances have been obtained (FHWA 2006). Thus, the Greenbush case confirms that recommendation by the delay it experienced by awarding its DB contract prior to receiving environmental clearance from third-party stakeholders. Looking at the DB projects, the five projects either finished or are on track to finish on average of 5% ahead of schedule. If one takes the Greenbush project out of the sample, the average is 23% ahead of schedule. Thus, it seems that implementing DB on transit megaprojects accrues a measurable benefit in terms of compressing the project delivery period if the agency ensures that critical permitting actions are cleared before the DB contract is awarded. The CMR projects had a similar result in being able to compress the project delivery period, but to a more modest degree. This would be expected in that these projects rely on cooperation between the designer and the construction manager during the design phase and would typically not have the ability to overlap design and construction activities to the degree of a DB project where both the design and the construction are obtained from a single entity. These results are generally consistent with the Konchar and Sanvido finding for project delivery schedule performance on building projects (Konchar and Sanvido 1998).

Looking at the financial side of the case study projects, four of the nine projects finished under or within budget (the Utah and Oregon projects). Two others, Weber County and T-REX, had cost growth that was attributable to a conscious decision by the agency to add scope to a project that was going well. The average cost growth for all the projects in the sample was a +6% with a range of –6% to +23%. If one drops the two projects where the cost growth was due to scope additions (T-REX and Weber County) the average is +3% cost growth. This compares very favorably to a recent study of transit project cost growth published by the Transportation Research Board (Booz.Allen 2006) which found average cost growth between Final Design and Operation phases on 28 US transit projects completed between 1989 and 2005 to be in the order of +12.2%. It should be noted that the TRB study sample population included projects delivered using alternative project delivery methods.

It is difficult to reach any conclusions regarding the Massachusetts DBB Multi-Prime case study project with regard to schedule. The project used a multi-prime approach so that they can overlap some design and construction activities and shorten the duration. While the project had some of its own issues, it was also impacted by the need to coordinate its work with the Boston Central Artery/Tunnel project which finished “five years late and billions over budget” (AP 2003).

Thus, it appears that alternative project delivery methods are effective in furnishing a mechanism for compressing the project schedules. These delivery methods are also effective in creating an environment of greater cost certainty, an inference confirmed in one of the interviews. Don Irwin, former TriMet project director and a consultant on the Weber County Rail project stated that “early

budget certainty is the most important benefit of alternative project delivery.” In other words, while using these methods does not eliminate cost growth, it seems to reduce it giving the owner a greater ability to control growth as it occurs, or to decide to add scope after award when the construction costs have been quantified.

Project Delivery Method Decision Rationale

The structured interview technique was particularly well-suited for collecting valuable information in this category. The respondents were very open and forthright about not only sharing their rationale but also in giving the researchers the detailed explanation behind it. The first part of this section sought to determine what experience the interviewees had upon which to base their decision to employ the various project delivery options. As it turned out, all the respondents, save the Silver Line, had experience with both DBB and DB. Additionally, the Colorado, Oregon, and Utah agencies also had CMR experience.

Next, the agencies were asked to state their reasons for selecting a given project delivery method indicating the most important one. They were given the following list of possible reasons:

- Reduce/compress/accelerate project delivery period
- Establish project budget at an early stage of design development
- Get early construction contractor involvement
- Encourage innovation
- Facilitate Value Engineering
- Encourage price competition (bidding process)
- Compete different design solutions through the proposal process
- Redistribute risk
- Complex project requirements
- Flexibility needs during construction phase
- Reduce life cycle costs
- Provide mechanism for follow-on operations and/or maintenance
- Innovative financing
- Other

Reducing/compressing/accelerating the project delivery period was the reason cited by all but one agency for the alternative project delivery case study projects. The Silver Line project respondent indicated that DBB-Multi-Prime was selected because it was the only available delivery option at the time the project was formulated. The agency did not have authority to use DB or CMR. The TREX project provides an excellent example of this schedule savings. The Regional Transportation District and the Colorado Department of Transportation estimated before the project started that DB was saving a number of years when compared to a DBB schedule and then the DB contractor finished the project significantly ahead of the contracted schedule for completion. This qualitative finding tracks directly with the quantitative finding regarding schedule compression discussed in the previous section and an early study found in the literature (Songer and Molenaar 1996) which reported that schedule reduction was the major reason owners selected DB. This convergence of three separate lines of research serves to validate the inference per Yin’s model (2003). This was also cited as the *most important* reason for selecting the given project delivery method in most of the cases.

Thus, the agencies are looking to alternative project delivery to achieve aggressive schedules and are apparently being successful in realizing a quantifiable benefit from the decision.

“Encourage innovation” was also cited by the majority of the interviewees as being a reason why they selected the project delivery method that they did for their given project. The literature generally touts this aspect when discussing alternative project delivery. Follow-up questions indicated that these agencies believed that they were successful in achieving this goal. The Utah Transit Authority (UTA) cited a \$7 million value engineering change that was adopted based on recommendations of the CMR contractor on the Weber County Rail project. Because the change was made as a part of the CMR’s preconstruction services during the design phase, UTA accrued 100% of the savings. The fee for preconstruction services on this project was \$550,000. Thus, UTA realized an excellent return on their investment for picking a delivery method that encouraged early construction contractor involvement in the design process. This project also cited the CMR’s innovative involvement in dealing with a third party stakeholder, the Union Pacific Santa Fe Railroad, as key to the project’s ability to bring this project in ahead of schedule.

This connects with the third most popular reason for selecting alternative project delivery on the case study projects: “Early budget establishment” and “Early contractor involvement.” Once again the response tracks exactly with the previously cited 1996 study by Songer and Molenaar which found that “early budget establishment” was the second most important reason for selecting alternative project delivery. This speaks more toward the concept of cost certainty rather than cost savings. Unlike most highway transportation projects, transit projects are generally associated with a revenue stream derived from their ultimate expanded ridership. Thus, cost certainty becomes increasingly important to an agency that must validate the pro forma financial analysis used to justify the capital expansion program with which a given project is associated. As was observed in the Weber County Rail project, the agency utilized the early involvement of the construction contractor through a CMR contract to not only establish the budget at an earlier point in time than DBB but to also improve the project’s bottom-line by making real-time cost estimating and constructability analysis available to the designer at a point in the design process where incorporating variations on the original design concept could be done efficiently.

Over half the interviewees also indicated that they selected a given alternative project delivery method to facilitate “Flexibility needs during the construction phase.” The two Utah DB projects needed to be completed before the 2002 Winter Olympics, a milestone that carried an enormous amount of weight when compared with typical transit project completion dates. Thus, UTA selected DB as a means to gain maximum flexibility by not delaying early construction activities for the completion of the entire project’s design. In fact, this flexibility allowed UTA to complete the two projects nine months ahead of schedule and under budget. Additionally, TriMet selected CMR for its Portland Mall project to enhance the contractor’s flexibility to deal with the City of Portland’s requirements for traffic control during construction by allowing it to make the necessary constructability input regarding this critical aspect during design.

When asked to briefly describe the process that led to the final project delivery method decision, the answers ranged from a decision made in the governor’s office to a decision that came out of a formal risk analysis workshop. In the case of Greenbush and Hudson-Bergen, the motivation involved using a method that would expedite the design process along with its attendant review and comment by local jurisdictions. The Weber County Rail project was able to negotiate an agreement with the municipalities through which it ran to waive individual permits for any improvements made

on the final right-of-way. UTA created an innovative incentive payment scheme that puts one-half of the CMR's construction fee at risk contingent on a monthly evaluation of satisfaction by a panel of third-party stakeholders including the railroad and the local authorities. This process is working as intended and the project enjoys great support both in the local press and among local authorities for the context sensitive manner in which it is being executed. TriMet in Oregon also utilized incentives on both their CMR and DB projects.

Given the above discussion, it appears that the major reasons for deciding to utilize alternative project delivery methods are to compress the schedule, to encourage innovation, to enhance project cost certainty, and to leverage the benefits of early construction contractor involvement in the design process. Additionally, DB furnishes a mechanism to create a momentum to expedite the design review process by essentially starting the “meter running” and avoid endless iterations of design review comments by third party stakeholders.

Project Issue Data

This section of the interview was broken up into the following categories of potential issues:

- Project-level Issues
- Agency-level Issues
- Public Policy/Regulatory Issues
- Life Cycle Issues
- Other Issues

Project level issues were defined as those that are specific to the given case study project and included such items as project size, cost, and schedule as well as project-specific risk management/allocation and possible certification for sustainable design and construction. In nearly all cases, the project delivery method selected was considered as beneficial to solving project-level issues. While this might seem intuitively obvious, it maps with the responses in the previous section and fundamentally confirms that the rationale used to arrive at the project delivery method selection decision was sound. None of the projects sampled had been configured to obtain certification for sustainability. However, several of the interviewees mentioned that this would be a part of the decision process on future projects.

Agency-level issues were defined as those that dealt with agency-specific items such as experience with the delivery method, workforce requirements, goals and objectives for the capital improvement program, control of the project and third party agreements. In some cases, the interviews indicated that the workforce requirements such as number of agency staff devoted to the project and ability necessary for those people to adequately monitor the project was considered a benefit of the project delivery method. For example, the Weber County Rail CMR project has only two full-time UTA staff members assigned to this multi-year mega-project. At the other extreme, MBTA has its own design group that consists of electrical, mechanical, track, and signal subgroups. Additionally, most of the interviewees cited a lack of agency experience and a reduction in agency control over the project associated with the given project delivery method as constraints that had to be overcome as they executed their projects. Finally, there were mixed results regarding the effectiveness of alternative project delivery to deal with third party issues such as permitting. On one hand, the two Massachusetts projects suffered multi-years delays due to third party permitting and coordination issues, while the Weber County Rail project and the Portland Mall project reported the CMR's ability

to work well with third parties which is enabling the projects to meet or beat their required schedules. The TREX project interviewee stated that their DB process limited third party input into the station design, but that the limitation could be overcome in future DB contracts.

Public policy/regulatory issues involved assessing the impact on the project delivery method decision of existing laws, mandated social programs, labor unions, and other factors that establish the “legal” environment in which the project must be delivered. All but one agency, UTA, felt that the use of these methods reduced competition. However, that was tempered by the fact that all these projects are quite large and that fact alone will impact the depth of the pool of qualified competitors. Indeed, the Hudson-Bergen Project reported that most of the smaller firms that were not able to compete as the prime contractor ended up as subcontractors to the DBOM prime and hence participated in the project. There was also a concern about the ability to attract qualified Disadvantaged Business Enterprises (DBE) and other small businesses to these large complex projects to achieve mandated goals for participation in public projects. However, the Hudson-Bergen DBOM project reported that they mandated 50% DBE participation in their RFP and were able to easily achieve that goal. Additionally, the two Oregon projects used DBE participation in their evaluation scheme and believed that the delivery methods actually enhanced DBE participation. Conversely, the TREX project had difficulty meeting the DBE goals due to a number of contracting and project constraints. These findings appear to be project specific at this point in the research and it is difficult to draw conclusions on trends.

The life cycle cost issue category attempted to place the project delivery methods in a long-term, post-construction context in the minds of the respondents. These dealt with project aspects that impacted not only maintainability and the cost of operations and maintenance, but also the sustainable design and construction goals that are starting to emerge as measures of an agency’s commitment to the environment. For obvious reasons the Hudson-Bergen project DBOM delivery method was rated as beneficial in this particular category. Interestingly, the Utah and Oregon DB projects rated life cycle considerations as a constraint because of the loss of agency control over the design process. It may be that as the two Utah projects had an exceptionally immutable completion milestone, the 2002 Winter Olympics, that UTA chose to give up more control over the details of design than it would if the projects would have taken place in a routine DB delivery period.

Finally, the “Other Issues” category was deliberately left open-ended to allow the interviewees to interject issues that were of particular importance to themselves. In nearly all the case study projects, the respondents indicated that they experienced a measurable drop in construction claims as compared to their typical DBB projects. Going hand in hand with this, was a report that adversarial relationships greatly reduced. Thus, it appears that one impact of implementing alternative project delivery is an improvement of the legal/professional environment in which the engineering professionals from both the agency and its design consultants and construction contractors must work. One exception to this was Greenbush project where the project director reported as the project is approaching its completion date, they are witnessing a surge in contractor’s claims mostly related to “change of scope.” This has come as a surprise to the project owner especially in earlier phases of the project, because they “thought there was supposed to be no changes in Design-Build!”

To summarize this analysis, one finds that the project delivery methods used in the case study projects apparently were responsive to the needs of each individual project. Most agencies are not finding that they need to hire additional internal workforce beyond its existing size to implement these methods and in some cases are able to streamline their project supervision staff. This ability

probably stems from the change in the inter-organizational environment from one of adversarial relationships where the agency must staff up to protect itself from construction claims to one of partnership where the agency feels that the procurement process used to select the designer and builder is one that filters out those that may be unsuited to properly execute the project. The “filter” comes at the cost of reduced competition and potentially a decreased ability to grow DBEs unless the agency makes a specific effort in its procurement documents to articulate its requirements for small business participation through subcontracting.

Project Risk Analysis Process Data

This portion of the interview sought to capture each case study project’s process for identifying, quantifying, and allocating risk, and this area is the one with the clearest trend found at this writing. The two case study projects that had either no (Greenbush) or partial (Silverline) formal risk analysis were the two projects that suffered large multi-year delays in completion.

For those that did conduct formal risk analysis, the efforts were focused on schedule first, followed by project scope and contract risk. Three projects, Utah’s Weber County, Portland Mall and Portland I-205 Extension, used formal risk analysis on project costs and invested in Monte Carlo simulation-based analysis of both cost and schedule. One project, Hudson-Bergen, took the time to develop range cost estimates to supplement their understanding of cost risk. The Oregon projects utilized the FTA “top-down” risk analysis procedures though they were not entirely confident in their output. The most used risk identification technique was brain-storming followed by scenario planning and expert interviews. Those that conducted formal risk analysis used risk registers and risk charters and produced risk management and mitigation plans. They also mapped the outcome of their risk analyses into their contracts developing a number of contract clauses and mechanisms to clearly allocate the risk between the agency and its contractors/consultants.

The following contract elements were developed as a result of the risk analysis:

- A risk allocation matrix for allocating critical DB project risks– TREX Colorado
- Payment clauses for railroad flagging during construction, subcontractor payment, and unsuitable subgrade excavation/replacement – Weber County Commuter Rail, Utah
- Risk assignment clauses that detailed the risk that the agency would retain – University Line and Medical Center Extension, Utah
- Commercial risk table used by TriMet in both CMR and DB that quantified the risks financially and assigned them to either the owner or the contractor.

In summary, the case study analysis in this category underscores the need to invest in formal risk analysis. In fact since 2003, the FTA is requiring all the grantees to conduct a formal risk assessment for all *New Starts* projects that apply for federal funding. The requirement includes an extensive contingency analysis and is designed to ensure that the grantees have thought about all potential causes of cost escalation and schedule delay. Another benefit of a risk assessment exercise is that it forces stakeholders to discuss difficult issues and develop a better understanding for the challenges created by the project. This is especially critical in projects of the magnitude that were sampled in this study.

Project Procurement Process Data

This portion of the analysis must necessarily be split up between the three project delivery methods because the procurement process is inherently different for each method. The researchers were able to sample five DB projects and one DBOM project which can be taken together as the DBOM project is fundamentally the same as the other in the design and construction phases. The discussions on CMR and DBB are necessarily more brief as the number of data points is fewer and statistical analysis was not feasible.

Table 4.1 shows the types of design and quality management elements that were contained in the DB project solicitation documents (RFQ and RFP). One can see that in most cases the details of design were pretty much left up to the design-builders with little mandating of standard agency design details and specifications. For example, The TREX project required the design-builder to obtain ISO 9000 certification within one year of award, but did not dictate how to obtain this certification. The cases were a bit surprising in that transit projects have a great need to ensure system compatibility of new projects with the existing network. Nevertheless, only one interviewee expressed dissatisfaction with the resultant product. That was the Greenbush project where the agency felt that it had not been prescriptive enough in its procurement documents.

Table 4-1 - Procurement Phase Solicitation Document Content

Elements of DB RFQ/RFP	Number of Observations (out of 6)
Design criteria checklists	3
Standard design details	3
Standard guide specifications	4
Standards for sustainability	1
Construction testing matrix	1

Table 4.2 shows the responses that were received to the questions regarding the requirements for the design-builders' proposal and whether those elements were formally evaluated as part of the best-value award decision. All asked for a lump sum price rather than unit prices. It can be seen that the majority asked for and evaluated the qualifications of key personnel on the design-builders' teams. Schedule was also evaluated. About half the respondents requested and evaluated the various quality management plans and implemented independent quality assurance to verify the design-builders' quality management success. Only one asked for design submittals in the DB proposal.

Table 4-2 - Procurement Phase Proposal Information

Elements of the Design-build proposal	Required proposal submittal (out of 6)	Evaluated for award (out of 6)
Qualifications of the Project Manager	5	5
Qualifications of the Designer-of-Record	6	6
Past performance record on similar projects	5	5
Proposed schedule	5	5
Proposed schedule milestones	4	4
Lump sum price	5	5
Schedule of values	4	3
Unit prices	0	0
Qualifications of the Project Quality Manager	4	4

Qualifications of the Design Quality Manager	4	4
Qualifications of the Construction Quality Manager	4	4
Design quality management plan	2	2
Construction quality assurance plan	5	5
Construction quality control plan	5	5
Independent quality assurance	3	3
Design submittals	1	1
Proposed sustainable design/construction	1	1*
Outline specifications	0	0

*NOTE: Proposed sustainability enhancements were treated as a betterment in this RFP from the Tri-Met I-205 Extension project.

Table 4.3 shows the division of responsibility for various design management tasks during the design phase of a DB project. One can see that the agencies are assigning the majority of the design management responsibility to the design-builders' design staff and only retaining the final approval of construction documents and payments.

Table 4-3 - Design Phase Responsibilities

Design management tasks	Agency personnel	Design-builder's design staff	Design-builder's construction staff	Agency-hired consultant
Technical review of design deliverables	4	6	4	3
Checking of design calculations	1	6	0	2
Checking of quantities	2	4	3	0
Acceptance of design deliverables	5	0	1	2
Review of specifications	4	5	4	3
Approval of construction documents	6	3*	2	3
Approval of payments for design progress	6	0	1	3
Approval of post-award design QA/QC plans	6	0	1	2

* In these projects, the owner required construction documents to be reviewed by the DB designer before accepted for review by the owner.

Table 4.4 shows the division of responsibility for various construction management tasks during the design phase of a DB project. One can see that the agencies are assigning some of the construction administration responsibilities to the design-builders' design staff and agency-hired consultants. They are also more involved in the construction phase than in the design phase, though they still retain the final approval of construction QA/QC plans and construction progress payments.

Table 4-4 - Construction Phase Responsibilities

Construction management tasks	Agency personnel	Design-builder's design staff	Design-builder's construction staff	Agency-hired consultant
Technical review of construction shop drawings	2	6	1	2
Technical review of construction material submittals	3	6	1	2
Review of construction schedule	5	0	2	5
Checking of pay quantities	4	0	1	2
Routine construction inspection	3	0	6	3
Quality control testing	2	0	6	1
Establishment of horizontal and vertical control on site	0	1	6	0
Verification/acceptance testing	3	1	5	4
Approval of progress payments for construction progress	6	0	2	3
Approval of construction post-award QA/QC plans	5	0	0	2

This analysis leads to identifying the delegating of many of the classical DBB design and construction management responsibilities to the design-builder. This trend seems to reinforce the idea expressed in an earlier section that the project delivery environment has improved to a point where the agencies are willing to trust their design-builders and show it by assigning them many of the important responsibilities that ultimately impact quality. This then leads to the final section in the interview which specifically deals with quality management in the various project delivery methods.

Construction Manager-at-Risk Projects

There were two CMR projects: the Weber County Commuter Rail in Utah and the Portland Mall Light Rail in Oregon. The Utah project had an agency-hired consultant on hand while the Oregon project did not. As a result, there were few trends observable between the two projects. The only one was that both agencies reserved the authority to approve final products and payments and that would be intuitive.

The procurement phase differences between the two CMR projects were quite stark; this was the result of one agency having a consultant to oversee the CMR's work and the other having to do it themselves. The Oregon project's RFQ/RFP required submission and evaluation of qualifications and a number of proposed management plans including a constructability review plan, a cost engineering review plan, a construction quality management plan and a construction quality control plan. Whereas, the Utah project only asked for the qualifications of the construction quality manager and the firm's past performance record on similar projects.

During the design phase the UTA confined its activities to the review and acceptance of design deliverables and payment for design progress. It used its consultant to review cost engineering reviews by the CMR and furnish recommendations of progress payments before they were made.

The CMR also assisted in the review of design deliverables as well as other typical preconstruction services such as constructability reviews and cost estimate validation. TriMet on the Oregon CMR project was much more heavily involved in the design process as a result of not having consultant assistance. It expected virtually the same amount of preconstruction services out of the CMR as well as specific design quality assurance activities from its designer as part of the final design acceptance process.

The real difference between CMR project delivery with and without a consultant was observed in the construction phase. UTA involved its consultant in virtually every phase of the construction management and engineering process except routine construction inspection, construction quality control and establishing vertical and horizontal control. The agency restricted its oversight activities to schedule review and approval of progress payments as well as the final system for construction quality management. In Oregon, the agency was involved in virtually the same amount of construction engineering tasks as it would in a traditional DBB project.

Thus, from the above analysis, it appears that the decision of whether or not to engage a general engineering consultant to furnish assistance to the transit agency during a CMR project is an important one. The result of adding the consultant seems to be a reduced need for agency personnel to conduct design and construction oversight tasks during project execution. As both projects are performing well, no conclusion can be reached as to the value added by the agency-hired consultant in CMR project delivery.

Design-Bid-Build Projects

As previously mentioned the DBB-Multi-Prime project in Massachusetts was the only DBB project sample in the research. Its performance was adversely impacted by the Big Dig and thus no trends can be reported on this delivery system as a result of the interview. However, each interviewee was asked to discuss their reasons for selecting DBB in their agency. In most cases, they indicated that DBB was reserved for smaller projects with well-defined scopes of work and a decent pool of competent competitors.

One variation worth noting is the *negotiated procurement* approach used by the New York's Metropolitan Transit Authority (MTA). Currently, MTA is not using CMR because they do not see price certainty in this approach. On projects that are less than \$100-150 million, they prefer the traditional DBB approach. For complex projects, the State of New York has allowed the MTA to proceed with a negotiated contract as long as they can convince the MTA Board that the project is *complicated*. The negotiated procurement method consists of two steps:

Step 1 – RFQ phase – short-list the contractors.

Step 2 – RFP phase - allow the qualified contractors a period of 6-8 weeks to come forward with initial proposals (both cost and technical). A Best and Final Offer (BAFO) is negotiated with the successful contractor and is taken to the Board for final approval. In the last two years they have given out \$2 billion worth of contracts using this approach. We believe that this development has to be carefully monitored; if successful, it may be worthwhile to consider this as an alternative delivery system in future work.

Project Quality Management Data

This section of the structured interview contained eleven questions that were designed to supplement the quality management information gained in the previous section. It first sought to determine if the agencies were utilizing different QA/QC plans on DB and CMR projects than they normally used on their DBB projects. In most cases, their management of design quality did not change, but their approach to construction QA/QC planning did. The Hudson-Bergen DBOM project indicated that with the post-construction operations and maintenance portion of the contract, the agency did not feel the same pressure to independently verify quality that it did in other project delivery methods.

All the respondents indicated that they specified the contents of the design-builder and CMR's quality QA/QC plans and then reviewed and approved them as noted in the previous section. The two CMR projects, Weber County and the Portland Mall, required the use of standard agency specifications and the use of standard design details in the design process. None mandated specific construction means and methods in their project contracts. In summary, it appears that transit agencies are evolving a new set of quality management practices that attempt to furnish the necessary control over design and construction quality that is appropriate for the project delivery method in use on a given project.

MAJOR FINDINGS

This research has uncovered a number of interesting trends and findings. The following is a list of those findings:

- The use of DB, DBOM and CMR seems to be driven by the transit agency's need to achieve aggressive delivery schedules for their projects. The delivery methods appear to support this need in fine fashion. Only one of the projects sampled that used these three project delivery methods finished behind schedule with the others all either finishing or appearing to be able to finish on time or ahead of their contract completions dates.
- Alternative project delivery also appears to have a positive impact on cost certainty. The average cost growth of the projects in this sample was below the published national average.
- When formal risk analysis is undertaken on transit megaprojects, those projects appear to perform well. The projects in this sample that had substantial delays were also the ones that did not formalize the risk analysis for their projects. When one looks at the financial size of these megaprojects, it becomes easy to justify the added expense for the risk analysis process. Additionally, those that did conduct formal risk analysis used the output from that effort to craft project-specific contract clauses and risk allocation mechanisms that bore fruit during project execution.
- One reason the agencies used DB appears to be the ability of this delivery system to shorten the cycle of reviews and approvals that might plague regular DBB projects by lengthening the design development and delaying construction NTP.
- Transit agencies are evolving a new set of quality management practices that attempt to furnish the necessary control over design and construction quality that is appropriate for the project delivery method in use on a given project.

- The agencies in these case study projects did not avail themselves of the opportunity to integrate sustainable design and construction features into their projects. Nevertheless, there was a belief that this would become an important feature of future contracts.

LESSONS LEARNED

The above discussion of case study findings leads to three lessons learned in this research.

1. Implementing DB on transit megaprojects accrues a measurable benefit in terms of compressing the project delivery period if the agency ensures that critical permitting actions are cleared before the DB contract is awarded. Transit agencies should emulate the FHWA rule for DB highway projects by obtaining rights-of-way and NEPA clearance before awarding DB contracts.
2. Invest in formal risk analysis. Use that process to develop contract language that supports the design and construction process and clearly allocates the identified risks between the agency and its design and construction partners.
3. If the agency has specific technical requirements for system compatibility, it should promulgate prescriptive specifications in its procurement documents to ensure that it actually receives what it needs in the constructed product.

These can be combined with the findings to develop a set of conclusions:

- Alternative delivery methods work on a variety of transit project sizes and types.
- Time needs to be a major factor in the project delivery method selection decision.
- Risk analysis should be used in the project delivery method selection decision.

The three-tiered project delivery decision approach appears to be valid. No one project delivery decision process was prevalent so the decision-making tool was designed to be flexible. The case studies assisted the team in developing the flow chart, determining weighting criteria for the decision matrix, and creating a risk-based approach from those items discussed in the interviews.

RECOMMENDATION FOR IMPLEMENTATION

The most important recommendation that can be made as a result of this research comes from triangulating the interview data and the literature with the above discussed trends. Simply stated the recommendation is as follows:

Transit agencies should carefully study the risks, costs and benefits associated with each project delivery method in the context of the project under consideration and select the project delivery method that best suits legal, technical, and business environment in which the project must be built.

The three case study projects in Utah best support this recommendation. UTA selected DB for the two that had an immutable project completion date knowing that they would be giving up much control over the details of design. However, they balanced the risk of dissatisfaction with the final constructed product's design against the risk that the project would not be constructed on time and selected a delivery method that permitted the contractor the greatest amount of schedule flexibility and ended up with a product with which they are not only satisfied but was also completed ahead of

schedule. On the Weber County Commuter Rail project, UTA was faced with a potential nightmare of third party coordination on a project that passed through ten communities and needed to share right-of-way and track with the Union Pacific Santa Fe Railroad. UTA selected CMR project delivery because it allowed them to retain control over the design while engaging the construction contractor in both design development and early coordination with third-party stakeholders. Again their decision was rewarded by expedited project execution and cost certainty.

This recommendation underscores the need for the ultimate product of this research project: a guidebook that assists transit agencies in making the project delivery method decision. The reader can see that the information yielded by the structured interviews on a good range of case study projects across the nation has been of a quality and level of detail that will facilitate the production of a valuable tool for transit agencies on this important topic.

CHAPTER 5 – ADVANTAGES/DISADVANTAGES OF EACH DELIVERY METHOD

Introduction

There are numerous factors that transit agencies need to consider when deciding to select a project delivery method. These influencing factors and their interactions with different project delivery methods are studied in this chapter in the format of a descriptive pro-con analysis. These factors were identified through literature search, personal experience, case studies and interviews with project directors of the case study transit projects during this effort. These factors are categorized as follows:

1. project-level issues,
2. agency-level issues,
3. public policy/regulatory issues,
4. life cycle issues, and
5. other issues.

Each pertinent issue is defined first and then if a delivery method is a favorable choice for that issue, it is considered as “pro”, and if it is an unfavorable choice, it is considered as “con”. The analysis is based on the trends found in the interviews [which are cited using right brackets] and is supported by quotations from relevant literature. A listing of references directly used is provided in Appendix A. It should be noted that there will be overlaps and redundancies in the characteristics of some of these pertinent issues and how they are affected by the choice of delivery methods. While there was an effort to separate these issues such that redundancy and double-counting will be minimized, it was not possible to choose completely independent issues.

Purpose

The purpose of this chapter is to synthesize the information collected during this research on important factors and to use this information in the selection process. The research team used this information in Tier 1 and Tier 2 of the selection system presented in the Guide.

Project-Level Issues

Project-level issues are defined as those that are specific to the project under consideration and include such items as project size, cost, and schedule, as well as project-specific risk management/allocation and possible certification for sustainable design and construction (e.g., LEED Certification, etc).

1) Project size: It reflects the dollar value and physical dimensions of the transit project. Transit projects are usually larger than \$100 million in value; however, transit agencies sometimes get involved in smaller projects such as construction of parking garages. By studying this issue one seeks to determine which delivery method is suitable for a project with a given size, and how changing the size may impact the choice of delivery method. Intuitively, project size would influence the choice of delivery method. However, current literature and the case studies conducted in this research, document successful projects in a range of sizes using DBB, CMR, or DB project delivery methods. Because each of the three main delivery methods can be applied to projects of all sizes, this issue needs to be considered in combination with other issues such as schedule, agency staffing, risk management, and others. A possible exception seems to be the DBOM that has been considered mainly for larger transit projects.

2) Cost: This issue represents several aspects of project cost like ability to handle budget restrictions, early and precise cost estimation, and consistent control of project costs. In other words this issue checks the abilities of each delivery method in terms of cost control and cost estimate.

DBB: This delivery method may benefit from competition in the market and get low bids when bidding out a project. Having a complete design before awarding the project increases the certainty about cost estimates because the owner has the engineer's estimate as well as several estimates submitted by the bidders. The level of cost certainty increases even more when the payment method is lump-sum. As an advantage for DBB, transit agencies can choose unit price bids as the payment method when the project line items and their cost estimates are known but the quantities are not known with certainty. This payment method allows the constructor to bid on unit prices rather than the total price. In this way, the constructor does not have the risk of fluctuating quantities, while the owner will not have to pay for constructor's contingencies included in the bid because of quantity uncertainties.

CMR: This delivery method has two main characteristics relevant to project cost: 1) it is usually combined with a GMP payment mechanism and 2) the constructor is involved in the project before bidding the project out. These two characteristics directly affect the performance of this delivery method in regards with project cost. As an advantage, there may be cost savings because of early constructor's inputs to the project (Oregon Public Contracting Coalition, 2000) and also competitive pricing through "open book" accounts (Irwin, 2003). Usually, the owner can negotiate and set the GMP at about 60% design complete (AGC 2004). It is advisable that in case the project requires the services of major trade or specialty subcontractors, to bring them on board during the design phase. This way, the project team can benefit from their knowledge and experience and establish a more reliable budget early on. The drawback is losing the opportunity of putting this work to bid. Potential schedule compression by some overlap between design and construction will be an advantage to CMR if the inflation rate has a significant effect on the project cost escalation. Also, compared to the traditional DBB method, the owner will know the estimated cost earlier in the project life-cycle. But at the same time the owner needs to have a close cost monitoring on the project because of the cost reimbursable payment method (Walewski *et al*, 2001). Also, it is somewhat difficult to evaluate the validity of the GMP compared to a traditional bid process.

DB: DB has a relatively good performance when there is budget restriction (Gordon & REES LLP., 2005) because it reduces the potential of cost overruns due to claims and delays. A TCRP study shows that there are fewer cost overruns in DB (TCRP, 2002). Another study shows that DB outperforms CMR in O&M costs, unit cost, and cost growth (Konchar *et al*, 1998). The DB method can also provide the owner with a firm fixed price earlier in design.. Through the use of a lump sum contract in a DB procurement, the owner can establish a firm cost estimate relatively early in the process (Walewski *et al*, 2001; Gransberg *et al*, 2007). The AASHTO Procurement Guide states that DB gives earlier cost certainty and has less cost growth compared to traditional DBB (Molenaar *et al*, 2005).

DBOM: Early certainty in project costs and mainly O&M costs is a direct result of awarding operation and maintenance to the constructor of the project. The constructor generally cannot seek additional compensation for excessive operations or maintenance costs resulting from inadequate design since it is a responsibility of the DB entity. On the other hand, it can be difficult to estimate O&M costs at the early stages of a DBOM project (when the price proposals are being evaluated) since in most cases the project is only at a 15%-30% design level. This can lead to increased contingencies which result in higher prices if the entities submitting proposals are required to price O&M in response to the DBOM RFP, since the constructor will have to cover all risks and uncertainties.

Awarding the project with a DBOM contract extends the scope of the contract. This expansion in the contract scope gives opportunity to the constructor to bring some innovations to the project in order to decrease the project costs (Kessler *et al*, 2005).

3) Schedule: This factor shows two aspects of project schedule and includes both the ability to shorten the schedule and the opportunity to control and prevent time growth. In other words this issue checks the abilities of each delivery method in terms of schedule control and schedule compression.

DBB: Design-bid-build has a sequential process and usually does not have room for significant schedule compression. This sequential process results in a longer schedule compared to the three alternative delivery methods (Walewski *et al*, 2001; Gordon, 1994). A lengthy schedule is the price that is paid for the owner to have the project designs completed prior to the project award. DBB schedule growth tends to be higher compared to other delivery methods. The NCHRP Best-Value contracting study found that DBB projects had the greatest average time growth (Scott *et al* 2006). Lack of ability to compress the schedule in DBB has been one of the main reasons for owners to choose other delivery methods. One way of compressing DBB projects is to break down the program into several packages and let each package separately [Silver Line]. One problem in this approach seems to be the coordination effort required and the issue with abutting primes.

CMR: Having a constructor on board helps the project team develop a more practical and doable schedule for the project. A study has shown that CMR has the ability to meet or exceed schedule requirements (Minchin, 2007). This delivery method can also help the owners with projects that are schedule sensitive (Walewski *et al*, 2001) and can save some time in the project because of concurrent design and construction (Oregon Public Contracting Coalition, 2000).

DB: Flexibility in schedule increases in this delivery method because designer and builder are one entity (Oregon Public Contracting Coalition, 2002). Many experts believe that DB results in a faster schedule delivery (Walewski *et al*, 2001; Konchar *et al*, 1998; Gransberg *et al*, 2007; Molenaar *et al*, 2003) and has the least schedule growth (Konchar *et al*, 1998, Scott *et al* 2006). Another effect of DB is earlier schedule certainty (Molenaar *et al*, 2005) because the design-builder submits the project schedule at the time of contracting which is comparatively early in the project life. Another important characteristic of DB for transit agencies is that it obligates design and construction funds before the end of a given fiscal year (Gransberg *et al*, 2007). This can help the agencies award the project and allocate the available funds to a project without waiting for its design to be complete.

DBOM: This delivery method can increase schedule certainty and early delivery of project (Kessler *et al*, 2005). It has all the characteristics of DB, so one can use this delivery method as a means of schedule compression.

4) Risk management: Each new project has some level of uncertainty during various phases of its project development. Methods to cope with these uncertainties are inherent to each delivery method. The effect of delivery methods on risk identification, quantification, and mitigation is different; therefore, selection of a delivery method is dependent upon the owner's risk management approach. These differences are considered under this issue. Tier 3 of the selection system developed in this Guide is based on risk allocation. Also, it should be noted that the effect of risks is prevalent in many of the issues discussed in this chapter and is not limited to the items 4 and 5 of this chapter.

DBB: This delivery method has a long history of application and a rich background in terms of statutory laws and standard contracts which entail developed risk management processes. When the project scope is clearly definable, the owner of a transit agency can follow the traditional methods of managing risks in DBB (Gordon, 1994). Although risks and rewards are easy to understand in this method, disputes arise often over authority, responsibility and quality (Walewski *et al*, 2001). In other words having separate contracts for design and construction may or may not help the owner manage the risks of a transit project and the owner's success in mitigation of risks depends upon the proficiency and experience of the owner and its consultants in risk management.

CMR: The risk for the construction manager at risk comes from the CM holding the trade contracts and taking the performance risk of the project (AGC, 2004). The use of a guaranteed maximum pricing structure can create a mechanism to share cost risk between the constructor and the owner agency in the hopes of ultimately reducing costs. Early constructor involvement may result in a better understanding of the project risks and more efficient risk allocation can be achieved. This delivery method is conducive to team work. The constructor shares information with the owner and designer on trade subcontracts, value engineering, *etc.* That is why some experts believe that CMR theoretically reduces the risks of every entity involved in the project (Minchin, 2007).

DB: Risk allocation and risk management are inherently different in DB delivery compared to DBB and CMR. The risk for errors and omissions in the plans is transferred from the owner to the DB contractor. Having single point accountability for design and construction helps the owner avoid designer-constructor blaming each other on changes in cost or time

of project execution (TCRP, 2002; Riley *et al*, 2005; Irwin, 2003). From the owner's perspective, the DB approach reduces the size and frequency of change orders (Molenaar *et al*, 2003; Riley *et al*, 2005) as long as the owner understands the loss of its control over design and also does not change the scope. Agencies should realize that though the risks are contractually transferred to the design-builder, a poorly defined initial scope in the RFP may result in significant cost increases. According to the design-builder's scope of work which includes the project design, the DB contractor may be required to have errors and omissions insurance (which is usually required from design firms) in this transfer of risks (AGC, 2004; Irwin, 2003). In essence, the risk for errors and omissions does not go away, but it is transferred to the DB contractor, who has an economic incentive to manage the risk better than the owner in the DBB system.

DBOM: In addition to the risks assumed by the constructor in DB delivery, the DBOM entity also assumes the risks involved with operations and maintenance and mainly the system integration and project start-up. Agencies expect that the DBOM entity will therefore be more inclined to ensure quality of design and workmanship since it will be responsible for operation and maintenance. Also the delivery method does not allow the DBOM entity to claim compensation from the agency for inadequate O&M considerations since the designer and the constructor are on the same team. As the contract includes the O&M phase, uncertainty during O&M period is reduced by awarding the whole package to the constructor (Garvin, 2003). One problem that may surface with DBOM delivery is the commercial/financial approach to risk management by constructor (Kessler *et al*, 2005). The DBOM constructor makes money out of the project and may accept higher levels of risk in safety or commuter satisfaction to increase its income. This difference between the viewpoints of an agency and a contractor may increase the risk of having safety issues or commuters' satisfaction problems.

5) Risk allocation: Research in the area of risk management has indicated that the most effective approach in risk allocation is to assign project risks to the parties in the best position to manage them. This means that the party assuming a certain risk should be the party who has the most control over that risk and is also most likely to survive the negative impact of such risk. The main vehicle for risk allocation is the contract. The type of project delivery method will have a profound impact on risk allocation. Some methods allow the owner greater flexibility in allocating risks to the parties involved. Tier 3 of the project delivery method selection system developed under this Guide is based on an effective method of risk allocation. As an example, schedule risk is sometimes addressed by choosing a DB approach. This was also covered earlier under Item 3. It is emphasized that risk allocation affects many of the pertinent issues discussed in this chapter and is not limited to Items 4 and 5.

DBB: This delivery method can help the owner divide risks between the designer and the contractor, but the risk of additional construction costs resulting from erroneous design remains with the owner (AGC, 2004) which the owner usually transfers to the design team. Scope definitions of design and construction contracts in DBB play an important role in risk allocation. The owner will face challenges if the duties are not defined clearly and ambiguity remains in the contracts.

CMR: Although CMR facilitates risk management, it is not necessarily the best method for risk allocation. Having an experienced constructor on board improves the whole process of

risk management including risk allocation but the increase in the number of parties directly involved in the project and some overlaps between their duties may make the risk allocation more difficult [Portland Mall; Weber County SLC]. Although GMP as a means of risk allocation should decrease the owner's risks, there is always a possibility that the owner and the on-board contractor do not come to an agreement on GMP in a timely fashion. The owner in this case may have to bid out the project and will suffer from the resulting delay imposed on the project and will be subject to the uncertainty of getting higher than expected bids.

DB: Because design-builder is the single point of responsibility in this delivery method, risk allocation is simpler. The owner must carefully decide which risks it can best manage and assign the design-builder those where it is the best party to bear them. It is not wise to allocate total risks to the DB contractor because that would drastically increase the contingency and constructor's insurance costs which will be transferred to the owner through the bid (AGC, 2004). Examples of other risks include the risk of obtaining various environmental permits, or purchasing the real estate. Experience shows that the owner is in the best position to assume these risks [Greenbush].

DBOM: Risk allocation in this method is similar to DB, but adds an allocation of risks for the O&M phase. If the owner can identify the risks of the project early enough to allocate them at the time of project awarding, DBOM would be a "pro" for this issue. In other words, DBOM facilitates risk allocation if the owner is able to identify the project risks up front. DBOM has an advantage over other delivery methods in case the system provider does not guarantee the system if operated by another entity (Kessler et al, 2005). One of the major risks in this approach is the owner's ability to provide clear *scope* and *objectives*; otherwise the consequences of disputes in the later stages may be significant.

6) LEED certification: Sustainable design and construction features are becoming more common and may become mandatory in the future for public infrastructure projects. Thus, it is important to gauge a project delivery method's ability to include these features in accordance with the owner's needs. The US Green Building Association's Leadership in Energy and Environmental Design (LEED) certification is often used by public agencies as a means to articulate its desire to design and build both energy efficient and environmentally responsible projects. Although LEED certification has not become a requirement in transit projects, how each delivery method facilitates this issue can be a benefit or a drawback. For example, one benefit of establishing LEED as a criterion is that it can be used as a metric to evaluate sustainable design and construction options regardless if LEED certification is sought for the project. LEED prerequisites (including selection of site, and construction activity pollution prevention) can yield greater environmental benefits while reducing regulatory risk. On the other hand, LEED requirements may increase project costs because of extra tasks and documentation. One important fact to remember is that the LEED standards are evolving and trying to accommodate a range of project types. The adoption of LEED criteria as a selection requirement may need to be phrased to include the most current iteration rather than a particular standard.

DBB: The owner has a clear opportunity to define sustainable design with LEED criteria. The lack of builder input can limit the opportunity for input into sustainable design and the owner, in certain cases, can thereby risk losing LEED certification.

CMR: The owner has a clear opportunity to define sustainable design with LEED criteria. Sustainable construction features are more likely to be implemented considering the cooperative nature of the owner/builder contract.

DB: The owner can clearly articulate its expectations regarding the use of LEED criteria by assigning weight in relation to other factors in the DB evaluation plan as well as using sustainable design and construction as performance criteria during design and construction. There is some evidence that the use of DB may hamper the objective of achieving LEED certification. This is due to the perception of risk by the DB contractor when considering whether to bid on a DB project with LEED goals. The owner needs to be cautious in defining the project scope and goals clearly to ensure reasonable competition, especially if LEED certification is desired.

DBOM: While owner and O&M personnel may be acquainted with the LEED standard and requirements there may be limited ability to incorporating evolving standards as well as restricted opportunities to “push the envelope”. The addition of post-construction operations and maintenance, allows the owner to hold the DBOM contractor responsible for delivering the life cycle costs savings that were incorporated as a result of the design process with the DBOM contractor being at risk for failing to achieve the savings associated with the approved design. Life-cycle cost (both economic and environmental) of sustainable design strategies is a means of selection of those strategies and is a fundamental LEED component. The selection of design strategies that may produce increased first-costs are balanced and ultimately chosen by utilizing the offsets achieved through reduced life-cycle costs.

Agency-Level Issues

Agency-level issues relate to the owner agency. These will include items such as experience with various delivery methods, workforce requirements, goals and objectives for the capital improvement program, control of the project, and third party agreements.

7) Agency experience: This issue focuses mainly on the level of experience of an owner’s staff in terms of alternative delivery methods application. It shows the interaction between the level of experience and comfort and confidence using a specific delivery method. Owners who have used a project delivery method in the past would have a higher level of experience with that method.

DBB: Transit agencies have historically employed DBB project delivery. This historic experience with DBB makes the delivery method a good candidate (TCRP, 2002). This experience can be a motivator or a detractor for using alternative delivery methods. The most experienced owners may find that some of their negative experiences with DBB (e.g. contractor’s claims, erroneous designs, delay in schedule, and cost overruns) will push them to try alternative methods. Other owners will be comfortable with DBB delivery and therefore be hesitant in trying new delivery methods.

CMR: Most of the agencies have not applied CMR in their projects, as this is a relatively new method in transit. The agencies’ experience with CM is mainly about hiring a construction manager as a consultant (or Agency CM) (Please refer to chapter 2 for detailed

discussion on the CM definition). Nonetheless, agency staff with DBB management experience should have most skills necessary to manage CMR because of the similarities between CMR and DBB, [Portland Mall and Weber County SLC]. One missing skill may be negotiating the construction manager's preconstruction services fees and the guaranteed maximum price (GMP) in CMR.

DB: There have been several examples of transit projects executed with the DB approach. Many transit agencies as well as other public agencies have managerial experience required for a DB project. Although agency staff with DBB management experience should have most skills necessary to manage DB, the differences between DB and DBB are significant enough that some sort of training seems to be inevitable for agencies with no background in DB. The primary difference is managing a contract that contains the designer and constructor as one entity. This difference affects the manner in which the design-builder is procured (e.g. using best value method instead of bidding based solely on cost), the manner in which design is reviewed, and some aspects of how construction is overseen by the owner. Additionally, agency staff will need to learn how to conduct project oversight without the presence of a completed design for early features of work. This may require training and change of skills of owner employees which may make DB more difficult to administer [Utah Med. Center, Utah University, Green Bush, TREX, I-205 Light Rail].

DBOM: DBOM represents a significant departure from DBB and few agencies have experience with this method. The advantage to using DBOM is that the agency can transfer most of the traditional responsibilities of the agency staff to the DBOM contractor. Some experts believe that this delivery method is best suited for small agencies without substantial in-house expertise (Kessler et al, 2005). However, the loss of control that goes with this transferring of responsibility can be a disadvantage if the agency does not have experience in managing outsourced responsibilities for design, construction and maintenance to constructor.

8) Staffing Required: This issue reflects how each delivery method drives the owner's direct involvement in the project. Each delivery method assigns specific duties to each party including the owner. The scope of these duties and the dependency of the project progress on the owner's involvement in decisions show the extent of owner's involvement. The total number of required owner's employees for each delivery method is one measure of the extent of owner involvement. A second measure is the variation in the number of staff required throughout the project development process. It is assumed that in general, a smaller staff is more desirable, although this has to be measured against potential reluctance within the agency to buy into a method that can reduce the need for agency staff.

DBB: An owner in a DBB project should administer two separate contracts for design and construction. Because of this and the high level of involvement in decision making and quality management, a relatively large number of owner employees are needed in this system (AGC, 2004; Gordon, 1994), [Silver Line]. The owner's responsibilities in DBB are spread throughout the project (mainly dealing with the designer at the beginning and shifting to the contractor after project award); fluctuation in the number of employees required during the project is minimal.

CMR: The owner hires a new party in CMR and delegates some parts of its managing duties to this party. This system can arguably require the least number of owner's employees because the CMR can expand to meet the owner's staffing needs (Gordon, 1994). The owner may however need to add some professionals to its staff (either as an employee or consultant) if special expertise (GMP or construction manager's fee negotiation as an example) in managing a CMR contract is desired.

DB: The owner should develop a comprehensive set of project specifications before advertising the project because the design-builder takes responsibility for the project in both design and construction phases only after the project is awarded and will base the project design on the specifications. The owners may hire consultants for developing the RFQ/RFP documents or use their own staff. A study shows that most of the agencies have not changed the size of their staff after implementing DB mainly because the owner must be involved with substantial amount of pre-advertising design and engineering effort (Gransberg and Molenaar, 2007). Another study shows that some public agencies had spent considerable effort in developing the design documents as a means of performance risk reduction in large DB projects (Molenaar, 2005). The number of staff required for project administration decreases after the award as the number of check points and controls is reduced in this delivery method and the oversight procedures are usually streamlined (TCRP, 2002). Another driver with respect to the size of staff is the way QA/QC is handled in DB projects. In most DB projects, the constructor is put in charge of day-to-day quality control functions. The owner's role is to design and implement a quality assurance program.

DBOM: Early decisions in this delivery method cover a wide range from feasibility of project in conceptual design to safety in operation phase. This broad range of expertise requires a good size owner's staff to handle the project at least in pre-design and preliminary phases of design [Hudson-Bergen]. On the other hand some experts believe that a transit agency with a small staff would prefer to choose DBOM and outsource many of its duties (Kessler *et al.*, 2005). In most DB projects, the constructor is put in charge of day-to-day quality control functions. The owner's role is limited to spot checks and quality assurance functions.

9) Staff Capability: This issue mainly focuses on the quality and competence of the owner's employees. This factor seeks to measure the owner's requirement to furnish a highly capable staff to complete the duties it must undertake in each delivery method. There is a concern about retirement of experienced employees which can negatively affect the capability of owner's staff during the project. So the availability of the experienced staff until the end of the project should be considered while evaluating the staff capability.

DBB: Transit agencies have more experience with DBB. This experience helps them gradually build up the capability in their staff at all levels of the organizational chart. An important issue here is the different expertise required in owner's agency to handle a design contract with the designer of project and a construction contract with the general contractor. So the owner may end up with a longer list of required competencies [Silver Line].

CMR: Some professionals believe that CMR requires special capabilities to administer this type of delivery method while others think that the owner agency is delegating most of its duties to the CMR. While the work can be delegated, agency staff must have the capability to

oversee CMR work and notice errors or omissions in their work [Portland Mall and Weber County SLC]. Another managerial skill required in CMR is related to the relations between the onboard constructor and the designer. The owner should carefully manage the process by which the constructor gives inputs (constructability, value engineering, *etc*) to the designer, and the way these inputs are received, analyzed and implemented. Designers are not used to taking on-going criticism by a contractor and there is potential for this process to cause conflicts. Also, the experience of the agency staff in GMP negotiations is a key factor in this delivery method. It seems that while the agency would need a smaller staff in this method, the staff needs to be especially competent and versatile in dealing with these additional requirements.

DB: As an alternative delivery method, DB contracts require owner's competency in terms of managing the process, keeping up with the speed and understanding the procedures. A recent research shows that the traditional design and construction engineering tasks performed by public agency professional engineers (e.g. design deliverable approvals, construction inspection) were performed by the same staff in the design-build projects (Gransberg and Molenaar, 2007). While the required skills for DBB are similar to DB, owners tend to put their most experienced staff on DB projects because they need to be better prepared to understand conceptual designs, conceptual estimates, and performance criteria. These skills typically only reside in the most experienced staff (Gransberg and Molenaar, 2007) [Utah Med. Center; Utah University; Green Bush; TREX: I-205 Light Rail].

DBOM: The variety of early decisions that freeze the main portion of project scope demands capable employees with high level of expertise [Hudson-Bergen]. The owner will also need to have financial analysis capabilities in its staff because this delivery method may include project financing which in turn will require more extensive financial analysis on project viability, contract incentives, and owner's financial security (FTA, 2006).

10) Agency Goals and Objectives: Agency goals can be described in broad terms such as providing service to the community or achieving its growth goals. Agency goals can align with project delivery attributes (pro) or can be in conflict (con) with them. Agency goals are different from project goals. Agency goals also entail statutory requirements for safety, equal opportunity, and other legal/regulatory requirements. Project goals on the other hand are specified in procurement documents and are usually described in terms of time and cost expectations.

DBB: An agency can incorporate its goals and objectives in prescriptive specifications and detailed designs. Having control over the design on one hand and requirement of design approval for construction commencement on the other hand helps the owner assure the achievement of its goals and objectives. Examples include specifying targets for DBE participation and stakeholders concerns with regard to agency and project objectives.

CMR: The agency can work with CMR during the design phase, and when negotiating the GMP to develop project goals and objectives in alignment with agency goals and ensure that they are achieved by the project. Since this is typically a qualifications-based selection, the request for proposal can help assure that agency goals and objectives are clearly incorporated in CMR proposals. Compared to DBB this delivery method may contribute to a better owner-constructor relationship that can facilitate the achievement of agency goals. [Portland Mall; Weber County SLC]

DB: Compared to DBB, the DB approach reduces the agency's control over the details of the design. To the extent that these details affect the agency's goals, the DB may have a negative impact on achieving its goals. Examples of the agency goals that could be compromised include aesthetic considerations, safety, and commuter satisfaction. If an owner is not absolutely clear on its goals prior to procurement, DB can yield unsatisfying results (Molenaar *et al*, 2005), [Utah Med. Center; Utah University; Green Bush; TREX; I-205 Light Rail].

DBOM: A DBOM contract covers a wide area of project issues. This comprehensive agreement may push the project through different steps of decision, and help the owner achieve its goals. There is a concern that DBOM may hinder the owner in achieving its social goals. Although a TRB study states that decrease in quality and safety of services provided by private entities has not been proven (Kessler *et al*, 2005), some experts believe that using this delivery method may limit the agencies' power to serve the public, *e.g.* a change required in operation phase will be extremely costly in DBOM (Kessler *et al*, 2005). Advocates of this method believe that a comprehensive agreement with appropriate level of detail can address this issue, however, it should be noted that there is insufficient precedence to ensure success.

11) Agency Control of Project: Different delivery methods have different check points and decision making steps. Owner's control over the details of design and quality of construction is studied in this issue while cost control and time control are studied in other issues.

DBB: The owner in this delivery method may benefit from checks and balances by having the designer and constructor under two separate contracts. Having periodic decision points in DBB and mainly during the design phase helps the owner control the project's design (TCRP, 2002; Garvin, 2003; Irwin, 2003). Having a specific contract based on bid plans helps the owner control construction and material quality. The owner will have objective control over the quality of design through the design team. Also, if flexibility is required during the construction, DBB can comparatively have a better performance because there are established procedures for implementing changes. However, change orders are usually accompanied by corresponding cost increases.

CMR: The owner agency benefits from the involvement of the construction manager in most of the decisions during the design phase. The construction manager can assist in controlling the details of design. The owner therefore has a similar level of control in CMR as compared with DBB if the working relationship with the CMR is good. This delivery method gives more control and flexibility to the owner in implementing changes in the details of design during design development compared to DB. Furthermore, having the construction manager on the team may make implementing changes more effective than in DBB. (Walewski *et al*, 2001; Minchin *et al*, 2007).

DB: Although DB arguably provides the owner with the same quality of design and construction as DBB does (Konchar *et al*, 1998; FHWA 2006), the owner will lose control over the details of the design that are not defined in the request for proposal. Loss of control over the design (and possibly lack of check points) has the potential to expose the owner to shortcomings in the quality of design and construction (Gordon & REES LLP, 2005; Irwin, 2003; Gransberg *et al*, 2004) [Utah Med. Center; Utah University; TREX, I-205 Light Rail].

DBOM: The owner in this delivery method loses its control over the details of design and even details of operation and maintenance. DBOM is not a good option for the owners who want to extend their existing systems mainly because of the integration needed in operation phase (Kessler et al, 2005). Loss of checks and controls after awarding the contract is a disadvantage of this delivery method especially if the owner is expecting a high level of control over the project.

12) Third Party Agreement: This issue concerns each delivery method's impact on facilitating agreements with third parties, such as political entities, utilities, railroads, *etc.* involved in the progress of project.

DBB: DBB can help during lengthy negotiations with some project stakeholders [Silver Line]. It gives some flexibility and time to the owner to get required agreements before the commencement of construction phase. Third parties on the other hand, will have the ability to examine 100 percent complete designs before a contractor is hired. The disadvantages of completing designs before hiring a contractor may include a lengthy design schedule (including numerous instances of stakeholder inputs that can disrupt the most generous schedules) and also a lack of construction contractor input into the third party agreements.

CMR: The main advantage of having a construction manager is the constructability advice and responsibility for that advice (for example, construction knowledge and an understanding of construction methods) during the development of third party agreements. This delivery method may also have a significant impact on getting into an agreement with third parties involved in a project when compared to DBB if the owner includes the responsibility to make agreements with third parties as part of the CMR contract. As an example, among the projects interviewed for this work, one agency clearly mentioned the benefit of having a contractor on board while negotiating with third parties [Weber County SLC]. In general, the CMR's knowledge of construction processes and sequencing can help clarify various aspects of project impact on communities and institutions; this will hopefully facilitate achieving understanding and approvals.

DB: The DB process can move third party agreements earlier in the delivery process, often before the design is complete. Agencies have experienced both benefits and drawbacks of having the design-build contractor on the team before all third party agreements are in place. As the design and construction is awarded in one contract, the time required to develop agreements with other parties can be shorter than desired. Additionally, these agreements must often be written in performance terms because the design is not completed at the time of award. However, some other experiences with DB show that the DB contractors have been successful in obtaining responses from project stakeholders by exerting pressure on them. The constructors have different approaches to negotiating agreements with third parties compared to owners and these can often be very effective [Utah Med. Center; Utah University; Green Bush; TREX; I-205 Light Rail].

DBOM: Since the DBOM contractor will be maintaining the project for a significant period of time after construction, they need to exert much more control over the third party agreements. The DBOM contractor may negotiate some of the agreements with little input from the owner. The remainder of the agreements will be similar to the DB process. In

some cases with less schedule constraints, the owners may treat third party agreements similar to a DBB project [Hudson-Bergen].

Public Policy/Regulatory Issues

Public policy/regulatory issues analyze the choice of project delivery method decision in the face of existing laws, mandated social programs, labor unions, and other factors that establish the legal environment in which the project must be delivered.

13) Competition: Each delivery method may affect the level of competition. In many cases, agencies are operating under a legal requirement which requires “free and open” competition. The owners benefit from a competitive market mainly because of the reduction in bid prices; so if the choice of a certain delivery method reduces the number of qualified proposers/bidders, it would be considered a disadvantage. Currently, the volatility of bid prices in transportation projects is a major concern for the owners of transit (and other modes of transportation) projects. Additionally, alternative project delivery methods may inadvertently lead the agency to package projects in sizes that can effectively reduce competition due to bonding limitations and contractors’ capacities. This factor is about the evaluation of facilitating effects of each delivery method on competition.

DBB: Compared to other delivery methods, availability of a relatively large pool of potentially qualified bidders ensures a high level of competition (Walewski *et al.*, 2001; AGC, 2004). The owner can benefit from this market competition and get a low bid/proposal for its project. This approach also enables the owner to divide the project into smaller packages and bid them separately to further increase competition. The drawback to the multi-prime approach is that the coordination between various contracts may prove difficult.

CMR: Using RFP procedures and taking into consideration qualifications-based factors when evaluating the bidders can help the owners weed out unqualified proposers. The issue in this system is that the selected CMR constructor becomes the *de facto* winner of the construction contract, giving the owner less competitive leverage when pricing the construction (Irwin, 2003). This can be alleviated to some degree by requiring that the project components be bid competitively among various trade subcontractors. Also, the owner can reserve the right to go to regular bidding if it cannot agree on a GMP with the CMR.

DB: The RFP process can weed out unqualified DB entities but at the same time, the size of the bid package and the bid preparation costs may reduce the number of qualified bidders (AGC, 2004).

DBOM: Adding operation and maintenance to the scope of work will lengthen the contract duration compared to other delivery methods on one hand and requires some extra competencies that typical construction contractors usually lack. The prime contractor usually hires operation and maintenance subs as parts of the consortium. These factors may decrease the number of potentially qualified bidders when a DBOM project is bid out. In most DBOM projects so far, the number of responsive bidders has not exceeded two!

14) *Disadvantaged Business Enterprise (DBE) Impacts:* Delivery methods may facilitate the fair competition for DBEs for DOT-assisted contracts and reduce burdens on small businesses. The effect of each delivery method on promoting participation by disadvantaged businesses is evaluated under this issue. In general due to the size of most transit programs, it would be unlikely that a DBE firm serve as the lead constructor. What is more common is to set aside a certain percent of budget to assure DBE participation.

DBB: The owner has the chance to include requirements for participation in both design and construction contracts. For example, in the RFP for soliciting design services, the owner may stipulate the nature and extent of DBE participation as part of the design team. In the same way, the owner may require that the general contractor perform a pre-set percentage of construction using DBE subcontractors. Usually, the minimum level (as well as the desired target level) of participation is stipulated in terms of percent of contract price. On the other hand, the low bid environment may force DBE subs to submit dangerously low prices, potentially harming the future viability of these fledgling companies.

CMR: A constructor that submits a proposal for a CMR project is usually more sophisticated than a DBB construction contractor. Lack of enough experience is a negative point for DBEs in a qualifications-based selection. One method to ensure DBE participation is to require a pre-set minimum (and target) percentage of the GMP for DBE firms when the GMP contract is negotiated.

DB: Lack of enough experience and finance does not allow a DBE to become the main contractor but small businesses/DBEs may become subcontractors of the design-builder. As the owner is not directly involved in selecting subcontractors and suppliers, requirements for DBE participation as a percentage of the project budget should be included in DB RFP and then in the contract. This should be based on the number of DBEs associated with the various trades that will be required in the project. The design builder should report (usually monthly) actual payments to all the DBE subcontractors and suppliers. As owner has less control in this delivery approach, the enforcement of DBE participation may be harder than DBB or CMR.

DBOM: This delivery method performs very similar to DB and it has the same advantages and disadvantages. The dollar value and the size of main contract do not work against small businesses if relevant considerations are included in the contract. For example there were DBE goals in Hudson-Bergen light rail which were achieved by putting a clause in the contract for outsourcing some parts of the project to local contractors [Hudson-Bergen]. It should be noted however that because agency's control is minimized in this delivery method, there may be some risk that the DBOM contractor does not achieve the desired level of DBE participation.

15) *Labor Unions:* Each delivery method covers certain phases of a project life cycle. For example DBOM delivery covers almost all the phases while DBB delivery only affects the construction phase. The choice of delivery method may have an impact on labor usage and hence labor union issues. The legal protections for transit laborers such as Section 13 (c) of Federal Transit Act complicates the application for federal grants and transit agencies should show that fair and equitable protective arrangements are made to protect employees affected by such assistance (for more information on Section 13 (c) please refer to a legal research done by TCRP in 1995). Other

acts like Davis-Bacon act should also be taken into consideration while determining the laborers' minimum wages in any delivery method.

DBB: This is the traditional way of doing the project in which the contractor hires the laborers directly or through a subcontractor. Union or non-union labor may be used in this approach (unless local conditions and considerations limit constructor's options) and there would be no fundamental opposition to DBB unless the contractor fails to comply with the relevant rules and regulations set forth.

CMR: The constructor in this delivery method plays a similar role to the contractor in DBB and there would not be fundamental issues between the unions and the constructor. If there are union issues in the project's location, the constructor does not usually guarantee the maximum price of the project and may not absorb the risks of the labor union issues. Unions may support alternative delivery methods as these methods give more weight to qualifications rather than cost; unions assert they are more qualified than non-union labor (Bearup, *et al* 2007).

DB: Design-builders are usually joint ventures and dissolve after the end of the project. This may make the process of dealing with unions a bit complicated as they expect a reliable and established party to have an agreement with. Awarding the design to a design-builder in some cases (California for example) where state engineers have their own unions may cause conflicts and challenges for the owners who seek to use DB (although this has more precedence in highway rather than transit). Unions may support alternative delivery methods as these methods give more weight to qualifications rather than cost; unions assert they are more qualified than non-union labor (Bearup, *et al* 2007).

DBOM: Labor unions may affect this delivery method more than DB because the scope of this method entails operation and maintenance which are usually done by union laborers employed by public entities. The law requires that the jobs of the laborers already employed by the agency be protected according to the requirements of Section 13 (c). Because of this, there must be an agreement between the constructor and the related unions to guarantee the availability of O&M personnel with reasonable rates during the operation phase. Also, there may be some opposition from agency's maintenance employees to award of such contracts. In any case, there is already considerable experience with O & M contracting in transit.

16) Fed/State/Local Laws: Based on the research done on the federal and state laws, use of some delivery methods may not be allowed for transit agencies. Some of the states mandate that transit agencies go through several steps before being allowed to use an alternative delivery method. This issue studies the level of difficulty of using a delivery method from a legal standpoint. Due to constant changes in state and local laws, each agency should check all the relevant codes in order to find out the legality of each delivery method at the time when possible delivery methods are studied for each project. (Please refer to Chapter 2 for more information on this issue).

DBB: All the state codes accept DBB as a project delivery method for a transit project. Relevant procurement processes are well-developed and details of DBB execution are available nationwide.

CMR: More than half of the states do not allow CMR to be used in transit projects (Ghavamifar and Touran, 2008). Some have imposed limits or extra approval requirements and only about 14 states have fully authorized CMR application in transportation projects. Even in those cases, approval for transportation projects may not mean that CMR can be used in a transit project. Because of these complications, the legality of the CMR or any other alternative delivery method should be carefully reviewed in a specific state.

DB: This delivery method has been used more than CMR, but there are still 13 states where this delivery method is not allowed in transportation projects.

DBOM: Awarding a project with DBOM delivery method is similar to DB and owners are required to go through the same laws and regulations that in some locations make DBOM application impossible. In addition, if the DBOM arrangement calls for contractor's financing, then additional regulations and laws may need to be considered.

17) FTA/EPA Regulations: The effect of various environmental regulations on project cost and schedule can be profound. These include obtaining various types of permits and complying with various regulations. Additionally, FTA specifies that a number of requirements be met before a project can receive commitment for federal funding (*i.e.*, receive the Full Funding Grant Agreement (FFGA) in case of New Starts projects). Currently the FTA accepts all types of project delivery methods; specifically, they modified their evaluation process to accommodate DB and DBOM in the 1990's.

DBB: The traditional approach is the most familiar for the FTA and the environmental agencies. This familiarity can be an advantage in the permitting and funding process.

CMR: FTA has less experience with CMR. This may cause some problems or delays although the agency maintains that it can accommodate all legal delivery methods. Environmental issues would be similar to DBB as the owner remains involved and is in control throughout the design phase.

DB: FTA started an initiative to experiment with DB early in the 1990's. Five pilot projects were constructed using the DB approach. FTA has since modified its procedures to accommodate the DB delivery method. The owner agencies prefer to receive the FFGA before the project goes to bid, while the project is at the end of Preliminary Engineering (PE) and subject to many uncertainties. Current regulations require that the agencies work closely with FTA which may cause some delay. The FTA had some problems with the first generation of DB projects. Currently, most of these problems have been resolved and the agency has matured in dealing with DB projects. The environmental permitting process can be problematic though. As an example, in a commuter rail project [Green Bush], a major cause of delay was that the owner had left the obtaining of environmental permits to the constructor, a task for which the DB contractor was ill-equipped. This caused a delay of longer than one year.

DBOM: Concerns here are similar to DB.

18) Stakeholder/Community Input: This issue discusses the opportunities afforded by the delivery method to the owner for coping with community inputs. The delivery method should strive

to leverage stakeholder and community input to achieve project goals in a meaningful and transparent fashion.

DBB: Separate design and construction phases give more time and opportunity to the owner to get stakeholders and communities' inputs to the project design and incorporate their expectations in the project scope before the commencement of the construction phase. This characteristic of DBB can lengthen the project pre-construction phase and cause delays in the project.

CMR: The construction manager is on board during design in this method and can help the owner negotiate with stakeholders and understand their expectations while pushing the project forward. Additionally, community outreach and public information can be made part of the CMR's preconstruction service package. Depending on the CMR's experience and qualifications, this may enhance project chances for obtaining community consent and stakeholder agreements.

DB: The owner of a transit project needs to get all the important inputs from stakeholders before issuing a RFP because changes in the project after that would be difficult and costly. On the other hand, after the contract award, the DB contractors have sometimes been able to proceed through community pressure more effectively compared to state agencies [TREX]. Additionally, the agency can require the DB contractor to include a public information and outreach program in the project to facilitate stakeholder input during design and construction.

DBOM: This delivery method decreases the decision points and covers a longer period of time in project life cycle. This characteristic makes pre-construction negotiations between owners and stakeholders more complex. The DBOM contractor may be able to push through construction phase and deal with community pressures more effectively. At this point, there is little evidence to support how the DBOM will cope with this issue.

Life-Cycle Issues

The life-cycle issues category attempts to place the project delivery methods in a long-term, post-construction context in the minds of the respondents. These issues deal with project aspects that impact not only maintainability and the cost of operations and maintenance, but also the sustainable design and construction goals that are starting to emerge as measures of an agency's commitment to the environment.

19) Life-Cycle Costs: Effects of delivery methods are extended to the operation and maintenance phase. This issue focuses on the opportunities or barriers that each delivery method provides in regards to life-cycle costs.

DBB: The owner is in control of design and quality and can tailor these to project's long-term life-cycle goals.

CMR: The owner keeps almost the same level of control over the design of the project and also benefits from constructor's advice regarding future costs of the project.

DB: The owner needs to have a close eye on the issue of increasing life cycle costs of the project mainly because the design-builder has a motive to decrease the initial costs of the project and bring it down to the agreed upon amount regardless of possible increases in the future operation and maintenance costs of the facility.

DBOM: In this delivery method the constructor is in charge of operating and maintaining the built facility. Transferring the responsibility of long-term O&M to a private constructor creates opportunities to leverage private sector expertise and to realize life cycle costs reduction by integrating delivery activities and private sector efficiencies (Garvin, 2003; FTA, 2006). There are usually provisions in DBOM contract that motivate the constructor to keep the O&M cost to the lowest possible amount. DBOM delivery method is primarily used for financial purposes in other countries and has been the most suitable delivery method for the public owners if the project initial costs are beyond the available funding resources (TCRP, 2002)

20) Maintainability: Maintainability is affected by the choice of delivery method in two different aspects: level of quality and ease of maintenance. This issue describes positive or negative effects of each delivery method on these two aspects.

DBB: The owner can check the maintainability of the finished design before awarding the project. Having check points in the design phase can help the owner assure the quality of the design of the end product.

CMR: The owner of a CMR project can benefit from all the advantages of DBB and also the constructor's advice on maintenance of the end product if the constructor has previously operated similar facilities.

DB: As the quality control is transferred to the design-builder and details of the design are not known at the time of awarding, many owners have some concerns about maintainability and quality of the end product. This has led some owners to require multi-year warranties from DB contractors.

DBOM: This delivery method works similar to DB but as O&M is included in the contract and the constructor is in charge of operating the facility after it is built, the owners have less concern about the quality and maintainability of the end product.

21) Sustainable Design Goals: Sustainable design is becoming ever more important in helping to achieve sustainability goals for the projects. The effect of delivery method in facilitating the process of implementing sustainability issues in the design is the focus of this discussion.

DBB: The Owner has a clear opportunity to define sustainable design intent and shape social and environmental impact. This method presents opportunities to promote and enhance sustainable design criteria by allowing for materials research and the development of strategic stakeholder input. One drawback may be that the O&M personnel could ultimately be unfamiliar with sustainable systems operational requirements, but this is an issue that can be resolved with careful planning.

CMR: The owner has a unique opportunity to realize the economic returns for sustainable systems performance as well as using sustainability as an evaluation factor for the selection of a builder. The design schedule could, however, outlive systems performance criteria and impact public participation limiting social equity issues.

DB: This project delivery method can result in an inherent coordination of design and performance with potential for accelerated economic returns for sustainable systems performance by shortening the project schedule. The owner has an opportunity to use multiple design-builders to present innovative designs that are consistent with clearly defined sustainable criteria. The owner can clearly articulate expectations regarding sustainability by assigning weight in relation to other factors in the DB evaluation plan. The design schedule could, however, impact public participation thereby limiting social equity issues. Due to the normally time consuming processes associated with municipal and state requirements for mandatory announcement and the convening of public hearings, certain sustainability measures such as wetlands mitigation and avoidance of undeveloped areas raises concerns for eminent domain and brown fields redevelopment which can impact time performance.

DBOM: While O&M personnel are intimately aware of sustainable requirements there may be limited access to incorporating evolving standards or expectations as well as restricted opportunities to “stretch the limits”. The DBOM can realize accelerated economic returns for sustainable systems performance since the owner/operator has an inherent bias toward minimizing operations and maintenance life cycle costs. The compressed timeframes could, however, impact public participation limiting social equity issues. Furthermore, O&M personnel may be unfamiliar with sustainable systems requirements. For example, materials may require alternate maintenance procedures, or systems controls may incorporate technologies requiring specialized training that may be beyond the scope of the initial proposal.

22) Sustainable Construction Goals: Sustainable construction is an important vehicle for achieving sustainability goals for new projects. The disconnect between designer and builder with some delivery methods can create limitations on the means and methods available to the project. The effect of a delivery method on facilitating the process of sustainable construction is the focus of this discussion.

DBB: An experienced constructor does not have opportunity to give sustainable design features as inputs during the design phase. The availability of sustainable materials and practices relevant to regional procurement and construction methodology may be unavailable to designers unfamiliar with the project location.

CMR: The owner has a unique opportunity to realize the economic returns for sustainable systems performance as well as using sustainability as an evaluation factor for the selection of a builder. Sustainable construction features are more likely to be implemented considering the cooperative nature of the owner/constructor contracts when using this delivery method.

DB: This project delivery method can result in an inherent coordination of design and performance with potential for accelerated economic returns for sustainable systems performance. The owner has an opportunity to use sustainability to evaluate potential

design-builders although innovation with sustainable criteria related to more advanced technology could be limited due to the lack of previous installations.

DBOM: There is an inherent coordination of design and performance with the requisite guaranteed ability to implement sustainable construction and operational features as designer, builder, and operator are contractually united. The DBOM can realize accelerated economic returns for sustainable systems performance since they have an inherent bias toward minimizing operations and maintenance life cycle costs. Added benefits can include participation in the development of evaluation criteria for new technologies as part of an ongoing review of installed systems and life-cycle costs.

Other Issues

The Other Issues category consists of issues that are important to project success but not categorized previously in this chapter.

23) Construction Claims: The effect of each delivery method in exposing the agency to potential conflicts and claims is studied under this issue. If a delivery method can reduce the exposure to construction claims, that delivery method is a favorable choice (“pro”), and if it increases the possibility of construction claims, it is an unfavorable choice (“con”).

DBB: This method typically has the highest occurrence of claims & disputes. Disputes arise often over authority, responsibility and quality (Walewski *et al*, 2001). Furthermore, as the owner is responsible for design completeness, errors and omissions claims is a common occurrence in DBB projects. Some contractors may bid low to win a job and try to enhance their final profit margin through claims and change orders, especially if design errors or ambiguities are present in the construction documents. Studies have shown that this delivery method resulted in the highest rate of cost growth which could be an indication of large number of claims (Konchar, 1998).

CMR: Assuming a well-structured contract, there is less probability for claims and disputes once a GMP is agreed upon and the contract is signed. As the CMR has been present during the design process there will be less need for information and clarification of the design documents. Some professionals consider that this approach will result in very few construction claims. This is then a major advantage of the CMR approach [Weber County SLC]. The qualifications-based selection methodology creates an effective deterrent to initiating claims by requiring the CMR to be “successful” on the current contract in order to be competitive for future projects. The qualifications-based selection process may reduce the possibility of hiring litigious contractors.

DB: A study shows that the size and frequency of change orders are less in DB (Riley *et al*, 2005). This delivery method is less prone to claims and disputes, assuming a well-structured contract. As an example, claims for design errors, a major source of DBB contractors’ complaints, is reduced considerably in DB. At the same time, early pricing leaves the owner vulnerable to claims for scope that was missing in the RFP. The qualifications-based selection methodology creates an effective deterrent to initiating claims by requiring the

design-builder to be “successful” on the current contract in order to be competitive for future projects.

DBOM: An advantage of DBOM is that at the time of the agreement between all the parties, the maximum level of contractual obligation is signed. In other words, all parties have obligated themselves not only for the construction phase but also for several years of O&M. This will minimize the challenges of start-up claims and system integration in complex projects (Kessler *et al*, 2005). On the other hand, if the DBOM contractor does not have the competencies and characteristics expected by the owner, or if the owner has not defined the scope of work adequately, the whole project will face difficulties during design, construction, and operation phases.

24) Adversarial Relationship: Transit projects can be hampered by conflicts between parties to the design and construction contracts. The higher the level of adversarial relationships in a project, the more likely the project will suffer from cost, schedule, and quality problems. Delivery methods define the relationships among all project parties. If the project delivery method encourages project parties to work together as a team to achieve the project goals and characteristics, it is considered a benefit (pro). Conversely, if the project delivery method increases the possibility of adversarial relationships, it is considered a detriment (“con”).

DBB: This delivery method can create an adversarial relationship between the parties and mainly between the owner and the construction contractor (Walewski *et al*, 2001; Irwin, 2003; Mahdi *et al*, 2005). Furthermore, the engineer and the contractor may assume adversarial roles as one is in charge of approving the other’s work. The division of responsibilities may also result in these two parties blaming each other in case of project failures or during major disputes (Halpin 2006).

CMR: Including construction contractor collaboration during design phase builds constructive team work and facilitates project team formation (Irwin, 2003; Minchin *et al*, 2007) although it requires extensive coordination of consultants and/or subcontractors.

DB: Single point of responsibility for design and construction decreases the potential for conflict between the engineer and constructor (Walewski *et al*, 2001; TCRP, 2002; Halpin 2006). Although there should be less blaming between the designer and the constructor (since they are both on the same team and they are jointly responsible to the agency for the success of the project.), instances of disputes between them (on the same DB team) were observed during our interviews [Greenbush, NJ Transit]. It is worth mentioning that design-builders may be deterred from submitting frivolous claims to owners who have future DB projects to avoid poisoning the well on a qualifications based selection system (QBS) by making the owner angry with a claim.

DBOM: The owner is more immune from disputes between DB and O&M personnel. This delivery method also decreases the start-up challenges and system integration during initial years of operation (Kessler *et al*, 2005). Despite this, disputes between team members such as systems and civil contractors can adversely affect the project.

Conclusion

The analysis done in this chapter is not deterministic or judgmental. It only describes the advantages and disadvantages of delivery methods in dealing with each of the pertinent issues discussed. This in turn helps identify strengths or weaknesses of each delivery method in coping with important factors that can affect project goals. This analysis provides a broad picture of the issues affecting project delivery methods and develops a basis for a decision system which is introduced in the following chapters. Also, it should be noted that in many cases, advantages and disadvantages listed are not absolute and should be considered in comparison with competing delivery methods.

CHAPTER 6 – TIER 1 – ANALYTICAL DELIVERY DECISION APPROACH

Introduction

No single project delivery method is appropriate for every project. Each project must be examined individually to determine how it aligns with the attributes of each available delivery method. The Tier 1 – Analytical Delivery Decision Approach provides transit agencies with a structured approach to choosing the most appropriate project delivery method for each individual project. The Tier 1 approach has three primary objectives:

- Present a structured framework to assist agencies in examining 24 critical issues involved in the project delivery decision;
- Assist agencies in determining if there is a dominant or obvious choice of project delivery methods; and
- Provide a structure for documenting the project delivery decision in the form of a Project Delivery Decision Report.

The Tier 1 approach provides a framework for agencies to define project goals and examine the advantages and disadvantages of each delivery method within the context of these goals. The motivation for this approach is to help agencies understand project delivery method attributes and to determine if their specific project goals align with the attributes of a particular delivery method. The Tier 1 approach also provides a “go/no go” review to determine if one or more project delivery methods should be excluded from the examination.

At the completion of Tier 1, there is a possibility that the agency may not have a single, clear and logical choice for a project delivery method. If this is the case, the agency will be advised to move to the Tier 2 or Tier 3 selection processes with the best delivery method options and create a more detailed analysis to select the final project delivery method.

The Tier 1 approach is comprised of six distinct steps listed below and shown in Figure 6.1

- Step 1. Create Project Description
- Step 2. Define Project Goals
- Step 3. Review Go/No Go Decision Points
- Step 4. Review Project Delivery Method Advantages and Disadvantages
- Step 5. Choose Most Appropriate Project Delivery Method
- Step 6. Document Results

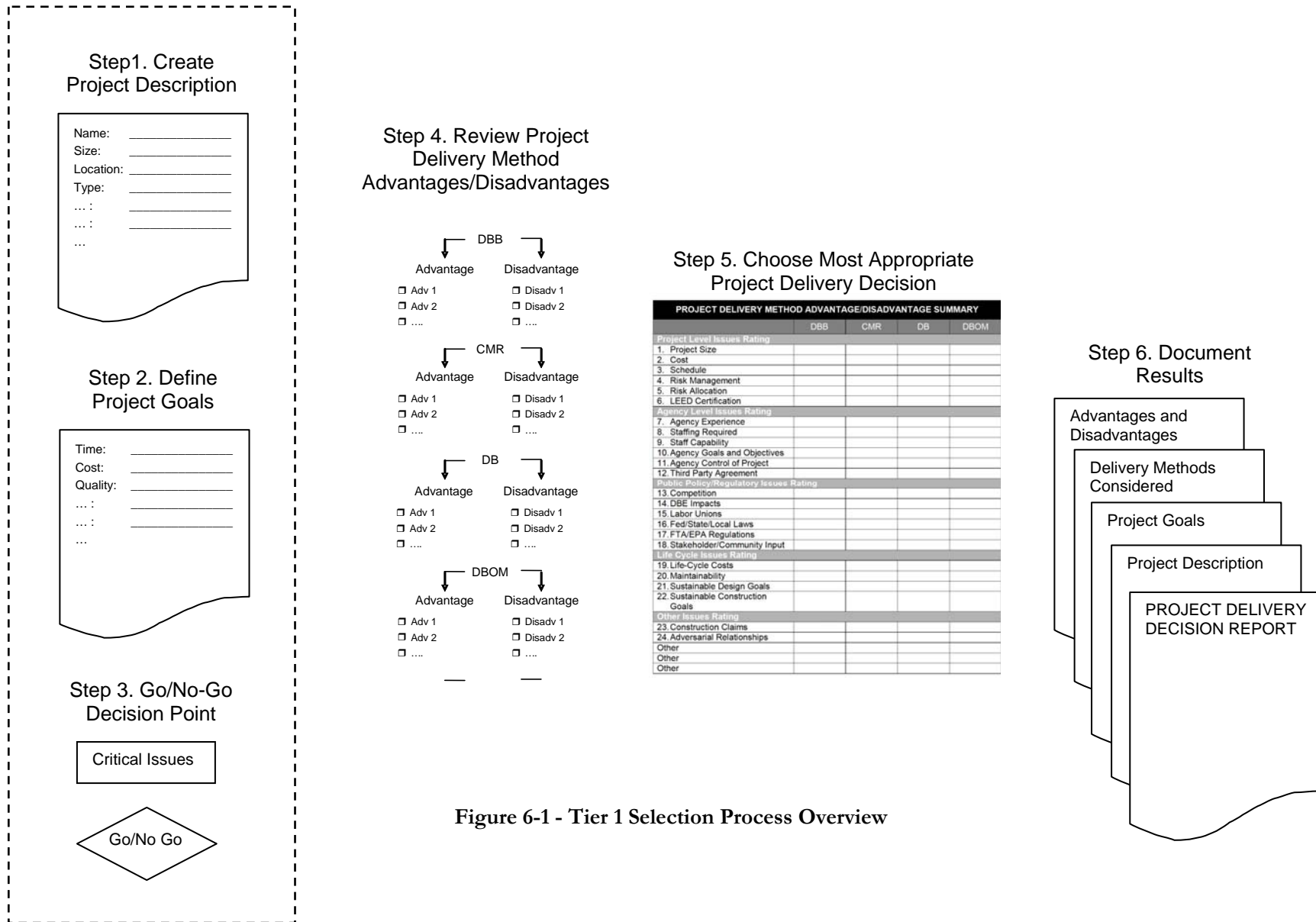


Figure 6-1 - Tier 1 Selection Process Overview

The objective of Step 1 is to create a project description in sufficient detail for documenting the project delivery decision. A template is provided to assist agencies in describing the appropriate level of detail. The description is provided to summarize only the key variables and provide a “snapshot” of the project scope at the time in which the project delivery decision was determined.

Research and practical experience have shown that the definition of project goals is a key success factor in the project delivery decision. The objective of Step 2 is to provide guidance to agencies on how to write and rank their project goals. The guidance provides general categories for goals. The section also provides a sample of goals from transit projects across the country as an illustration of how agencies have defined their project goals on a variety of project delivery methods.

The objective of Step 3 is to exclude those project delivery methods from consideration that are not viable options. A legal review of project delivery and procurement laws in the United States revealed that some alternative delivery methods are not allowed in all states. There are additional schedule and third party issues that could exclude a delivery method from consideration. Step 3 describes a quick “go/no-go” decision process to determine if certain delivery methods should be excluded from consideration.

Step 4’s primary objective is to present a comprehensive listing of generic *potential* advantages and disadvantages for each delivery method in 24 critical areas. *These potential advantages and disadvantages must be examined in the context of each individual project.* Variations in the *project* characteristics, the *people* involved, and the *processes* in use by the agencies (the “three Ps”) will determine if these potential issues are actual advantages or disadvantages for a particular project. Step 4 asks the agencies to consider these actual advantages and disadvantages and rate each project delivery method as “most appropriate, appropriate, least appropriate, or not applicable” for each of the 24 issues. A form for this rating and a structure for documenting comments are provided.

The objective of Step 5 is to make the final project delivery choice, given that a dominant or obvious choice exists. Upon transferring the 24 individual ratings from Step 4 into an overall summary, the process asks agencies to determine whether there is a dominant choice. Step 5 asks the agencies to consider the significant benefit as well as any risks or fatal flaws that might negate a delivery method even though the benefits make it a clear winner. If a dominant method is not apparent, the user will document the Tier 1 analysis and move to Tier 2 with the most applicable methods for further analysis.

The objective of the final step, Step 6, is to provide a framework for documenting the Tier 1 decision in the form of a Project Delivery Decision Report. The report will provide an archival record for the project delivery decision. It will serve to communicate the decision to interested stakeholders and to justify the decision if issues arise years later as the project is completed. The process organizes the report into sections that follow the five previous steps in the Tier 1 process – project description, project goals, delivery methods considered, advantages and disadvantages, delivery method decision, and any relevant appendices.

Step 1. Create Project Description

The first step in the delivery selection involves the creation of a concise project description that serves to communicate the important project characteristics to the decision makers and also to

document the project scope for the delivery decision report. Projects differ in their scope of work and their major elements (e.g., people involved, physical project characteristics, project duration, project budget, etc.). These distinguishing parameters affect the project delivery method selection. Agencies should choose the most appropriate delivery method on the basis of the project requirements and the opportunities that each delivery method can provide for them.

The objective of creating a project description is to explain the project in sufficient details to document the project delivery decision. The project description should be concise and also comprehensive. It should include the necessary information about the project and address all aspects of the project that may be influenced by the selected delivery method. The intent of the project description is to provide a “snapshot” of the project scope at the time in which the project delivery decision was determined. It will serve to communicate the decision to interested stakeholders and to justify the decision if issues arise years later as the project is completed. Listed below is a checklist of the important project characteristics that should be covered in the project description.

Project Description

- Project Name
- Location
- Mode of Transportation
- Estimated Budget
- Estimated Project Delivery Period
- Required Delivery Date (if applicable)
- Source(s) of Project Funding
- Project Type (In Street, Rail Corridor, etc.)
- Project Corridor or Site Dimensions
- Major Features of Work – track, stations, parking structures, platforms, etc.
- Ridership Forecast
- Rate of Return on Capital Investment/Payback Period (if applicable)
- Major Schedule Milestones
- Major Project Stakeholders
- Labor Union Status
- Major Challenges (as applicable)
 - With Right of Way, Utilities, and/or Environmental Approvals
 - During Construction Phase
 - During Operation and Maintenance
- Main Identified Sources of Risk
- Sustainable Design and Construction Requirements

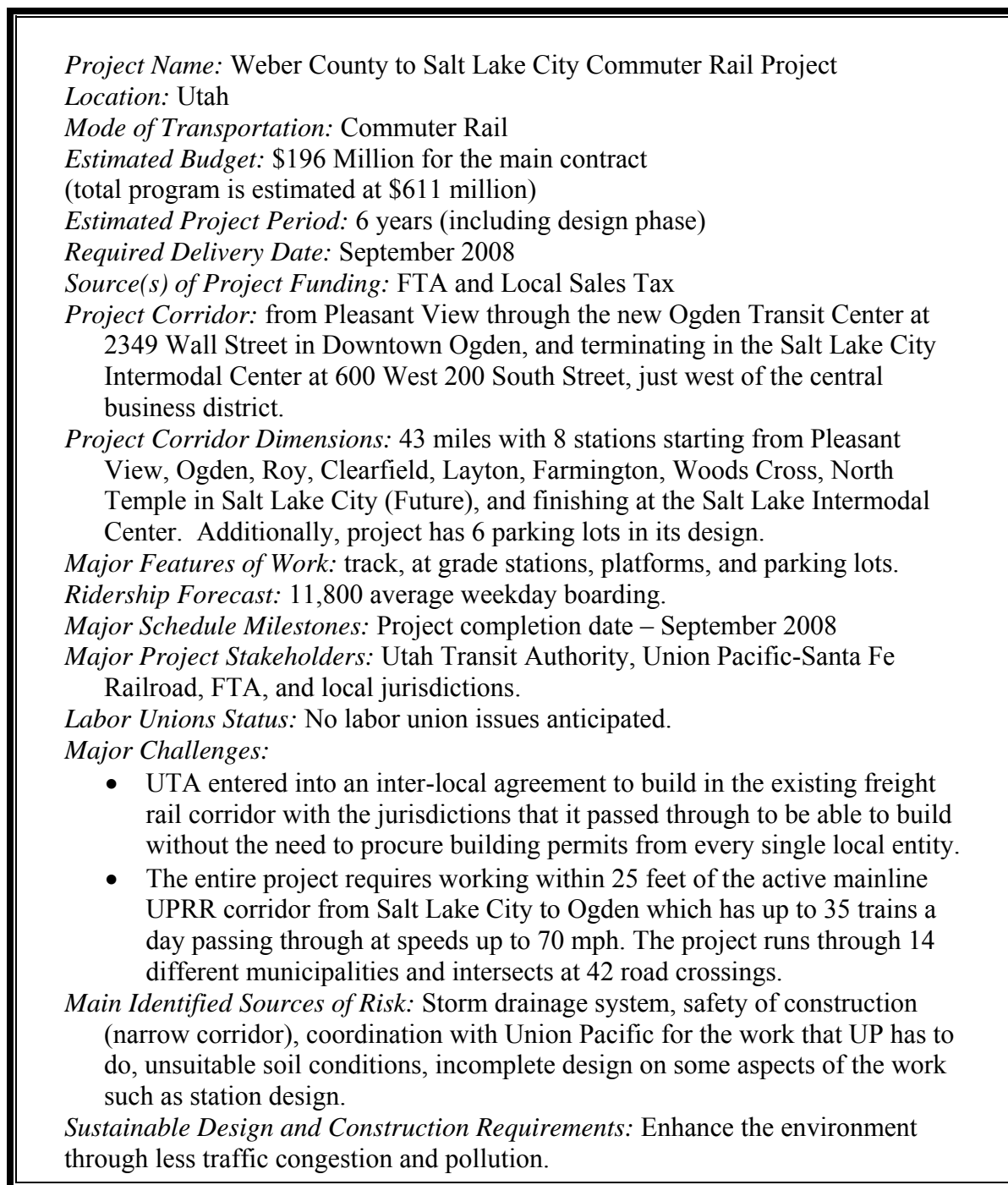


Figure 6-2 - Project Description Example

Step 2. Define Project Goals

Understanding and communicating a concise set of project goals is perhaps the most important element in selecting an appropriate project delivery method. The importance of project goals in

delivery method selection cannot be overemphasized in the guide. The definition of project goals is a key success factor in not only the project delivery decision, but also the development of procurement documents and the administration of a project. The project will have technical goals that must be met (e.g., meeting anticipated ridership, meeting design standards, meeting safety standards, etc.) and will also have performance goals regarding time, cost, quality, maintainability, and sustainability. It is the performance goals that typically drive the project delivery decision.

At project inception, the agency must identify the various performance aspects of the project to meet its requirements. Generally, these will fall into the categories of cost, schedule, and quality as defined by the technical design. Of these three factors, the project will normally have one which is the most important for this project's ultimate success – the preeminent factor. This preeminent factor is the factor for which the agency will sacrifice pieces of the other two to achieve the goal relating to this factor. A prime example of this comes from the University Line that was constructed for the Utah Transit Agency in Salt Lake City, Utah. While the Utah Transit Agency obviously had a fixed budget and certain standards to maintain with regard to quality, schedule was the preeminent factor because the project had to be finished prior to the start of the 2002 Winter Olympics and that factor was a primary reason why the Utah Transit Agency selected DB project delivery. In this case, the owner could not complete the necessary work using the traditional process in time to meet the deadline.

A clear and concise definition of project goals not only assists with selecting an appropriate project delivery method, but also provides the clear measure for project success and clear direction for the construction manager or design-builder to complete the project. These project goals set the stage for decision makers throughout the project life cycle and show them the priorities while analyzing different alternatives. Project goals provide input for choosing procurement method, risk allocation strategies, contracting, monitoring progress and at the end evaluating the project success.

To define project goals, thinking in terms of performance categories can be helpful. Time, cost, quality, and suitability are common categories. Table 6.1 below provides some generic goals in these categories.

Table 6-1 - Examples of Generic Project Goals

Generic Project Goals	
<p>Schedule</p> <ul style="list-style-type: none"> • Minimize project delivery time • Complete the project on schedule • Accelerate start of project revenue 	<p>Quality</p> <ul style="list-style-type: none"> • Meet or exceed project requirements • Select the best team
<p>Cost</p> <ul style="list-style-type: none"> • Minimize project cost • Maximize project budget • Complete the project on budget 	<p>Sustainability</p> <ul style="list-style-type: none"> • Minimize impact on the environment • Achieve LEED Certification

Choosing the goals that apply to a specific project is a first critical step in an agency's selection of delivery method. The second, and equally important step, is the ranking of the goals. Table 6.2 provides examples of goals from transit projects where alternative delivery methods were used.

Table 6-2 - Examples of Project Goals

Project	Delivery Method	Project Goals ⁷
Portland Mall Project, Oregon	CMR	<ol style="list-style-type: none"> 1. Work with builder to minimize disruption to businesses along ROW; 2. Minimize traffic control issues during construction; 3. Add auto and bike access routes in multi-modal approach; and 4. Enhance commitment to public art program furnishing space for expanded sculpture.
Weber County to Salt Lake City Commuter Rail, Utah	CMR	<ol style="list-style-type: none"> 1. Maximize cost effectiveness by the use of a 'bare bones/no frills' approach to design in order to meet the project budget and qualify for federal New Starts funding; 2. Deliver ridership by developing a system that delivers short trip duration and on-time performance; 3. Solicit federal funding 4. Develop means for outside local match dollars to be incorporated into the project; 5. Encourage the involvement in the project development process by including internal and external stakeholders; and 6. Build a sense of project ownership with the public and community stakeholders.
Transportation Expansion Project (TRES), Colorado	DB	<ol style="list-style-type: none"> 1. Minimize inconvenience to the community, motorists, and public; 2. Meet or beat the total program budget; 3. Provide for a quality project; and 4. Meet or beat the schedule of June 30, 2008.
Rail Runner Phase 2, New Mexico	DB	<ol style="list-style-type: none"> 1. Cost not to exceed project budget established at \$140,000,000; 2. High quality, safe, environmentally responsible, durable and maintainable project, that meets or exceeds all performance specifications and design criteria; 3. Minimum disruption to the traveling public during construction; 4. Contract awarded and Notice to Proceed (NTP) issued by August 31, 2007; 5. Completion of the entire Project by October 31, 2008, the Mandatory Completion Date, as specified in Contract Documents Part 1, Special Provision 108, Subsection 108.4.1; and 6. Valid basis for continued evaluation of D/B delivery system.
Hudson Bergen Light Rail	DBOM	<ol style="list-style-type: none"> 1. Increase project delivery speed from lengthy planning and slow design pace; 2. Seek innovation in cost savings throughout the lifecycle; 3. Seek innovative financing if possible; and 4. Maximize owner staffing capabilities.

The project goals in Table 6.2 vary in style and emphasis due to the unique project needs, but they all clearly link to the benefits of the project's delivery method. Take for example the Portland Mall project in Oregon, CMR was selected because there was a project goal of minimizing disruption to

⁷ The project goals from the TRES and Rail Runner projects were published in the Request for Proposals. The project goals for the Portland Mall project were published in the Tri-Metropolitan County Transportation District fact sheet. The Weber County to Salt Lake City Commuter Rail goals were published in internal project development documents. The Hudson Bergen Light Rail goals were stated in research interviews.

business and minimizing traffic control issues during construction. Construction Manager at Risk helps with both of the goals through early contractor involvement in design (something that is absent from the DBB method). Likewise in the TREX project, the design-builder's involvement in design helped to meet the agency's first goal of minimizing inconvenience. Additionally, the DB method's ability to confirm a fixed price and schedule early in design facilitates the goals of meeting or beating the total program budget and scheduled.

Although not all the goals in Table 6.2 are ranked, ranking of the project goals is important. On every project there are tradeoffs between schedule, cost, and quality. It is to the project's benefit if the agency, designers, and constructors are in alignment with these project goals. For example, the Rail Runner's first project goal is not to exceed the program budget and the third is to minimize inconvenience to the public. This ranking provides clear direction to the design-builders that maintenance of traffic is important, but not at the expense of exceeding the program budget.

As previously stated, understanding and communicating a concise set of project goals is perhaps the most important element in selecting an appropriate project delivery method. Agencies should take the time to identify project goals and achieve consensus on their relative importance. This time will be well spent as it will make the project delivery decision more clear. It will also help to define and communicate overall project success, thereby aligning the designers and constructors with the agency's project performance measures.

Step 3. Review Go/No-Go Decision Points

Among the pertinent issues that affect the project delivery decision, there are certain issues that render one or more delivery methods inappropriate. These issues involve project schedule constraints; federal, state, and local laws; third party agreements; and labor unions agreement. These issues and how they relate to the four primary delivery methods are shown in Table 6.3. The transit agency needs to review these issues to determine if they eliminate any of the delivery methods. In other words, the agency should make a "go/no-go decision" based on these pertinent issues. The result of this go/no-go study is a listing of delivery methods available to the agency and a documentation of those which are not available for further consideration. The flowchart in Figure 6.3 depicts a step-by-step approach to the decision; a description of the approach follows.

Table 6-3 - Go/No-Go Issue Summary

	DBB	CMR	DB	DBOM
Project Schedule Constraints	✓ / X			
Fed/State/Local Laws		✓ / X	✓ / X	✓ / X
Third Party Agreements			✓ / X	✓ / X
Labor Unions				✓ / X

Key: ✓ / X = Go/No-Go decision point

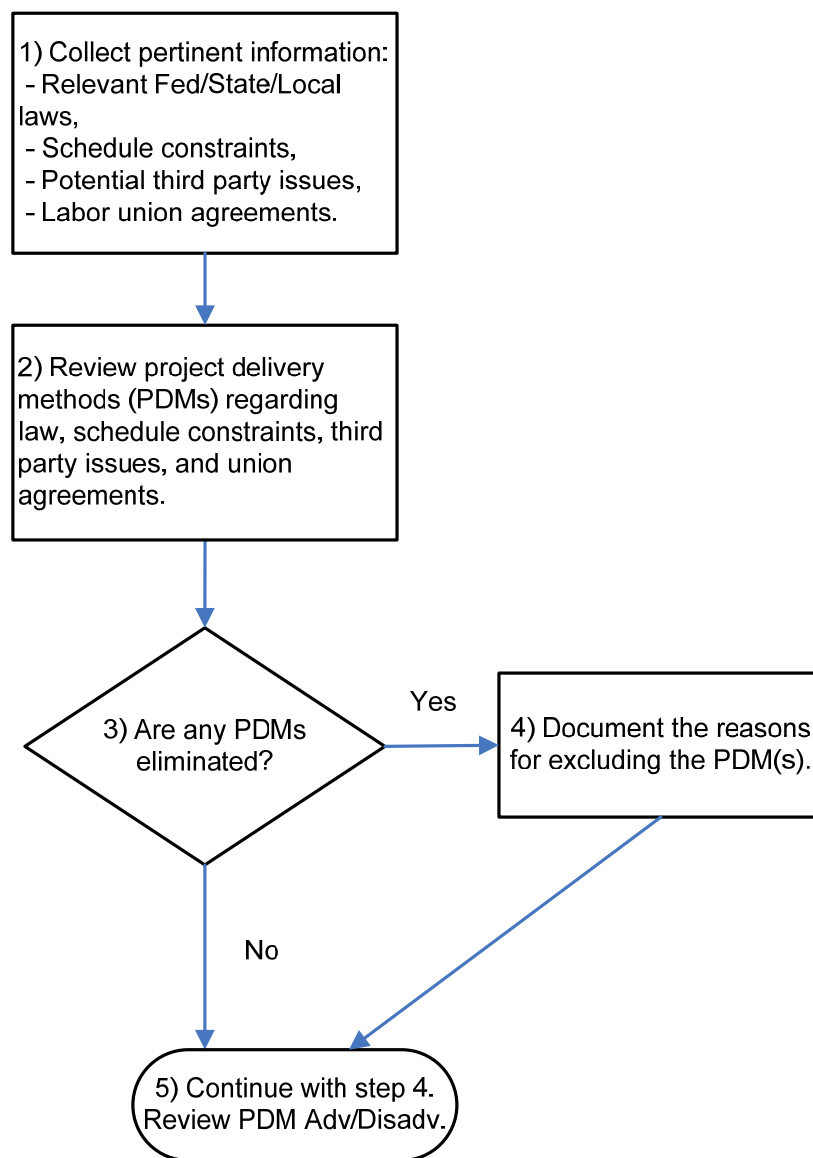


Figure 6-3 - Go/No-Go Decision Points

As depicted in the flowchart in Figure 6.3, the agency should first conduct research into the pertinent issues of project schedule constraints, federal, state, and local laws, third party agreements, and labor unions agreement. The agency should first review any major milestones that could create schedule constraints which would prohibit a traditional DBB delivery (e.g., an aggressive fixed end date, funding availability windows, etc.). Next, federal, state and local laws can be researched by the agency's general counsel to identify any constraints that must be met during the project delivery method selection process. For example, a jurisdiction that has a law that requires award of construction contracts to the low bidder may have to adopt the low-bid DB award method in order to use DB project delivery. The agency then needs to determine the third party agreements that will be required (e.g., railroad, utility, permitting, etc.). Last, the owner should collect any union agreements that deal with operations and maintenance issues of the transit system.

The agency's next step is to analyze the documents and information in relation to the constraints of each delivery method. As depicted in Table 6.3, each of the issues may exclude one or two of the delivery methods from further consideration. For example, if the project is located in a state where the law does not authorize CMR, this agency can eliminate CMR from the list of available options. Details follow for each of the go/no-go issues.

Project Schedule Constraints

The traditional DBB delivery method is a linear process that requires the longest delivery period of all four methods. If a DBB project delivery will not yield a finish date within the project's constraints, DBB need not be considered further. As mentioned in the previous section on project goals, project schedule can be a preeminent factor in project success. Agencies frequently give schedule the first priority of the competing project goals. Shortening of duration is the reason that agencies most frequently cite for using alternative methods.

Another case of schedule constraints involves an agency that would like to award construction before the design is complete, which the DBB method will not accommodate. This may occur when the agency has a fiscal year budget for construction and needs to award the project before the design is finished or if the agency has a window of opportunity to complete a portion of the project during an early work window before the design is complete (e.g., beginning construction before the end of the construction season).

Federal/State/Local Laws

The TCRP G08 research project conducted a comprehensive survey of federal and state laws as they pertain to alternative delivery methods. While some states have explicitly given full authorization to transit agencies to use CMR, DB and DBOM, there are still some states that prohibit the use of one or all alternative methods. In the spectrum between full use and prohibition, some states allow alternative project delivery methods with certain conditions (e.g., requiring extra approvals, putting dollar value limits on the volume of DB or CMR contracts, or putting limits on the number of projects using alternative delivery method in each year). Although the results of this search (based on state laws in December 2006) are included in the research report for reference, these laws often change and each transit agency is responsible to check the relevant state and local laws because of continuous change and evolution of these laws.

If the federal, state or local laws prohibit an agency from using an alternative delivery method, it should not be considered further. However, some agencies have determined that the use of an alternative delivery method was essential for project success and have been successful in drafting legislation to permit alternative delivery methods for a particular project or for general use. For example, DB was not permitted in the State of Colorado when the TREX project was envisioned. The Regional Transportation District in concert with the Colorado Department of Transportation was successful in helping to have legislation to permit design-build approved. These agencies pursued this approval as they developed the project scope. If an agency decides to take this path, it is wise to have a contingency plan for a traditional delivery in case the legislation is not approved. This contingency plan should be developed with an awareness of the duration of the process, the likelihood of achieving approval and also the benefits of using the alternative delivery method. Local laws may also put barrier on the use of a specific delivery method, so they should be checked along with the state laws.

Third Party Agreement

All major transit projects affect third parties and require agreements to manage the impacts. Some third parties require a completed set of construction documents to execute an agreement. In this case, the requirement for a complete design renders DB and DBOM inappropriate. For example, if the right of way is shared between the project and a railroad company, a full set of drawings may be required by the railroad company prior to signing an agreement or a memorandum of understanding (MOU). In such a project, depending on the circumstances and the rigidity of the third party, DB and DBOM might be eliminated from the list of available options.

Labor Unions

In the states where public sector labor unions are dominant, this issue may affect the choice of delivery methods. It primarily affects DBOM delivery in cases where public unions control the operation and maintenance of the transit project. Public labor unions can also affect DB delivery where transit agencies traditionally complete design with public sector designers. In both of these cases, agency maintenance employees or designers may not allow a delivery method that can outsource jobs to the public sector. In these cases, DBOM or DB may be eliminated from the list of available options.

Upon reviewing these four go/no-go issues, agencies will have a list of viable delivery methods to further consider. Additionally, they should document the reasons for excluding any methods from further consideration. Table 6.4 provides a form for summarizing this go/no-go analysis.

Table 6-4 - Go/No-Go Summary Form

	DBB	CMR	DB	DBOM
Project Schedule Constraints				
Fed/State/Local Laws				
Third Party Agreements				
Labor Unions				

Key: ✓ Applicable for further study
 X Not Applicable (discontinue evaluation of this method)

Comments _____

Step 4. Review Project Delivery Method Advantages and Disadvantages

Step 4 of the project delivery decision involves a critical examination of the advantages and disadvantages of each remaining delivery method. There is no single project delivery method that is appropriate for every project. The objective of this section is to determine how each project delivery method aligns with the project's goals, project characteristics, agency characteristics, policy/regulatory issues and life cycle requirements.

The process involves an examination of 24 separate issues relating to each delivery method. Upon examining each issue, the process asks users to relatively rate the delivery methods in terms of their appropriateness for each issue. The process can be summarized in the following steps.

- a. **Understand the Issue:** Read the brief description of each issue. Refer to Chapter three for an expanded description of the issue if needed.
- b. **Analyze the Delivery Methods:** Check the advantages and/or disadvantages of each delivery method *as they apply to the particular project in question*. Please note that these advantages and disadvantages are project dependent and may change with each new project analyzed. Again, refer to Chapter 3 for an expanded description of the issue if needed. *Analyze each check box and decide whether that check box is relevant or not. Do not attempt to check every box!*
- c. **Complete the Issue Summary Table:** Review the advantages and disadvantages that apply to each delivery method and analyze their implications. Complete the summary advantage/disadvantage table at the end of each section. A key is provided to rate each delivery method:
 - - most appropriate
 - ◐ - appropriate
 - - least appropriate
 - X - not applicable

Project Level Issues

1) Project Size

Project size reflects the dollar value and physical dimensions of the transit corridor.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> DBB has been shown to work on projects of all sizes.	<input type="checkbox"/> As projects grow in size, the amount of owner staffing required to oversee DBB can become very large.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<input type="checkbox"/> CMR has been shown to work on projects of all sizes.	<input type="checkbox"/> If not managed well, the use of multiple bid packages to facilitate CMR can be difficult.

DESIGN-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> DB has been shown to work on projects of all sizes. <input type="checkbox"/> Some owners have noted that DB can facilitate better management of large projects due to the single source of responsibility.	<input type="checkbox"/> As projects grow in size, there can be large peaks in owner staffing requirements with DB (e.g., during RFP development, during design review, etc.).

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<input type="checkbox"/> DBOM is appropriate for large projects. <input type="checkbox"/> Similarly to DB, DBOM can facilitate better management of large projects due to the single source of responsibility.	<input type="checkbox"/> DBOM is not appropriate for smaller project due to the overhead costs (e.g., for maintenance, etc.) <input type="checkbox"/> Similarly to DB, DBOM can necessitate large peaks in owner staffing requirements.

Table 6-5 - Project Size Advantages/Disadvantage Summary

	DBB	CMR	DB	DBOM
1. Project Size				

- Key:
- Most appropriate delivery method
 - Appropriate delivery method
 - Least appropriate delivery method
 - X Not Applicable (discontinue evaluation of this method)

Comments _____

2) Cost

This issue represents several aspects of project cost like ability to handle budget restrictions, early and precise cost estimation, and consistent control of project costs.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> Costs are known at bid time, before construction begins. <input type="checkbox"/> Project can benefit from low bid procurement. <input type="checkbox"/> Project can benefit from unit price bidding because quantities are defined prior to procurement. 	<ul style="list-style-type: none"> <input type="checkbox"/> Construction costs are not fixed (or locked in) until design is 100% complete. <input type="checkbox"/> Constructability advice and contractor innovations are not available to save cost until post bid. <input type="checkbox"/> The DBB process is prone to change orders and cost growth after award.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> CMR can be used in conjunction with a GMP pricing structure, which can be useful in negotiating and controlling costs. <input type="checkbox"/> If open book pricing can be used, all costs will be known by the owner. <input type="checkbox"/> Costs will be known earlier when compared to DBB. <input type="checkbox"/> Early constructor involvement or construction advice can lead to cost savings through value engineering and constructability reviews. 	<ul style="list-style-type: none"> <input type="checkbox"/> If multiple bid packages are used, the overall project cost could grow if later bid packages cost more than estimated. <input type="checkbox"/> If a GMP pricing structure is used, owners may have some difficulty in negotiation.

DESIGN-BUILD	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> If a lump sum pricing structure is used, costs will be fixed early in the project development process. <input type="checkbox"/> DB has been shown to have lower average cost growth than DBB or CMR. 	<ul style="list-style-type: none"> <input type="checkbox"/> If a lump sum pricing structure is used, constructors must develop prices before plans are 100% complete and therefore must assume some risk in pricing.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> Owner is provided with fixed cost for design, construction, and maintenance very early in the process. 	<ul style="list-style-type: none"> <input type="checkbox"/> Due to the large amount of risk being taken by the DBOM provider, costs may be higher if the providers are not given opportunities to find efficiencies. <input type="checkbox"/> DBOM pricing may be hard to negotiate due to the complexity and time frame of maintenance contracts.

Table 6-6 - Cost Advantages/Disadvantage Summary

	DBB	CMR	DB	DBOM
2. Cost				

- Key:
- Most appropriate delivery method
 - ◐ Appropriate delivery method
 - Least appropriate delivery method
 - ✕ Not Applicable (discontinue evaluation of this method)

Comments _____

3) Schedule

This factor shows two aspects of project schedule and includes both the ability to shorten the schedule and the opportunity to control and prevent time growth.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> None.	<input type="checkbox"/> Likely to yield longest delivery schedule. <input type="checkbox"/> Likely to yield the highest schedule growth. <input type="checkbox"/> There is a lack of opportunity to compress schedule due to the linear nature of DBB.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<input type="checkbox"/> Facilitates fast-tracking, or the ability to bid multiple design packages. <input type="checkbox"/> Studies have shown that CMR is faster on average than DBB, but slower than DB.	<input type="checkbox"/> Risk that overlapping design and construction packages may create delays if not properly coordinated. <input type="checkbox"/> Fast-tracking schedule will require owner effort in design and construction reviews.

DESIGN-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> Provides a single point of responsibility (DB contractor) for schedule control. <input type="checkbox"/> Provides early scheduled certainty. <input type="checkbox"/> Historically, provides the least schedule growth. <input type="checkbox"/> Provides opportunities for flexibility in schedule compression. <input type="checkbox"/> Studies have shown that DB is faster on average than DBB or CMR.	<input type="checkbox"/> Owner will sacrifice the checks and balances of having complete design prior to start of construction. <input type="checkbox"/> Rapid schedule will require owner effort in design and construction reviews.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> Provides a single point of responsibility (DB contractor) for schedule control. <input type="checkbox"/> Provides early scheduled certainty. <input type="checkbox"/> Historically, provides the least schedule growth. <input type="checkbox"/> Provides opportunities for flexibility in schedule compression. <input type="checkbox"/> Will facilitate start-up process due to a single point of responsibility for design, construction and operation. <input type="checkbox"/> Historically faster than DBB or CMR. 	<ul style="list-style-type: none"> <input type="checkbox"/> Owner will sacrifice the advantage of having complete design prior to start of construction. <input type="checkbox"/> Rapid schedule will require owner effort in design and construction reviews.

Table 6-7 - Schedule Advantages/Disadvantage Summary

	DBB	CMR	DB	DBOM
3. Schedule				

- Key:
- Most appropriate delivery method
 - Appropriate delivery method
 - Least appropriate delivery method
 - X Not Applicable (discontinue evaluation of this method)

Comments _____

4) Risk Management

The issue details methods to cope with project uncertainties that are inherent to each delivery method. For more detailed guidance, please see Tier 3 for a risk-based approach to selecting project delivery methods.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> Provides historically well defined and well understood risk management processes. <input type="checkbox"/> Prescriptive designs and specifications allow for greater detail in risk allocation. 	<ul style="list-style-type: none"> <input type="checkbox"/> Constructor cannot participate in risk management during design. <input type="checkbox"/> Constructor’s ability to manage risk is constrained by low-bid procurement.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<input type="checkbox"/> Construction manager understands and participates in risk management process during design.	<input type="checkbox"/> Risk management process can be more complex due to separate design, construction, and construction management contracts.

DESIGN-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> Single point of responsibility for risk management in design and construction.	<input type="checkbox"/> Owner may lose some ability to participate in the risk management process.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<input type="checkbox"/> Single point of responsibility for risk allocation in design, construction, operation and maintenance.	<input type="checkbox"/> Owner may lose some ability to participate in the risk management process for design, construction, operation, and maintenance.

Table 6-8 - Risk Management Advantages/Disadvantages Summary

	DBB	CMR	DB	DBOM
4. Risk Management				

- Key:
- Most appropriate delivery method
 - Appropriate delivery method
 - Least appropriate delivery method
 - X Not Applicable (discontinue evaluation of this method)

Comments _____

5) Risk Allocation

Each project delivery method has inherent risk allocation characteristics. The overarching goal should be to select the project delivery method with the best ability to assign project risks to the parties in best position to manage them.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> A clear risk allocation has been established due to history of use and statutory case law.	<input type="checkbox"/> Constructor cannot participate in risk allocation discussions during design. <input type="checkbox"/> Conflicts can exist in risk allocation between separate design and construction contracts.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> Construction manager understands and participates in risk allocation during design. <input type="checkbox"/> Prescriptive designs and specifications allow for greater detail in risk allocation. 	<ul style="list-style-type: none"> <input type="checkbox"/> Conflicts can exist in risk allocation between separate design, construction, and construction management contracts.

DESIGN-BUILD	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> Provides a single party for risk allocation in both design and construction. <input type="checkbox"/> Design-builder owns risk for design errors and omissions. 	<ul style="list-style-type: none"> <input type="checkbox"/> Risks must be allocated through conceptual design and performance specifications.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> Provides a single party risk allocation in design, construction and maintenance. <input type="checkbox"/> Constructor owns risk for design errors and omissions in construction, operations, and maintenance. 	<ul style="list-style-type: none"> <input type="checkbox"/> Risks must be allocated through conceptual design and performance specifications for design, construction, operation, and maintenance.

Table 6-9 - Risk Allocation Advantages/Disadvantages Summary

	DBB	CMR	DB	DBOM
5. Risk Allocation				

- Key:
- Most appropriate delivery method
 - Appropriate delivery method
 - Least appropriate delivery method
 - X Not Applicable (discontinue evaluation of this method)

Comments _____

6) LEED Certification

Each project delivery method has some inherent abilities to include features that will help in obtaining LEED Certification in accordance with the owner’s needs.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> LEED certification can be established in more detail during design period.	<input type="checkbox"/> Provides the least opportunity for constructor to participate in LEED process during design. <input type="checkbox"/> Separate design packages can create difficulty in coordinating LEED elements in construction.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<input type="checkbox"/> Construction manager can offer its construction expertise during design decisions that involve LEED issues.	<input type="checkbox"/> Separate design packages can create difficulty in coordinating LEED elements in construction.

DESIGN-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> Owner can use some LEED certification elements to select constructor. <input type="checkbox"/> Single point of responsibility is provided for LEED certification in design and construction.	<input type="checkbox"/> Owner may not be involved in all LEED decisions.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<input type="checkbox"/> Owner can use some LEED certification elements to select constructor. <input type="checkbox"/> In addition to having a single point of responsibility provided for LEED certification in design and construction, many LEED principles are in alignment with the constructor’s motivation to minimize operating costs.	<input type="checkbox"/> Owner may not be involved in all LEED decisions.

Table 6-10 - LEED Certification Advantages/Disadvantages Summary

	DBB	CMR	DB	DBOM
6. LEED Certification				

- Key:
- Most appropriate delivery method
 - Appropriate delivery method
 - Least appropriate delivery method
 - X Not Applicable (discontinue evaluation of this method)

Comments _____

Agency Level Issues

7) Agency Experience

The level of experience of an owner’s staff can affect the success of an alternative delivery methods application.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> Since this is the traditional method of project delivery, owners will likely have the most experience with this method.	<input type="checkbox"/> None.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<input type="checkbox"/> CMR is similar to DBB in many key aspects where agencies have experience (e.g., separation of design and construction).	<input type="checkbox"/> Agencies may not have experience with GMP pricing or the negotiation that can be involved. <input type="checkbox"/> Agencies may not have experience in the use of multiple bid packages to facilitate fast-track construction.

DESIGN-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> Agencies can take advantage of the sole point of responsibility for design and construction to leverage their experience.	<input type="checkbox"/> Agencies may not have experience authoring DB RFPs and conducting procurements. <input type="checkbox"/> Agencies may not have experience administering DB contracts, particularly in the area of design review and administration. <input type="checkbox"/> DB necessitates experienced staff to manage design and construction under one contract.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<input type="checkbox"/> Similar to DB, agencies can take advantage of the sole point of contact for design, construction and maintenance to leverage their experience.	<input type="checkbox"/> Agencies may not have experience authoring DBOM RFPs and conducting procurements. <input type="checkbox"/> Agencies may not have experience administering DBOM contracts, particularly in the area of design review and administration. <input type="checkbox"/> DBOM necessitates the most experienced staff to manage design, construction and maintenance under one contract.

Table 6-11 - Agency Experience Advantages/Disadvantages Summary

	DBB	CMR	DB	DBOM
7. Agency Experience				

- Key:
- Most appropriate delivery method
 - ◐ Appropriate delivery method
 - Least appropriate delivery method
 - ✗ Not Applicable (discontinue evaluation of this method)

Comments _____

8) Staffing Required

The total number of required owner’s employees for each delivery method is one measure of the extent of owner involvement. Another important measure for the owners is the variation in the number of staff required throughout the project development process.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> The separation of design and construction phases provides less variation in owner staffing levels.	<input type="checkbox"/> DBB typically requires a larger owner staff than the other delivery methods. <input type="checkbox"/> DBB typically requires a higher level of owner involvement.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<input type="checkbox"/> The CMR alternative can use the least number of owner staff if the CMR is allowed to take on the traditional owner tasks.	<input type="checkbox"/> The owner will need to have a number of staff with the ability to oversee and negotiate with the CMR during the process.

DESIGN-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> DB can greatly reduce the number of required owner staff. <input type="checkbox"/> Design and construction reviews can be done in shorter periods of time.	<input type="checkbox"/> DB creates peaks in owner staffing needs, particularly during procurement and design review periods. <input type="checkbox"/> While fewer owner staff is needed, more experienced staff is required.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> Similarly to DB, DBOM can greatly reduce the number of required owner staff. <input type="checkbox"/> Design and construction reviews can be done in shorter periods of time. 	<ul style="list-style-type: none"> <input type="checkbox"/> DBOM can create larger peaks in owner staffing needs during procurement and design review due to the inclusion of maintenance and finance issues involved in the process. <input type="checkbox"/> While fewer owner staff is needed, more experienced staff is required.

Table 6-12 - Staff Required Advantages/Disadvantages Summary

	DBB	CMR	DB	DBOM
8. Staff Required				

- Key:
- Most appropriate delivery method
 - Appropriate delivery method
 - Least appropriate delivery method
 - X Not Applicable (discontinue evaluation of this method)

Comments _____

9) Staff Capability

This issue regards owner’s requirement to furnish a highly capable staff to complete the duties it must undertake in each delivery method.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> DBB is traditionally aligned with owner staff capabilities. 	<ul style="list-style-type: none"> <input type="checkbox"/> As projects grow in size, more experienced staff is required. <input type="checkbox"/> Owner’s typically have different staff to oversee design and construction processes.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> The CMR can augment an owner’s capabilities with his own staff. 	<ul style="list-style-type: none"> <input type="checkbox"/> Owners must have experienced staff to oversee the CMR. <input type="checkbox"/> Owners may lack some capabilities in negotiating prices developing designs and managing the constructor’s inputs during the design phase.

DESIGN-BUILD	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> The owners will be able to rely on one source of responsibility for both design and construction. 	<ul style="list-style-type: none"> <input type="checkbox"/> Similarly to CMR, DB is an alternative delivery method and it is advisable to have staff members with DB oversight experience. <input type="checkbox"/> Owners will need capabilities to develop procurement documents and performance criteria. <input type="checkbox"/> Owners will need to have capabilities of reviewing design under a DB contract.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> The owners will be able to rely on one source of responsibility for design, construction, operations and maintenance. 	<ul style="list-style-type: none"> <input type="checkbox"/> Similarly to DB, DBOM is an alternative delivery method and it is advisable to have staff members with DBOM oversight experience. <input type="checkbox"/> Owners will need capabilities to develop procurement documents and performance criteria. <input type="checkbox"/> Owners will need capabilities to analyze complex financial proposals. <input type="checkbox"/> Owners will need to have capabilities of reviewing design under a DB contract.

Table 6-13 - Staff Capability Advantages/Disadvantages Summary

	DBB	CMR	DB	DBOM
9. Staff Capability				

- Key:
- Most appropriate delivery method
 - Appropriate delivery method
 - Least appropriate delivery method
 - X Not Applicable (discontinue evaluation of this method)

Comments _____

10) Agency Goals and Objectives

Agency goals define project success. The extent to which these goals align with the inherent attributes of each project delivery method has a significant bearing on delivery method selection.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> The DBB process allows for goals to be defined through the design process. 	<ul style="list-style-type: none"> <input type="checkbox"/> Separate design and construction contracts can make goals more difficult to align and manage. <input type="checkbox"/> If not developed correctly, detailed designs and prescriptive specifications can conflict with agency goals.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> Agency can involve the CMR in refinement of goals while working together to refine the scope and the GMP. <input type="checkbox"/> Qualifications-based construction manager selection can align the team with the project goals. 	<ul style="list-style-type: none"> <input type="checkbox"/> The agency must have the goals substantially developed when the construction manager contract is awarded. <input type="checkbox"/> The negotiation of a GMP may inhibit the alignment of project goals between the agency and the construction manager.

DESIGN-BUILD	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> Best-value design-builder selection can align the team with the project goals. <input type="checkbox"/> Properly written procurement performance criteria can help design-builders innovation to achieve project goals. 	<ul style="list-style-type: none"> <input type="checkbox"/> To ensure success, agencies must completely understand goals prior to awarding the DB contract.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> In addition to the DB advantages, DBOM allows owners to include life-cycle and maintenance goals into the contract. 	<ul style="list-style-type: none"> <input type="checkbox"/> Similar to DB, agencies must completely understand goals prior to awarding the DBOM contract.

Table 6-14 - Agency Goals and Objectives Advantages/Disadvantages Summary

	DBB	CMR	DB	DBOM
10. Agency Goals and Objectives				

- Key:
- Most appropriate delivery method
 - ◐ Appropriate delivery method
 - Least appropriate delivery method
 - X Not Applicable (discontinue evaluation of this method)

Comments _____

11) Agency Control of Project

The owner’s ability to control the detail of design and construction varies with each project delivery method. (Note that cost control and time control are described in other issues).

DESIGN-BID-BUILD	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> The use of prescriptive specifications and complete designs at the time of award provides agencies with the most control over the project. <input type="checkbox"/> Separate design and construction contracts provide clear checks and balances. 	<ul style="list-style-type: none"> <input type="checkbox"/> With additional control come added activities and responsibility for agency staff. <input type="checkbox"/> The DBB method can be prone to change orders if any design conflicts or constructability issues are found.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> The CMR method benefits from early constructor involvement, but still has the benefit of separate design and construction contracts. 	<ul style="list-style-type: none"> <input type="checkbox"/> Agency control of CMR delivery requires more effort due to the use of multiple design packages and the need for a GMP pricing structure.

DESIGN-BUILD	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> The transfer of design liability lessens the need for agency control over design. 	<ul style="list-style-type: none"> <input type="checkbox"/> Award at a conceptual design level means that the agency will loose control over the details of the final design.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> The transfer of design liability lessens the need for agency control over design and maintenance decisions. 	<ul style="list-style-type: none"> <input type="checkbox"/> Award at a conceptual design level means that the agency will lose control over the details of the final design. <input type="checkbox"/> Since the DBOM will be responsible for maintaining the project, the agency could lose control over the detail of some maintenance decisions.

Table 6-15 - Agency Control of Project Advantages/Disadvantages Summary

	DBB	CMR	DB	DBOM
11. Agency Control of Project				

- Key:
- Most appropriate delivery method
 - Appropriate delivery method
 - Least appropriate delivery method
 - X Not Applicable (discontinue evaluation of this method)

Comments _____

12) Third Party Agreement

Each delivery method can facilitate agreements with third parties, such as political entities, utilities, railroads, etc. in a different manner. The extent to which designers or constructors can facilitate third party agreements is the basis for the advantage and disadvantage of each delivery method.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> The use of complete plans and prescriptive specifications facilitates third party agreements.	<input type="checkbox"/> Expediting third party agreements in the DBB process can be cumbersome if it is required.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<input type="checkbox"/> Construction managers can help facilitate third party agreements.	<input type="checkbox"/> Construction managers typically do not guarantee costs involved with obtaining or which stem from problems with third party agreements.

DESIGN-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> Design-builders can use innovative methods to assist in obtaining third party agreements.	<input type="checkbox"/> Some third party agencies can have codes that negate the use of DB thereby excluding the DB method from consideration (see Step 3 Review Go/No-Go Decision Points). <input type="checkbox"/> Design-builders typically do not guarantee costs involved with obtaining or which stem from problems with third party agreements.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<input type="checkbox"/> Design-builders can use innovative methods to assist in obtaining third party agreements.	<input type="checkbox"/> Some third party agencies can have codes that negate the use of DBOM thereby excluding the DBOM method from consideration (see Step 3 Review Go/No-Go Decision Points). <input type="checkbox"/> Design-builders typically do not guarantee costs involved with obtaining or which stem from problems with third party agreements.

Table 6-16 - Third Party Agreement Advantages/Disadvantages Summary

	DBB	CMR	DB	DBOM
12. Third Party Agreement				

- Key:
- Most appropriate delivery method
 - ◐ Appropriate delivery method
 - Least appropriate delivery method
 - ✗ Not Applicable (discontinue evaluation of this method)

Comments _____

Public Policy/Regulatory Issues

13) Competition

Each delivery method may affect the level of competition. This concerns the evaluation of facilitating effects of each method on competition. Alternative project delivery methods allow agencies to package projects in sizes that can effectively enhance or reduce competition.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> Owner benefits from large pool of potential bidders and high level of competition.	<input type="checkbox"/> There are issues that follow low bid procurement such as a higher probability of request for change orders, disputes and claims.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<input type="checkbox"/> Qualifications-based selection factors can be applied to select only the most highly qualified construction managers.	<input type="checkbox"/> Presence of a constructor early in the project may give the owner less competitive leverage when pricing the construction.

DESIGN-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> Qualifications-based selection factors can be applied to select only the most highly qualified design-builders.	<input type="checkbox"/> Proposal package size and bid preparation costs can decrease the number of qualified bidders. <input type="checkbox"/> Opposition from public sector employees, unions or other interested parties can exclude the DB method from consideration (see Step 3 Review Go/No-Go Decision Points).

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> Qualifications-based selection factors can be applied to select only the most highly qualified design-builders. 	<ul style="list-style-type: none"> <input type="checkbox"/> Proposal package size and bid preparation costs can decrease the number of qualified bidders. <input type="checkbox"/> Lengthy contract duration and extra competencies required for O&M part of the contract decrease the number of bidders. <input type="checkbox"/> Opposition from public sector employees, unions or other interested parties can exclude the DBOM method from consideration (see Step 3 Review Go/No-Go Decision Points).

Table 6-17 - Competition Advantages/ Disadvantages Summary

	DBB	CMR	DB	DBOM
13. Competition				

- Key:
- Most appropriate delivery method
 - Appropriate delivery method
 - Least appropriate delivery method
 - X Not Applicable (discontinue evaluation of this method)

Comments _____

14) Disadvantaged Business Enterprise Impacts

The extent to which the delivery methods can be used to promote participation of disadvantaged businesses forms the advantages and disadvantages of this issue.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> Agencies can include DBE requirements in both design and construction requirements. <input type="checkbox"/> DBE involvement is known at time of award for design and construction. 	<ul style="list-style-type: none"> <input type="checkbox"/> Low bidding environment may harm future viability of DBE companies.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<ul style="list-style-type: none"> <input type="checkbox"/> Agencies can include DBE requirements in both design and construction requirements. <input type="checkbox"/> DBE involvement is known at time of award for design and construction. 	<ul style="list-style-type: none"> <input type="checkbox"/> Due to the phased nature of CMR contracts, the final DBE involvement may not be known until the project is ultimately completed.

DESIGN-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> Agencies can include DBE requirements in the RFP for design and construction requirements.	<input type="checkbox"/> Owners can set DBE requirements, but because all subcontractors are not known at the time of award, there is a risk that design-builders may not achieve the DBE goals they specify in their proposals.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<input type="checkbox"/> Agencies can include DBE requirements in the RFP for design, construction, and maintenance requirements.	<input type="checkbox"/> Owners can set DBE requirements, but because all subcontractors are not known at the time of award, there is a risk that design-builders may not achieve the DBE goals they specify in their proposals.

Table 6-18 - DBE Impacts Advantages/Disadvantages Summary

	DBB	CMR	DB	DBOM
14. DBE Impacts				

- Key:
- Most appropriate delivery method
 - Appropriate delivery method
 - Least appropriate delivery method
 - X Not Applicable (discontinue evaluation of this method)

Comments _____

15) Labor Unions

The choice of delivery method may have an impact on labor usage and hence labor union issues. These issues can be both internal to the transit agency as well as external with its contractors.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> The DBB process is well established, so there is generally no fundamental opposition from unions.	<input type="checkbox"/> None.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<input type="checkbox"/> Similar to DBB, there is generally no fundamental opposition from unions.	<input type="checkbox"/> Construction managers do not generally guarantee prices if there are issues with labor unions.

DESIGN-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> None.	<input type="checkbox"/> Opposition from public design unions can exclude the DB method from consideration (see Step 3 Review Go/No-Go Decision Points). <input type="checkbox"/> Design-builders do not generally guarantee prices if there are issues with labor unions.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<input type="checkbox"/> None	<input type="checkbox"/> Opposition from public design unions can exclude the DBOM method from consideration (see Step 3 Review Go/No-Go Decision Points). <input type="checkbox"/> Opposition from public maintenance unions can exclude the DB method from consideration (see Step 3 Review Go/No-Go Decision Points). <input type="checkbox"/> Design-builders do not generally guarantee prices if there are issues with labor unions.

Table 6-19 - Labor Unions Advantages/Disadvantages Summary

	DBB	CMR	DB	DBOM
15. Labor Unions				

- Key:
- Most appropriate delivery method
 - Appropriate delivery method
 - Least appropriate delivery method
 - ✗ Not Applicable (discontinue evaluation of this method)

Comments _____

16) Fed/State/Local Laws

Use of some delivery methods may not be allowed for transit agencies due to state or local laws. Some of the states mandate that the transit agencies go through several steps before being allowed to use an alternative delivery method. The level of difficulty of using a delivery method from a legal standpoint constitutes the advantages and disadvantages of this issue.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> All states are authorized to use DBB.	<input type="checkbox"/> None.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<input type="checkbox"/> Some states allow more flexible procurement regulations with CMR, which can be advantageous in appropriate situations to expedite project development.	<input type="checkbox"/> Some state agencies are not authorized to use CMR or need to get extra approvals (see Step 3 Review Go/No-Go Decision Points).

DESIGN-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> Some states allow more flexible procurement regulations with DB, which can be advantageous in appropriate situations to expedite project development.	<input type="checkbox"/> Some state agencies are not authorized to use DB or need to get extra approvals (see Step 3 Review Go/No-Go Decision Points).

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<input type="checkbox"/> Some states allow more flexible procurement regulations with DBOM, which can be advantageous in appropriate situations to expedite project development.	<input type="checkbox"/> State laws and regulations for DBOM are similar to DB (see Step 3 Review Go/No-Go Decision Points).

Table 6-20 - Fed/State/Local Laws Advantages/ Disadvantages Summary

	DBB	CMR	DB	DBOM
16. Fed/State/Local Laws				

- Key:
- Most appropriate delivery method
 - Appropriate delivery method
 - Least appropriate delivery method
 - X Not Applicable (discontinue evaluation of this method)

Comments _____

17) FTA/EPA Regulations

The extent to which the various delivery methods can facilitate FTA requirements and EPA regulations given the unique project characteristics constitutes the advantages and disadvantages of this issue.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> Familiarity of agencies with this method facilitates permit and funding process.	<input type="checkbox"/> The final cost and schedule are established long after the Full Funding Grant Authorization (FFGA) which can be problematic if FFGA cost and schedule estimates are not met.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<input type="checkbox"/> Construction managers can help facilitate the environmental process.	<input type="checkbox"/> The use of a GMP with separate design and construction packages can result in a final cost and schedule confirmation long after the FFGA.

DESIGN-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> FTA has gained some experience and has modified its procedures to use DB. <input type="checkbox"/> Cost and schedule are fixed near the FFGA.	<input type="checkbox"/> The design required to acquire environmental permits before hiring a design-builder may cause delays and negate some of the advantages of the DB method.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<input type="checkbox"/> FTA has gained some experience and has modified its procedures. <input type="checkbox"/> Cost and schedule are fixed near the FFGA.	<input type="checkbox"/> The design required to acquire environmental permits before hiring a design-builder may cause delays and negate some of the advantages of the DB method.

Table 6-21 - FTA/EPA Regulations Advantages/Disadvantages Summary

	DBB	CMR	DB	DBOM
17. FTA/EPA Regulations				

- Key:
- Most appropriate delivery method
 - Appropriate delivery method
 - Least appropriate delivery method
 - X Not Applicable (discontinue evaluation of this method)

Comments _____

18) Stakeholder/Community Input

This issue addresses the opportunity for stakeholder involvement afforded by the delivery methods.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> Separate design and construction phase gives opportunity to get stakeholders' inputs before the commencement of construction.	<input type="checkbox"/> The opportunity for stakeholder changes in design can cause delay in the project.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<input type="checkbox"/> The construction experience of the construction manager can help facilitate stakeholder input.	<input type="checkbox"/> Stakeholder input can make GMP negotiation troublesome if not managed correctly.

DESIGN-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> The owner can require the DB contractor to include a public information and outreach program to facilitate communities' inputs. <input type="checkbox"/> Design-builders can be innovative in helping gain community involvement.	<input type="checkbox"/> Any change because of community inputs after the issuance of RFP can be costly.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<input type="checkbox"/> The owner can require the DB contractor to include a public information and outreach program to facilitate communities' inputs. <input type="checkbox"/> Design-builders can be innovative in helping gain community involvement.	<input type="checkbox"/> Any change because of community inputs after the issuance of RFP can be costly.

Table 6-22 - Stakeholder/Community Input Advantages/Disadvantages Summary

	DBB	CMR	DB	DBOM
18. Stakeholder/Community Input				

- Key:
- Most appropriate delivery method
 - Appropriate delivery method
 - Least appropriate delivery method
 - ✘ Not Applicable (discontinue evaluation of this method)

Comments _____

Life-Cycle Issue

19) Life-Cycle Costs

Delivery methods can influence costs in the operation and maintenance phase. This issue focuses on the opportunities or barriers that each delivery method provides in regards to life-cycle costs.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> The agency can controls life-cycle costs through completed design and performance specifications.	<input type="checkbox"/> The DBB system allows for little constructor input into life-cycle costs.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<input type="checkbox"/> CMR has all benefits of DBB, plus the agency can leverage construction manager’s input into life-cycle costs.	<input type="checkbox"/> If life-cycle performance criteria are not well understood during the development of the GMP, life-cycle issues may be difficult to incorporate into the final product.

DESIGN-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> The agency can use performance criteria to set life-cycle performance standards and rely on design-builder innovation to achieve these standards.	<input type="checkbox"/> If life-cycle performance criteria are not well understood at the procurement stage, they will not be incorporated into the DB contract.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<input type="checkbox"/> The design-builder is responsible for maintenance in the DBOM contract and will be highly motivated to provide optimal life-cycle designs. <input type="checkbox"/> The agency can use performance criteria to set life-cycle performance standards and rely on design-builder innovation to achieve these standards.	<input type="checkbox"/> The agency will not have complete control over all life-cycle issues that are not included as performance criteria in the contract.

Table 6-23 - Life-Cycle Costs Advantages/Disadvantages Summary

	DBB	CMR	DB	DBOM
19. Life-Cycle Costs				

- Key:
- Most appropriate delivery method
 - Appropriate delivery method
 - Least appropriate delivery method
 - X Not Applicable (discontinue evaluation of this method)

Comments _____

20) Maintainability

There can be advantages and disadvantages to each delivery method in regards to how maintainability is achieved. This issue describes these advantages and disadvantage as it relates to the owner’s ability to specific quality and ease of maintenance.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> The opportunity to view completed plans before award allows agencies to review maintenance issues in designs.	<input type="checkbox"/> There is little opportunity for constructors to have input into maintenance issues.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<input type="checkbox"/> CMR has all benefits of DBB, plus the agency can leverage construction manager’s input into maintenance issues.	<input type="checkbox"/> If maintainability issues are not well understood during the development of the GMP, they may be difficult to incorporate into the final product.

DESIGN-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> The agency can emphasize maintainability issues through performance criteria and best-value award factors.	<input type="checkbox"/> If maintainability issues are not well understood at the procurement stage, they will not be incorporated into the DB contract.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<input type="checkbox"/> The design-builder is responsible for maintenance in the DBOM contract and will be highly motivated to provide optimal life-cycle designs. <input type="checkbox"/> The agency can emphasize maintainability issues through performance criteria and best-value award factors.	<input type="checkbox"/> The agency will not have complete control over all maintainability issues that are not included as performance criteria in the contract.

Table 6-24 - Maintainability Advantages/Disadvantages Summary

	DBB	CMR	DB	DBOM
20. Maintainability				

- Key:
- Most appropriate delivery method
 - ◐ Appropriate delivery method
 - Least appropriate delivery method
 - ✕ Not Applicable (discontinue evaluation of this method)

Comments _____

21) Sustainable Design Goals

Sustainable design is becoming ever more important in achieving overall sustainability goals for the projects. The effect of delivery method in facilitating the process of implementing sustainability issues in the design is the focus of this issue.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> Agencies can work with designers to incorporate sustainable designs into complete designs.	<input type="checkbox"/> The process provides little opportunity for constructability reviews to ensure that sustainable designs can be constructed efficiently and are not cost prohibitive.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<input type="checkbox"/> CMR has all benefits of DBB, plus the agency can leverage construction manager’s input into sustainable design issues.	<input type="checkbox"/> The use of separate bid packages can create barriers in the integration of sustainable solutions if not approached correctly.

DESIGN-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> The agency can emphasize sustainable design issues through performance criteria and best-value award factors. <input type="checkbox"/> Integration of the design and construction team can enhance constructability of designs.	<input type="checkbox"/> If sustainable design issues are not well understood at the procurement stage, they will not be incorporated into the DB contract.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<input type="checkbox"/> The agency can emphasize sustainable design issues through performance criteria and best-value award factors. <input type="checkbox"/> Integration of the design and construction team can enhance constructability of designs. <input type="checkbox"/> DBOM contractors can realize economic returns for sustainable designs since they have an inherent bias toward minimizing operations and maintenance life cycle costs.	<input type="checkbox"/> If sustainable design issues are not well understood at the procurement stage, they will not be incorporated into the DB contract.

Table 6-25 - Sustainable Design Goals Advantages/Disadvantages Summary

	DBB	CMR	DB	DBOM
21. Sustainable Design Goals				

- Key:
- Most appropriate delivery method
 - ◐ Appropriate delivery method
 - Least appropriate delivery method
 - ✗ Not Applicable (discontinue evaluation of this method)

Comments _____

22) Sustainable Construction Goals

Sustainable construction is an important vehicle for achieving overall sustainability goals as well. The effect of delivery method in facilitating the process of sustainable construction is the focus of this issue.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> Prescriptive specifications can be used to define sustainable construction practices prior to construction.	<input type="checkbox"/> There is little opportunity or incentive for constructor to do more than what is specified in terms of sustainable construction practices. <input type="checkbox"/> Agencies can assume liability when prescribing construction methods.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<input type="checkbox"/> The agency can leverage construction manager's input into sustainable construction issues.	<input type="checkbox"/> The use of separate bid packages can create barriers in the integration of sustainable solutions if not approached correctly.

DESIGN-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> The agency can emphasize sustainable construction issues through performance criteria and best-value award factors. <input type="checkbox"/> Integration of the design and construction team can enhance the use of sustainable construction practices.	<input type="checkbox"/> If sustainable construction issues are not well understood at the procurement stage, they will not be incorporated into the DB contract.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<input type="checkbox"/> DBOM contractors can realize economic returns for sustainable designs since they have an inherent bias toward minimizing operations and maintenance life cycle costs.	<input type="checkbox"/> If sustainable construction issues are not well understood at the procurement stage, they will not be incorporated into the DBOM contract.

Table 6-26 - Sustainable Construction Goals Advantages/Disadvantages Summary

	DBB	CMR	DB	DBOM
22. Sustainable Construction Goals				

- Key:
- Most appropriate delivery method
 - Appropriate delivery method
 - Least appropriate delivery method
 - X Not Applicable (discontinue evaluation of this method)

Comments _____

Other Issues

23) Construction Claims

The effect of each delivery method in exposing the agency to potential conflicts and claims is addressed under this issue.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> DBB has well understood legal precedent for construction claims.	<input type="checkbox"/> DBB historically has the highest occurrence of claims and disputes, which often occur in the areas of authority, responsibility and quality. <input type="checkbox"/> The low bid environment can provide incentives for constructor to file claims – particularly if any ambiguity in plans exist.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<input type="checkbox"/> Having the constructor on the team early during design can lessen the likelihood for disputes and claims regarding designs.	<input type="checkbox"/> Since design and construction contracts are separate, the potential for disputes and claims regarding design still exist. <input type="checkbox"/> If multiple bid packages are not managed correctly, the coordination of these bid packages can result in claims.

DESIGN-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> The single source for design and construction eliminates claims for design errors or omissions from the agency’s perspective.	<input type="checkbox"/> There is potential for claims in regards to scope definition if the form of the DB contract is not well understood.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<input type="checkbox"/> DBOM has similar advantages to DB and additionally eliminates claims regarding operating performance due to the integration of the operator.	<input type="checkbox"/> There is potential for claims in regards to scope definition if the form of the DBOM contract is not well understood.

Table 6-27 - Construction Claims Advantages/Disadvantages Summary

	DBB	CMR	DB	DBOM
23. Construction Claims				

- Key:
- Most appropriate delivery method
 - Appropriate delivery method
 - Least appropriate delivery method
 - ✗ Not Applicable (discontinue evaluation of this method)

Comments _____

24) Adversarial Relationship

The extent to which a delivery method can avoid adversarial relationships on the project team varies depending upon the nature of the project and the owner’s experience with the delivery methods.

DESIGN-BID-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> Roles and responsibilities in DBB contract are very well understood in the industry.	<input type="checkbox"/> DBB can create an adversarial relationship between the parties; primarily between the owner and construction contractor.

CONSTRUCTION MANAGEMENT AT RISK	
Advantages	Disadvantages
<input type="checkbox"/> Inclusion of the construction manager in the design process can align team members and lessen adversarial relationships.	<input type="checkbox"/> Negotiation of GMP can create an adversarial situation if the process is not well understood.

DESIGN-BUILD	
Advantages	Disadvantages
<input type="checkbox"/> Inclusion of the designer and constructor on the same team can lessen adversarial relationships.	<input type="checkbox"/> Due to the loss of control over the details of design, DB requires a high level of trust between the owner and design-builder. Without this trust, design-build can become adversarial.

DESIGN-BUILD-OPERATE-MAINTAIN	
Advantages	Disadvantages
<input type="checkbox"/> Inclusion of the designer, constructor and maintenance contractor on the same team can lessen adversarial relationships.	<input type="checkbox"/> Similar to DB, a DBOM delivery requires a high level of trust to succeed.

Table 6-28 - Adversarial Relationship Advantages/Disadvantages Summary

	DBB	CMR	DB	DBOM
24. Adversarial Relationship				

- Key:
- Most appropriate delivery method
 - Appropriate delivery method
 - Least appropriate delivery method
 - X Not Applicable (discontinue evaluation of this method)

Comments _____

Step 5. Choose the Most Appropriate Project Delivery Method

Steps 1-4 of the process provide all the individual pieces of the information to make a project delivery decision. The final step involves combining this information into a final comprehensive format that will aid in the decision. Table 6.29 presents a table to summarize the advantages and disadvantages. Following the table is an outline for documenting the final decision. Step 5 requires the following steps:

- a. **Review Project Goals:** Review the project goals documented in Step 2 to be certain that any project delivery method selection is in alignment with the goals.
- b. **Transfer Issue Summary Ratings:** Transfer the summary ratings from end of each issue analysis to Table 6-29 to provide a complete picture of the analysis.
- c. **Review Table 6-29 for Dominant Delivery Method:** Upon completing Table 6.29, a delivery method may rise to be dominant. A dominant delivery method will contain a large number of “Most Appropriate” ratings in areas that align with the project goals. A dominant method will also have few or no “Least Appropriate” ratings. Counting or translating the ratings should be avoided. If needed, review any comments from the previous issue analysis to help with the delivery decision.

Note: If dominant method exists, make delivery choice and move to Step 6.

- d. **Review “Least Appropriate” Ratings:** Review any “Least Appropriate” ratings to determine if any of the issues create red flags or problems that would make a delivery method significantly less desirable.
- e. **Choose Delivery Methods to Study in Tier 2:** If a dominant method is not apparent, remove any inappropriate methods, document the decision as described in Step 6, and move to Tier 2 for a more detailed analysis.

Table 6-29 - Project Delivery Method Advantage/Disadvantage Summary

PROJECT DELIVERY METHOD ADVANTAGE/DISADVANTAGE SUMMARY				
	DBB	CMR	DB	DBOM
Project Level Issues Rating				
1. Project Size				
2. Cost				
3. Schedule				
4. Risk Management				
5. Risk Allocation				
6. LEED Certification				
Agency Level Issues Rating				
7. Agency Experience				
8. Staffing Required				
9. Staff Capability				
10. Agency Goals and Objectives				
11. Agency Control of Project				
12. Third Party Agreement				
Public Policy/Regulatory Issues Rating				
13. Competition				
14. DBE Impacts				
15. Labor Unions				
16. Fed/State/Local Laws				
17. FTA/EPA Regulations				
18. Stakeholder/Community Input				
Life Cycle Issues Rating				
19. Life-Cycle Costs				
20. Maintainability				
21. Sustainable Design Goals				
22. Sustainable Construction Goals				
Other Issues Rating				
23. Construction Claims				
24. Adversarial Relationships				
Other				
Other				
Other				

- Key:
- Most appropriate delivery method
 - ◐ Appropriate delivery method
 - Least appropriate delivery method
 - X Not Applicable (discontinue evaluation of this method)

Project Goals and Pertinent Issue Comments

Step 6. Document Results

The final step in the Tier 1 decision process is to document the results in a Project Delivery Selection Report. Whether one delivery method rises to be the dominant choice or none of the four delivery methods are eliminated from consideration in the process, documentation is a vital step. Documentation will assist in developing procurement and contracting strategies for the ultimate project delivery method. It will also serve to communicate the project delivery choice to interested stakeholders.

The six-step process forms the basis for the Project Delivery Selection Report. Steps 1 to 5 can be combined for a complete report. The advantage/disadvantage checklist and the related comments will be important to documentation. An executive summary should be added to the beginning of the report to summarize the decision. Any pertinent data or research (e.g., schedule constraint calculations, delivery code research, etc.) should be added as appendices. A report outline is offered below.

- Project Delivery Decision Report Outline
 - Executive Summary
 - Project Description
 - Project Goals
 - Delivery Methods Considered
 - Advantages and Disadvantages
 - Delivery Method Decision
 - Appendices

Conclusions

The Tier 1 Analytical Delivery Decision Approach provides transit agencies with a structured approach to choosing the most appropriate project delivery method for each individual project. At the end of Step 5, there may be a single, clear and logical choice for a project delivery method. If this is the case, choose that delivery method and document the decision through a Project Delivery Decision Report. If at the end of this stage, a dominant choice does not appear, the agency should document the results and move to the Tier 2 selection process for a more detailed analysis of the remaining delivery methods.

CHAPTER 7 – TIER 2 – WEIGHTED-MATRIX DELIVERY DECISION APPROACH

Introduction

The Tier 2 Weighted-Matrix Delivery Decision Approach provides a means for owners to further examine and document a project delivery decision for an individual project. In the case that an obvious choice was not found in the Tier 1 Analytical Delivery Decision Approach, the Tier 2 approach provides owners with a process to select a delivery method by prioritizing project objectives and selecting the delivery method that best aligns with these objectives. The Tier 2 Weighted-Matrix Delivery Approach is founded upon successful delivery decision tools developed by academics and professionals over the past 20 years (Loulakis 2000; CII 2003; Skitmore & Marsden 1988).

Owners should complete a Tier 1 review before conducting a Tier 2 review. The Tier 1 review provides owners with two key pieces of information. First, Tier 1 requires owners to define their project goals in terms of cost, schedule, quality, maintainability, sustainability, and other options. These project goals are critical to the Tier 2 review. Second, Tier 1 provides a short list of available project delivery options. Only those project delivery methods that are feasible and which have the best potential for a successful application will pass through the Tier 1 filtering process. The filtering process involves an examination of go/no-go issues and also an examination of 24 critical issues involved in the project delivery decision. Knowledge of these critical issues will be helpful in the Tier 2 decision-making process.

The Tier 2 approach has three primary objectives:

- Present a structured framework to assist agencies in prioritizing their unique project goals and delivery selection issues;
- Assist owners in aligning their unique goals and issues with the most appropriate project delivery method; and
- Further document the project delivery decision in the Project Delivery Decision Report established in Tier 1.

The Tier 2 approach provides a framework for agencies to prioritize their project goals and select the project delivery method that best aligns with these goals. The motivation for this approach is to capture the fact that priorities for project goals and critical selection issues are unique to each project. Likewise, the delivery methods vary in their ability to achieve these goals and deal with these issues. The Tier 2 approach will align these two facets of the delivery decision.

At the completion of Tier 2, there is still a possibility that the agency may not have a single, clear and logical choice for a project delivery method. If this is the case, the agency will be advised to move to the Tier 3 selection processes with the best delivery method options and make the final decision based upon a detailed risk analysis of the issues involved with each delivery method.

The Tier 2 approach is comprised of five distinct steps listed below and shown in Figure 7.1.

- Step 1. Define Selection Factors
- Step 2. Weight Selection Factors
- Step 3. Score Project Delivery Methods
- Step 4. Choose Most Appropriate Project Delivery Method
- Step 5. Document Results

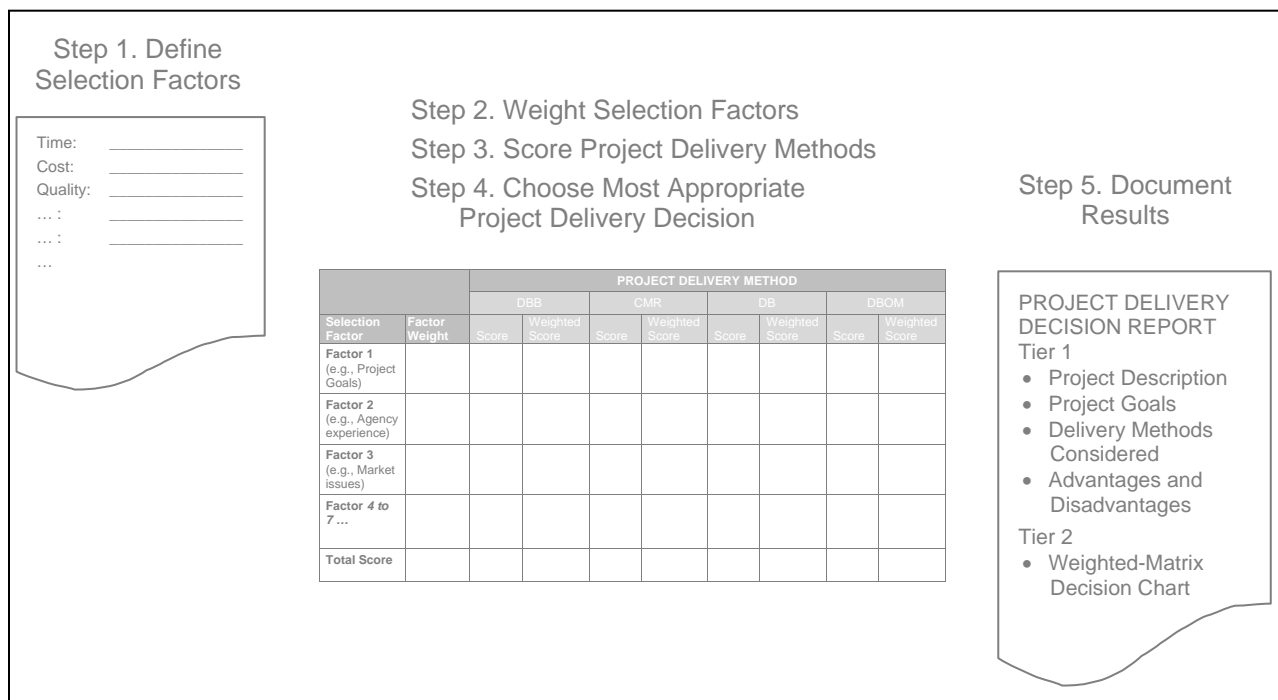


Figure 7-1 - Tier 2 Selection Process Overview

Step 1 of the Tier 2 process begins by defining a concise set of selection factors. These selection factors consist of the project goals and any additional critical issues examined in Tier 1. The Tier 1 process asks owners to establish their project goals at the very beginning of the process. The first step in Tier 2 asks the owners to develop a concise set of selection factors by combining their project goals and with the most important of the 24 critical issues examined in Tier 1. The Tier 2 method will use these selection factors throughout the process.

Step 2 asks owners to rank and then weight selection factors. The project goals may overlap with the critical issues, in which case they can be combined. Other critical issues will stand alone for analysis. Step 2 will result in a list of up to seven project goals and critical issues for further analysis.

Step 3 of the Tier 2 process requires owners to score each delivery method in terms of the selection factors. A further examination of the advantages and disadvantages for each delivery methods will form the basis for these scores. Since the scores will be subjective, the owners will need to be diligent in documenting the reasons for the scores.

Step 4 involves a determination of the most appropriate delivery method through the completion of the weighted decision matrix. Owners will make the determination by multiplying the selection factor weights by the project delivery scores and then summing the values. The delivery method with the highest score will indicate the best choice. However, since the scores will be subjective, the owners will be encouraged to review the totals to determine if the values are logical and defensible on the basis of their professional judgment.

The objective of Step 5 is to supplement the documentation of the Project Delivery Decision Report developed in Tier 1. The Tier 1 report will provide project description, project goals, delivery methods considered, advantages and disadvantages, delivery method decision, and any relevant appendices. The Tier 2 documentation will include a documentation of the weighted decision matrix to supplement the archival record for the project delivery decision. It will serve to communicate the decision to interested stakeholders and to justify the decision if issues arise years later as the project is completed.

Step 1. Define Selection Factors

As stated in Step 1 of Tier 1, understanding and communicating a concise set of project goals is perhaps the most important element in selecting an appropriate project delivery method. The definition of project goals is a key success factor in not only the project delivery decision, but also the development of procurement documents and the administration of a project. It is the performance goals (e.g., time, cost, quality, maintainability, and sustainability) that typically drive the project delivery decision.

The first step in Tier 2 requires owners to combine the project goals and critical issues into a set of selection factors for use in the weighted decision matrix. This step requires a review and filtering of the project goals and critical issues for use as selection factors. Figure 7.2 depicts this process.

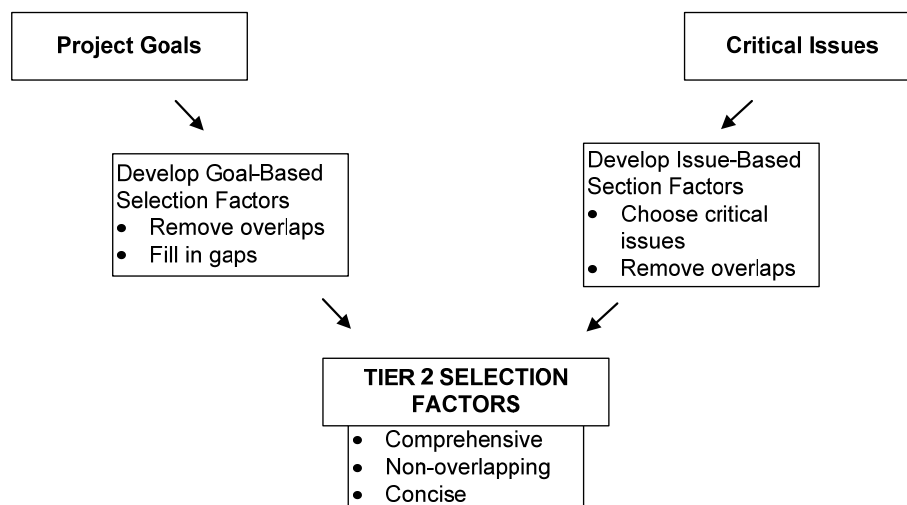


Figure 7-2 - Tier 2 Selection Factor Development

To create the goal-based selection factors, owners should review the project goals that were established in Tier 1. The Tier 1 review of the delivery method advantages and disadvantages may have revealed overlaps or gaps in the originally established project goals. While the original project goals should not change, these overlaps and gaps will need to be removed for the development of section factors. Step 1 in the Tier 2 decision process invites edits to these goals as they are rewritten into selection factors. In developing the selection factors from the project goals, owners should consider the following questions:

- Are there significant overlaps in the project goal statements that can be revised to make them more independent?
- Are there missing goal statements that are needed to define the ultimate project success?
- Can any of the goals be stated more concisely?

The Tier 1 process provided an opportunity to review 24 critical project delivery issues. However, the Tier 1 process treated all of the issues as equally important. Upon reviewing the issues, owners will certainly find that all of the issues are not of equal importance. A small number of these issues will likely be critical to the final project delivery decision. The next task in Step 1 is to select up to seven of the most critical issues to examine to develop as selection factors. The owner should select the most critical issues based on the following criteria:

- The critical issue should be independent of the project goals;
- The critical issues should be independent of each other; and
- No more than seven critical issues should be chosen.

The final task of Step 1 is to provide a consolidated list of the goals-base and issue-based selection factors into one comprehensive list. The next step in the Tier 2 process involves a ranking of the goals and critical issues; therefore one combined list is required. Figure 7.3 provides an example listing of selection factors for a hypothetical project. This example will be used throughout the Tier 2 process description that follows.

The list of selection factors in this example illustrates a concise set of criteria that can be used for selecting the appropriate project delivery method. The list below shows examples of project goals relating to time, cost and sustainability and a critical issue regarding the agency staffing. While other issues of technical quality, maintainability, third party agreements, etc., undoubtedly exist on the project, the list below constitutes the primary goals and issues that will measure the success of the project at its completion and can thereby be used as selection factors.

Project Name: Example Project

- Project complete by November 1, 20XX.
- Cost not to exceed \$1.5 billion.
- Enhance the environment through less traffic congestion and pollution.
- Minimize staffing requirements during design and construction.

Figure 7-3 – Example Listing of Selection Factors

Step 2. Weight Selection Factors

The Tier 2 process is based on the premise that owners can establish a unique hierarchy of selection factors. In other words, each project will define success differently and the criteria for success can be described by a few key selection factors. The objective of Step 2 is to weight the list of selection factors.

Step 2 involves a process of first ranking and then weighting the selection factors. There are numerous methods to achieve a weighted ranking of the factors. The most straight-forward method is a direct ranking and weighting through a discussion and consensus-building meeting with project decision makers. The decision will by nature be somewhat subjective, so a group decision with diligent documentation should be applied.

To achieve the weighted ranking, owners should apply the following steps:

- a. List the selection factors in rank order from the highest to the lowest bearing project success.
- b. Include a minimum of four (4) and a maximum of seven (7) factors.
 - Remove factors not ranked in the top seven (7).
- c. Using 100 total points, weight the factors according to their influence on project success.
 - Avoid equal weighting of factors.
 - Remove any factors with a value of less than five (5) of the 100 points and redistribute points.

These three steps describe a simple method for achieving a weighted ranking of the selection factors. Decision sciences provide more precise methods for achieving weighted rankings and developing a consensus.

The result of Step 2 will be a weighted ranking of up to seven (7) selection factors. The weightings should total 100 points. Equal factor weightings are not recommended because distinguishing the importance between factors (goals and critical issues) is necessary for the decision process. Additionally no single factor should have a point value of less than five (5) because it will not have an influence on the final decision and may in fact make the selection more difficult. The next steps will involve combining the weighted rankings with a scoring of the project delivery methods to arrive at a final selection of the most appropriate delivery method. Figure 7.4 continues the previous example by providing weighted rankings for factors.

The list below shows examples of project goals and issues that have been weighted to reflect their influence on success for the given project. These weightings are project dependent and should be agreed upon by key owner team members.

Project Name: Example Project

Weight	Goal/Issue
50	Project complete by November 1, 20XX.
25	Cost not to exceed \$1.5 billion.
15	Enhance the environment through less traffic congestion and pollution.
10	Minimize staffing requirements during design and construction.
100	Total

Figure 7-4 - Example of Weighted Ranking for Selection Factors

Step 3. Score Project Delivery Methods

The third step involves a scoring of the alternative delivery methods from the Tier 1 analysis. Each of these delivery methods will have a bearing or influence on the selection factors, which stem from the project goals and critical issues. The key decision makers must translate this influence into a score to arrive at a decision. To achieve the total scores for each delivery method, owners should apply the following steps:

- a. Using the scale in Table 7.1, assign a score to each delivery method as they relate to the selection factor. Score all delivery methods for each factor before moving to the next factor.
- b. Repeat step “a” for each for each selection factor.
- c. When all delivery methods have been scored, multiply the factor weight by the score to achieve a weighted score for each delivery method.
- d. Sum all of the weighted scores to arrive at a total score for each delivery method.

Table 7.1 provides a scale for scoring each delivery method as they relate to the selection factor. The scores range from 1 to 10 so that, when they are multiplied by the factor weight, the total score

will range from 0 to 1000. The scores are subjective, so a detailed definition for each is provided adjacent to the score. When scoring the delivery methods, owners should discuss the advantages and disadvantages of each delivery method. The alignment of these advantages and disadvantages with the selection factors forms the basis for the scoring. In assigning the scores, the owner should work in a team, build a consensus decision, and carefully document the reasons for choosing each individual score. Consideration should be given to the relative scores for each delivery method to ensure consistency.

Table 7-1 - Project Delivery Scoring Scale (adapted from Saaty 1990)

SCORE	DEFINITION
10	The evidence that the delivery method positively aligns with the project objective or issue is of the highest possible order of affirmation.
8	The delivery method strongly aligns with the objective or issue and is demonstrated in practice. There is a slight risk that the objective or issue may not be beneficial.
6	Experience and judgment point to the delivery method strongly aligning with the objective or issue. There is a mild risk that the objective may not be beneficial.
4	Experience and judgment slightly points to the delivery method aligning with the objective or issue. There is a strong risk that the objective will be negatively affected.
2	There is little benefit to applying the delivery method for this goal or objective. There is a strong likelihood that the object will not be achieved.
9,7,5,3,1	Intermediate values between two adjacent judgments.

Similarly to the development of factor weights, the scoring can be done simply through a group discussion among key owner team decision makers.

Table 7.2 provides a weighted decision matrix template. The matrix can contain up to four (4) delivery methods, depending upon the results of Tier 1. The matrix can also contain up to seven (7) selection factors for each project.

Table 7-2 - Weighted-Matrix Template

		PROJECT DELIVERY METHOD							
		DBB		CMR		DB		DBOM	
Selection Factor	Factor Weight	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Factor 1 (e.g., Project Goals)									
Factor 2 (e.g., Agency experience)									
Factor 3 (e.g., Market issues)									
Factor 4 to 7 ...									
Total Score									

The result of Step 3 will be a scored ranking of the delivery methods in question. The delivery method with the highest total score will be the most appropriate method for the given project. The next steps involve documenting the individual scores and creating a Project Delivery Selection Report. Figure 7.5 continues the previous example by scoring the delivery methods as they relate to each selection factor. A very brief documentation for the scoring follows the table.

The table below provides an example of how an owner might score the project delivery methods for a particular project. Note that only the CMR and DB project delivery methods made it through the Tier 1 filter for further consideration in Tier 2. Also note that the scores in the example below are project dependent and they will certainly change from project to project.

Example Project Decision Matrix

		PROJECT DELIVERY METHOD			
		CMR		DB	
Selection Factors	Factor Weight	Score	Weighted Score	Score	Weighted Score
Project complete by November 1, 20XX	50	6	300	8	400
Cost not to exceed \$1.5 billion	25	6	150	8	200
Enhance the environment through less traffic congestion and pollution	15	10	150	6	90
Minimize staffing requirements during design and construction	10	8	80	6	60
Total Score	100		680		750

Explanation of Scores

Project completion factor: The project completion factor relates to a project goal. In this case the project has a fixed end date of November 1, 20XX. The owner believes that CMR delivery can achieve the completion date. The owner also believes that CMR will require the use of multiple bid packages to achieve the schedule, which adds a risk for meeting the schedule date (CMR = 6). DB delivery provides for a single entity to coordinate design and construction. DB also allows for an owner to specify a fixed end date in the procurement documents and the contract. The owner is confident by what has been demonstrated in practice that the end date can be achieved through a DB delivery (DB = 8).

Cost containment factor: The cost containment factor relates to a project goal. The project has a maximum budget of \$1.5 billion. DB delivery has demonstrated in practice that a fixed price can be set early in the project development process and it has also been demonstrated that DB provides the lowest average cost growth of the two methods in question (DB = 8 in this case). CMR also provides the ability to meet a fixed price, but the owner is not as confident with the experience using a guaranteed maximum price contract structure. They also feel that there is more risk of not achieving the schedule with CMR when compared to DB (CMR = 6 in this case).

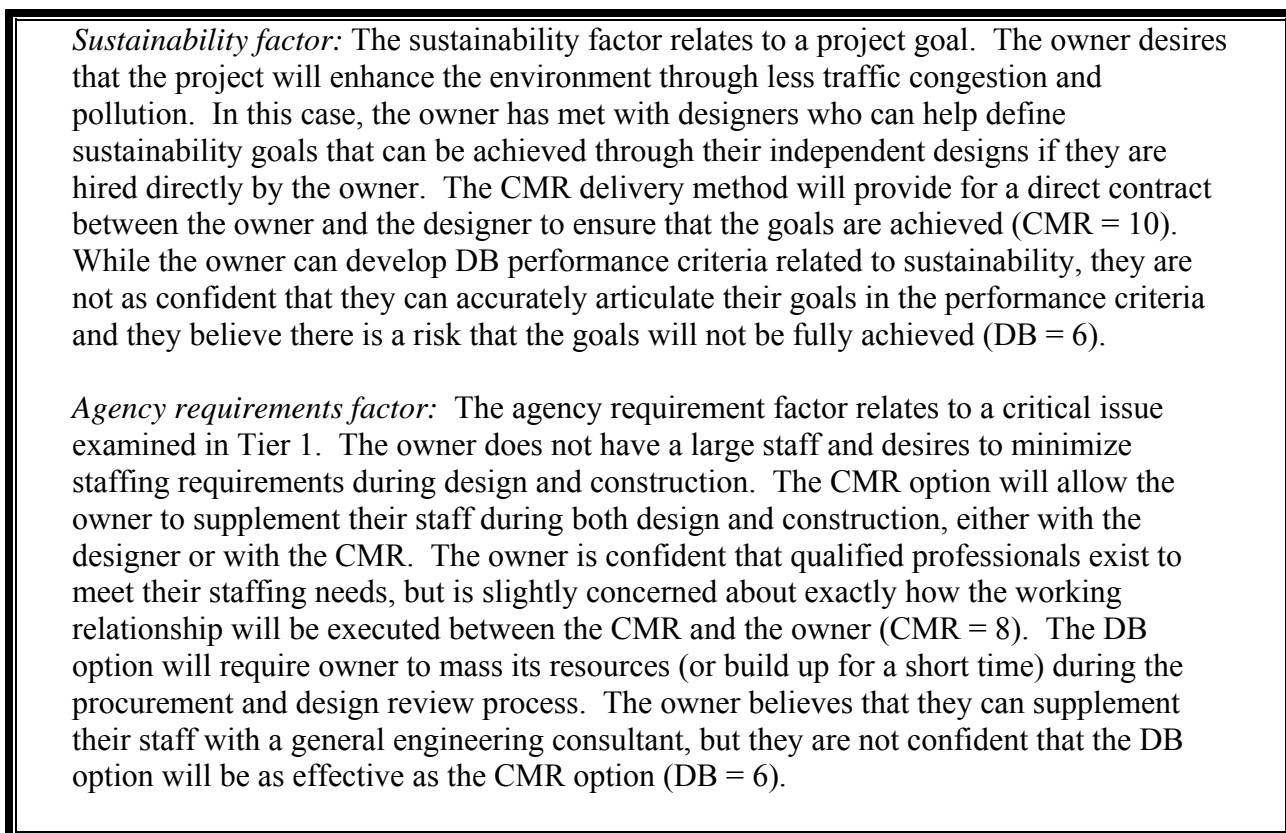


Figure 7-5 - Example of Weighted Ranking for Project Goals and Critical Issues

Step 4. Choose the Most Appropriate Project Delivery Method

At this point, choosing the appropriate delivery method is simply a matter of reviewing the total scores and making the project delivery decision. Since the factor weighting and the scores are subjective, the owner should review the totals and confirm that they are logical and defensible. If upon further discussion, a factor weight or project delivery score appears to be incorrect or overly influence the selection, it is acceptable to make changes and create a new total project score. The key is to document the reasons for each change. If the owner is not confident in a particular weight or score, they can conduct more research about a particular delivery method and revisit the scoring after gathering more information.

If at this point, a single project delivery decision is not apparent, the owner should document the results and move to the Tier 3 decision process (Chapter 8).

Step 5. Document Results

As in Tier 1, documentation of the delivery decision is a key portion of the process. Whether one delivery method clearly achieves the highest score or no dominant choice appears, documentation is a vital step. Documentation will assist in developing procurement and contracting strategies for the ultimate project delivery method. It will also serve to communicate the project delivery choice to interested stakeholders.

Documentation of Tier 2 involves supplementing the Project Delivery Decision Report developed in Tier 1. The Project Delivery Decision Report should contain the weighted matrix and also a detailed documentation of the reasoning that was used to assign each criterion weight and project delivery score.

Conclusions

The Tier 2 Weighted-Matrix Delivery Decision Approach extends the structured Tier 1 approach through an examination of how project delivery methods align with project goals and critical issues as defined through selection factors. The weighted ranking of project selection factors requires decision makers to examine their priorities and make a closer examination of the attributes for each delivery that passed the Tier 1 filter. At the end of Step 4, there may be a single, clear and logical choice for a project delivery method and the choice can be documented through a Project Delivery Decision Report. If a dominant choice does not appear, the agency should document the results and move to the Tier 3 selection process to examine how the delivery methods relate to the project risks.

CHAPTER 8 – TIER 3 – RISK-BASED APPROACH

Introduction

The Tier 3 optimal risk-based approach will leverage the current cutting-edge risk-based cost estimating methods that have emerged in the transit and highway agencies in the past few years (Touran 1994, Parsons 2004). The user should first complete Tier 1 and Tier 2. It is expected that most of the times the delivery method decision can be made by completing these two tiers. Even if a clear choice cannot be established after going through the first two tiers, then at least the first two tiers will short-list the number of viable choices. It is expected that by the time the decision-maker gets to Tier 3, they are only looking at two candidates for the delivery method. This is important because the effort involved in using Tier 3 (especially the quantitative approach) is considerably larger than either Tier 1 or Tier 2.

The risk-based approach as proposed here consists of two phases. The first phase is a qualitative approach consisting of developing a risk allocation matrix that clearly portrays owner's risk under competing delivery methods. By reviewing these risks, the owner (in our case mostly the transit agency) will have an opportunity to decide if a specific delivery method is superior. If this analysis cannot provide a definitive answer to the delivery selection question, then a quantitative approach should be considered. The quantitative approach emphasizes the effect of the Project Delivery Method (PDM) on project cost and schedule.

As can be observed in Fig. 8.1, a two-phase approach is suggested for the risk-based PDM selection. The process depicted should be repeated for all the short-listed PDMs surviving the Tier 2 process. In the first phase, the PDM is selected mainly based on the *Risk Allocation Matrix*. This phase of Tier 3 is called the Qualitative approach. If after this phase still more than one choice remains equally viable, then a complete risk analysis would be required to quantify the effect of PDM on project's cost and duration and finalize the PDM selection. This second process is called the Quantitative approach.

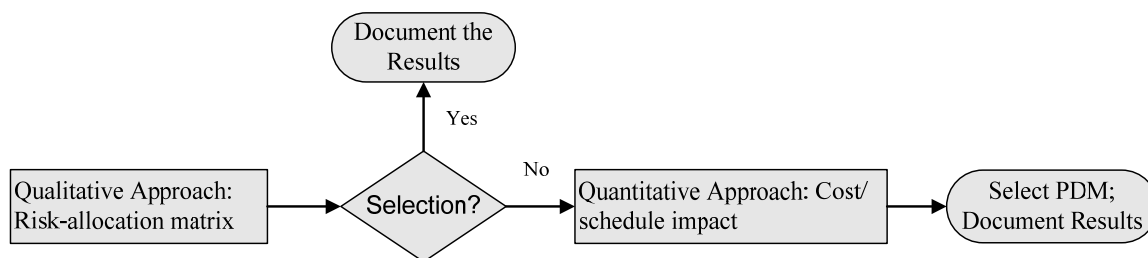


Figure 8-1 - Overview of the Risk-based Qualitative and Quantitative Approaches

Due to cost escalation on large transit projects, since 2002, the FTA has required that each “New Starts” project undergo a formal risk-based cost estimate. Specific requirements for these risk assessments are provided in FTA guidance documents⁸. A risk-based cost estimate generates a range of possible project costs rather than a single point estimate as seen in Figure 8.2. This distribution represents the combined effect of various risks that affect project cost. Using this distribution, the project owner would be able to estimate the probability of finishing the project within a specified budget. Alternatively, the owner can establish sufficient contingency budget to keep the probability of cost overrun or schedule delay below a specified threshold.

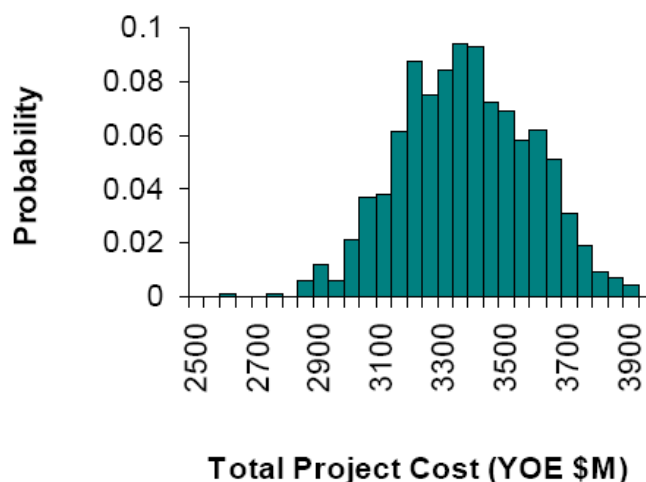


Figure 8-2 - Distribution of Project Costs

The same modeling method (and much of the same data) that is used to generate the cost and schedule risk analysis can be used to make more informed decisions and allocate risks appropriately, in essence, optimizing the project delivery and contracting decisions.

One of the major findings of the structured interviews (conducted with transit agencies as part of this effort) was the apparent effect of a rigorous risk analysis on the project success. It was found that projects that paid more attention to risk analysis fared better in terms of achieving their budget

⁸ As an example, the current FTA guidance on risk assessment is PMO Operating Procedures No. 40, “Risk Management Products and Procedures, 2007, FTA, U.S. D.o.T.

and schedule goals. The following sections describe qualitative and quantitative phases in more details.

Qualitative Approach

The overview of the process is shown in Fig. 8.3. The risk-based approach is superimposed on the project development life-cycle. The most likely time to decide on the PDM is either at the end of the Conceptual Design or during the Preliminary Engineering phase. If the project goes into the Final Design, the agency will lose the opportunity to effectively use alternative delivery methods and will be limited to the traditional DBB approach. At the end of the Conceptual Design, the agency usually has not done a detailed risk analysis. If the PDM selection decision cannot be finalized by going through the first two tiers described in previous chapters, the agency would need to conduct a preliminary risk analysis in order to be able to make an informed decision regarding the choice of the PDM.

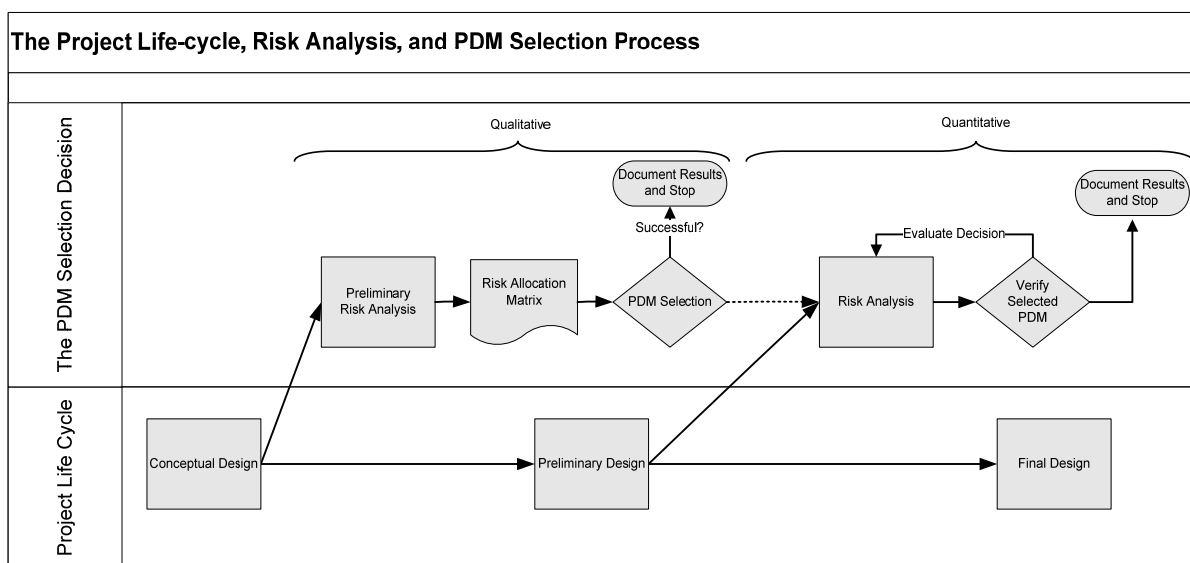


Figure 8-3 - Overview of the Risk-based Approach

The result of this preliminary risk analysis is a *Risk Allocation Matrix*. The risk allocation matrix has become an industry standard for legal teams when authoring alternative contracts for large infrastructure projects. As an example, a risk allocation matrix was a first step in creating the contract for the T-REX multimodal design-build project in Colorado. Table 8.1 shows a hypothetical risk allocation as envisaged in this guide. Risk factors are major events or conditions that can affect the project in a negative way (the events that can affect the project in a positive way are called opportunities and traditionally are far fewer than risks). Care should be taken to consider only the significant risks otherwise identifying and measuring all project risks would be a major effort. For each of these risk factors (that can be arranged according to their impact (rank) or their chronology) a main responsible party should be identified, given a certain project delivery method. As an example, the party responsible for Design defects in a DBB contract is the owner, whereas in the DB contract, the responsible party is the Constructor. To each risk factor, a *rating* will be assigned as to the effect of the PDM on the treatment of that risk factor, from the perspective of the

owner agency. As an example, in Table 8.1, for the hypothetical project under study, the use of a DBB has a favorable effect for “Permits/approvals” risk from the agency’s point of view. It is felt that the agency is the best party to obtain these permits and that the agency can most effectively do this under a DBB approach. A rating of “+” is assigned for such a case. The same risk factor, under a DB delivery method is unfavorable from the agency’s point of view, because the agency feels that the DB constructor is not the best party to obtain various permits and approvals (such as environmental permits). A rating of “-” is assigned for such a case. As another example, the risk associated with “Design Defects” has a rating of “-” for the agency under the DBB arrangement because in this delivery method the agency is responsible for the accuracy of design. A DB approach on the other hand gains a “+” rating for the agency because it transfers this risk to the constructor. In summary, the ratings always evaluate a risk from the standpoint of the agency.

If the choice of a PDM has no effect on a particular risk factor, then a rating of “0” will be assigned. In rating each risk factor, one can refer to the contents of Chapter 3 of this Guide, where advantages and disadvantages of various issues are documented. No attempt is made at this stage to quantify the impact of these risk factors (in terms of \$ or project delay). After the matrix is developed and rated, the evaluation team can review the outcome and see if any PDM seems superior in terms of its capacity in dealing with these risk factors. For example, reviewing the matrix of Table 8.1 may lead one to believe that the DB is the better choice for the owner agency because of the number of favorable ratings that it has obtained.

Table 8-1 - Example of Risk Allocation Matrix

Risk Factor	DBB		DB	
	Responsible	Rating	Responsible	Rating
Permits/Approval	Owner	+	Constructor/Owner	-
Different Site Conditions	Owner	0	Constructor/Owner	+
Design Defects	Owner	-	Constructor	+
QA/QC	Constructor/Owner	0	Constructor	+
Exchange Rate Risk	Owner	-	Owner	-
Other risk factors				

Preparation of the risk allocation matrix and rating the risk factors can be accomplished in a reasonable time. If the outcome points to a clear PDM winner, then the decision is finalized and the results, along with justification will be documented. If after going through the proposed process, the choice is still not clear, then the process should be moved to a more detailed quantitative approach.

It is emphasized that the ratings assigned to each risk factor is chosen from the owner agency's point of view (and the potential benefits/loss to the owner as a result of a specific PDM).

Quantitative Approach

The quantitative approach should be attempted only if the qualitative approach does not result in a clear choice for the PDM. As shown in Fig. 8.3, the quantitative approach is suggested to be used at the conclusion of the P.E. phase, when the agency has conducted the FTA mandated probabilistic risk analysis on project cost and schedule. The risk analysis process is a major undertaking that will require hundreds of man-hours over the course of several weeks. The outcome of the risk analysis can also be used as input to the PDM selection decision (Fig. 8.4). The quantitative phase of Tier 3 would then be contingent on the availability of the complete risk analysis. If this risk analysis is not a requirement (for example in projects that do not apply for federal funding), then it is suggested that the PDM selection decision be made without this phase as the cost of this phase could be prohibitive.

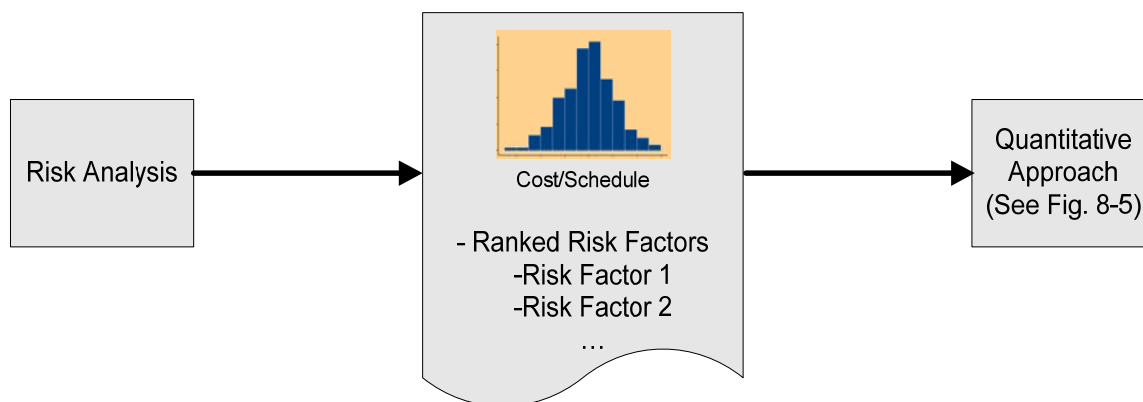


Figure 8-4 - Risk Analysis Outcome as an Input to PDM Selection

The outcome of the probabilistic risk analysis required by the FTA consists of a distribution (range of possible values) for project cost and duration. Also, a list of the most important risk factors ranked according to their impact on budget or schedule is provided as part of the risk mitigation report. Usually, the number of these ranked risks is limited (for example, in several risk assessments conducted by the Project Management Oversight consultants on behalf of the FTA, the list of significant risks factors were between 10 to 15). This approach follows the logic of the Pareto's law (also known as the 80-20 rule, the law of the vital few) which states that, for many events, 80% of the effects come from 20% of the causes. In the context of project risks, relatively few risks are responsible for most of the project cost or schedule overruns. The project cost distribution and the list of ranked risks will serve as inputs to the process of selecting the best PDM. For each ranked risk a distribution of risk costs is usually estimated. The highest ranked risks are those with large expected values and large ranges (an indication of high variability of the risk factor).

The proposed process, called the *quantitative approach* in this work, will involve estimating the effect of each major risk factor on the agency's budget, assuming a specific delivery method. The process starts by reviewing all the risk factors and select those risk factors where the choice of project

delivery will affect their value. Only the risk factors that are sensitive to the project delivery method will be selected for further analysis. For each of these risk factors, the range of cost will be estimated under assumed project delivery method. This can best be accomplished by some of the same experts that were involved in the risk analysis. Fig. 8.5 provides an example of a hypothetical project where four major risk factors have been identified as the risk factors that are affected by the choice of project delivery method. These risk factors consist of *permits*, *utility relocation*, *differing site conditions (DSC)*, and *third party issues*. Assume that the two choices for the PDM are DBB and DB. The cost of each risk is estimated using a triangular distribution, although many other distributions can be used depending on the nature of the risk factor. In a triangular distribution, the range of possible values is estimated with a lower bound (optimistic), an upper bound (pessimistic) and a most likely value. The triangular distribution is commonly used in probabilistic risk analysis because of its simplicity. The sum of these risk costs will give the distribution for the total risk costs. There are statistical methods to calculate this sum with relative ease. Comparison of distributions of these total risk costs will give the owner agency a valuable tool for assessing the effect of project delivery method on the project cost. A similar approach can be used to assess the effect of risks on project schedule. If the purpose is to examine the effect of delivery method on project duration, all the distributions depicted in Fig. 8.5 will have durations on the X-axis and the total effect will be the total impact on project schedule instead of cost.

The quantitative approach is a powerful tool for comparing competing PDMs. It focuses on those differences between the PDMs that affect cost and schedule and provides a consistent way of evaluating each PDM vis-à-vis major risk factors affecting the project. This will allow the decision maker to document the reasons for the selection of a specific project delivery method. The drawback of this approach is its dependency on the availability of the expensive risk analysis results and the higher skill level required for pricing out each risk under various PDMs. However, the choice of the PDM is a natural outcome of a risk analysis exercise because one of the most important benefits of any risk analysis is risk allocation/mitigation. A properly selected PDM is an effective risk mitigation instrument that can help keep project costs low and project delays minimized.

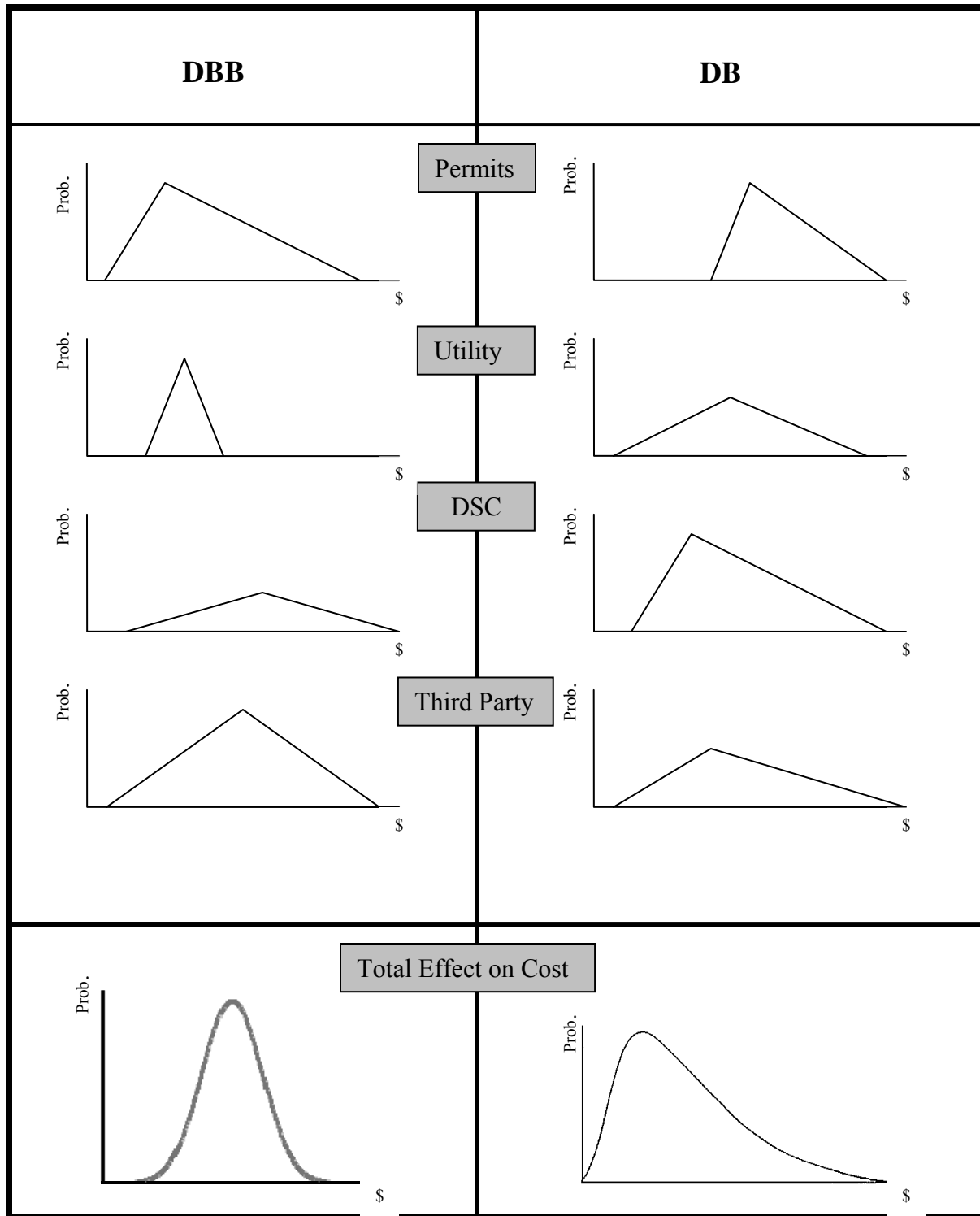


Figure 8-5 - Overview of the Quantitative Approach

Summary

Tier 3 may be needed in cases when Tiers 1 and 2 cannot provide a clear best choice for the project delivery method. In such a case, Tier 3 can be used at two levels: qualitative and quantitative. Both approaches are based on a risk allocation exercise that will outlay major project risks to the agency under various delivery methods. In the qualitative approach, the decision-makers will base their final decision on the careful examination of each risk factor and after deliberating over the anticipated effect of each risk factor on project cost and schedule. This critical review can help the agency decide on the most appropriate delivery method. If this process still does not yield a final outcome, the agency can then proceed with the quantitative approach. In this approach, the cost and schedule effect of each risk factor will be estimated with an appropriate range, summed up, and used in comparing the total effect of risks under competing delivery methods. The agency can then select the delivery method that results in the most favorable outcome considering both cost and schedule.

CHAPTER 9 – EVALUATION OF PROJECT DELIVERY METHOD DECISION TOOL

The structured interviews and case studies followed the methodology of Yin (2004) and Oppenheim (1992). According to Yin, case studies are appropriate to use for exploratory or explanatory questions, such as *what project characteristics can be matched with project delivery method advantages to make an effective project delivery method selection decision for major transit projects?* Case studies are also appropriate when the researcher does not require control over the events and when the research focuses on contemporary events. Both of these conditions apply to the study. The unit of analysis or the “case” is the project, starting with the project conceptual and systems planning and ending at the conclusion of construction.

To assure the quality of the case study design and evaluation, the following measures recommended by Yin were included:

- **Construct validity:** The team submitted the case study data collection and interview guide to the TCRP panel to establish that correct operational measures were used. This study included multiple sources of evidence by interviewing more than one expert in each transit agency, as well as having the experts review the key information included in the Interim Report. Additionally, a pilot study was conducted initially to refine data collection procedures.
- **Internal validity:** to establish a causal relationship between the critical factors and the strategies and techniques, this study applied the hypotheses to a number of cases that include 1) a range of project types, settings, and conditions, 2) a range of different project delivery methods, 3) a range of project performance outcomes (both positive and negative). Additionally, a draft of the Tier 1 and 2 decision tool was applied by a research team member to a project that was not included in the case study data collection to determine two factors. First, it demonstrated that the decision tool could be applied outside the universe formed by the case study projects and secondly, it confirmed the utility of the tool by comparing the PDM selected by the tool with the PDM that was favored by the agency at the time of the internal validation effort.
- **External validity:** a validation workshop was conducted at the 2007 DBIA Transportation conference Minneapolis and was used to confirm the findings from the case studies. Input from the workshop helped to focus the research on the four delivery methods covered by the decision tool. Once the tool had been developed it was given to four case study agencies who were asked to run through the process and if possible, compare the results with one of their projects.
- **Reliability:** to demonstrate that the study procedures and results were reliable and repeatable, this study prepared a detailed case study protocol. The research protocol

followed the methods that were reviewed and approved by the TCRP panel in the final work plan.

Final Validation of PDM Multi-Tier Decision Tool

The above validation discussion shows how the research team was careful to validate its work both before and during the study. This effort was valuable and paid dividends in the final validation efforts. Figure 9.1 demonstrates the process that was followed to achieve final internal and external validation.

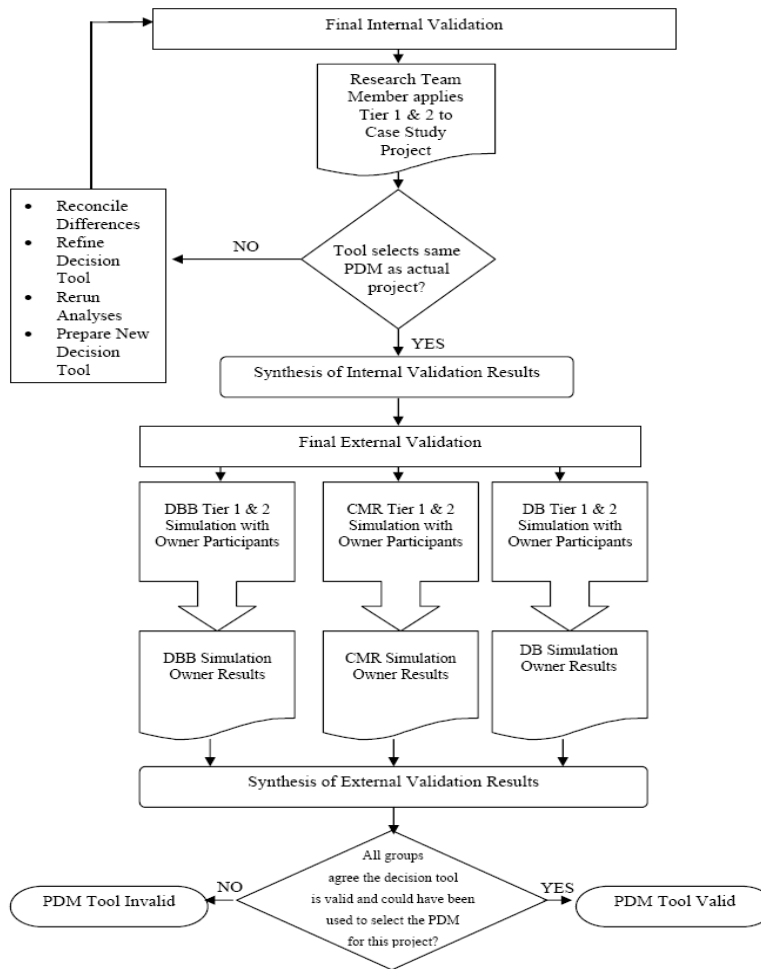


Figure 9-1 - Project Delivery Decision Tool Final Internal and External Validation Flow Chart

In essence, the process was to first apply Tiers 1 and 2 to an actual project by a member of the research team to identify if the tool was working as designed and identify the gaps in the process that needed to be filled. Once those results were synthesized and the two tiers were revised, the tool was distributed to four of the case study project agencies. They were asked to apply the tool to a project that they felt had been successfully delivered using the appropriate PDM. They were then asked to compare the resulting PDM from the tool matched the PDM that had been used on the test project. The tool is deemed to be valid if the internal and external parties determine that the tool led them to the logical PDM for the project characteristics that were considered. Finally, it should be noted that due to the relative rarity of DBOM projects, it was not possible to specifically validate the tool for that PDM. However, the DB validation in fact covers the initial capital delivery phase of these type projects and therefore, DBOM can be partially validated by the DB validation effort.

Final Internal Validation

As previously stated, a member of the research team applied the initial draft of the Tier 1 and 2 PDM decision tool to an upcoming project for a large metropolitan transit agency. The tool yielded a strong indication for DB project delivery. The effort was fruitful in that it pointed out some minor weakness in the Tier 1 logic and furnished constructive criticism on Tier 2. The major issue was the need for a multi-disciplinary group to collaboratively apply the PDM tool to ensure that critical aspects of design, construction, and operations are all adequately represented in consensus ratings of project issues.

Final External Validation

As previously discussed, the Tier 1 and 2 decision tool was furnished to four of the case study agencies. One of those agencies requested that their identity be not disclosed. Therefore, as the sample of case study agencies is small, no agencies will be identified in the subsequent paragraphs to comply with that reasonable request and prevent inadvertently identifying the agency by process of elimination. Each agency was asked to apply the tool to a specific project that was either upcoming or had been completed. The purpose for this suggestion was that it was the team's belief that the selection system works best when the user can carefully define project objectives and goals. It was felt that if the agencies had a specific project in mind they would be in a position to better define project characteristics and goals.

Additionally, each agency was asked to rate the effectiveness of the tool in the following categories (see Appendix E for a copy of the questionnaire and rating form):

- Comprehensiveness
- Clarity
- Applicability to real projects
- Contribution to resulting in a transparent and defensible decision
- Overall satisfaction

In all four cases, the tool was deemed to be valid. No unsatisfactory ratings were recorded. The specific adjectival evaluations in the specific categories are as follows:

- Comprehensiveness: 3 excellent; 1 very good
- Clarity: 4 very good
- Applicability to real projects: 3 excellent; 1 very good
- Contribution to decision: 2 excellent; 1 very good; 1 good
- Overall satisfaction: 3 excellent; 1 good

Specific comments were primarily directed at the Tier 1 process. Most users found it to be comprehensive. One agency indicated that it might include more detail in the political influence issue portion. Another thought that it could be broken into a first part that would apply to all projects and a second part that would be project-specific to streamline the use over time by the same agency. Finally, two of the agencies indicated that the tool would be particularly valuable to an agency that was facing the use of alternative project delivery for the first time. One agency had this to say about that issue: “I think that this would be particularly helpful to an agency using alternate delivery for the first time, but more experienced agencies can benefit from the comprehensive list of items to be considered.”

Overall comments regarding the validity of the tool from each of the four agencies are as follows:

- Agency with DBB, CMR, and DB experience: “Seems like a fine tool. The list of topics and advantages/disadvantages are very complete and thorough. The discipline of the Tier 2 analysis is a good way to stress the most important factors for the job under study.”
- Agency with DBB, CMR, and DB experience: “It is an excellent document and should be very helpful to those in the project development of major transit projects.”
- Agency with DBB and DB experience: “Very interesting approach.”
- Agency with DBB, DB, and DBOM experience: “At first the process looks a bit long but I think as people use it they will find it helpful.”

Thus, the Tier 1 and 2 PDM decision tool framework is found to be valid in accordance with the procedures established by the research team and approved by the TCRP oversight panel.

Another finding of the validation process was that in all cases, there remained no ambiguity on the choice of PDM after going through the first two tiers. Because of this, the validation and testing of Tier 3 could not be accomplished in the same way.

CHAPTER 10 – SUMMARY

The objective of this research was to study alternative project delivery methods for transit projects and to develop a guidebook for selecting the most appropriate delivery method for a transit project. The delivery methods considered were the traditional design-bid-build (DBB), CM-at-risk (CMR) or CM/GC, design-build (DB), and design-build-operate-maintain (DBOM). Until recent times the traditional design-bid-build approach was the common choice for the project delivery method used by transit agencies, mainly due to statutory limitations and agencies' experience with this delivery method. Legal limitations have been removed to a large degree and this has provided much flexibility in the choice of project delivery and contracting method. Five transit agencies were interviewed and an in-depth study was completed on nine transit projects executed by these agencies. Relevant literature on project delivery methods, decision support systems, public transportation and transit projects were reviewed. A comprehensive list of pertinent issues that can affect the project delivery decision was compiled and studied. It was found that various transit agencies have different motivations in selecting an alternative delivery method. The research conducted by the authors concluded that no single project delivery method was superior to all others and that transit agencies need to carefully analyze the characteristics of the given project and seek to find the project delivery method whose benefits are most closely aligned to project requirements. It also showed that the most common reasons for choosing an alternative project delivery method, as stated by the project directors that were interviewed, were as follows:

1. Reducing/compressing/accelerating the project delivery period;
2. Encouraging innovation;
3. Early budget establishment and early contractor involvement; and
4. Flexibility needs during the construction phase.

Transit agencies should carefully study the risks, costs and benefits associated with each project delivery method for the project under consideration and select the project delivery method that best suits legal, technical, and business environment in which the project must be built. This effort resulted in a 3-tier approach for project delivery method selection. The user goes through the three tiers sequentially and narrows down the viable delivery methods by a process of eliminating the inferior choices.

In Tier 1 or the Analytical Approach, this is accomplished by evaluating the viability of each delivery method against a number of pertinent issues that can be of vital importance for the project's success in achieving its goals and objectives. Among the pertinent issues that affect the project delivery decision, there are certain issues that may render one or more delivery

method inappropriate. These issues involve project schedule constraints; federal, state, and local laws; third party agreements; and labor union agreements. The transit agency needs to review these issues to determine if they eliminate any of the delivery methods. In other words, the agency should make a “go/no-go decision” based on these pertinent issues. After this stage, the user examines the remaining project delivery choices against a list of pertinent issues and rates each delivery method based on its advantages and disadvantages in coping with each pertinent issue. The summary of these ratings is compiled in a table and studied to see if a decision can be made based on the overall capabilities of competing delivery methods in dealing with these pertinent issues. If a clear winner emerges at this point, a report can be generated that describes the reasons for the choice of delivery method.

If more than one delivery method remains viable after going through Tier 1, the user should move to Tier 2. In this Tier a select subset of goals and pertinent issues will be identified that are of profound importance to the transit agency. Each goal or issue is weighted according to the clear instructions that are provided and an overall score is computed for each delivery method. Again, a report can be generated that documents the decision-making process.

If more than one delivery method remains viable after going through the first two tiers, the user should move to Tier 3. In this Tier, the user will review and identify project risks and prepare a table for risk allocation that provides a clear comparison between the remaining delivery methods in terms of risks that are inherent to them. This table should help the user to select the delivery method that results in a more favorable risk profile. Project risks can also be quantified through well-established risk analysis techniques and a decision regarding the most appropriate delivery method can be reached based on the expected cost of risks for each delivery method. However, the quantitative approach will require significant effort, and will depend on the willingness of the owner to embark on this analysis, and the availability of risk assessment report for input to this process.

The delivery selection system was tested and validated by several transit agencies. The overall assessment was very positive and the users found the process to be easy to follow and informative. Their comments and feedback were carefully reviewed and implemented in the guidebook. The authors believe that the guidebook developed as a product of this research is a valuable tool for transit agencies, especially those with limited experience with alternative project delivery methods.

APPENDIX A - REFERENCES

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APPENDIX B – ANNOTATED BIBLIOGRAPHY

ANNOTATED BIBLIOGRAPHY

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This white paper is about Construction Management at Risk (or so-called CM/GC). The authors give definitions for the terms commonly used in this delivery method and highlight its advantages and disadvantages. They try to address some concerns about CMR, like lack of competition. The projects best suited for this method are introduced by their characteristics and setting a GMP in those projects is discussed in the paper.

_____ (2002). “Design-Build Whitepaper, Public Contracting Coalition”, Oregon.

This whitepaper focuses on Design Build delivery system and explains all the relevant issues, like the best time to use DB, the best project for DB contracting, the best way to qualify design-builder, advantages and disadvantages of DB, different ways of payment, etc.

_____ (2004). *Early Contractor Involvement: Contract Guidance Manual*.

_____ (2004). “Report to Congress on Public-Private-Partnerships”, United States Department of Transportation.

Allen, L.N., D.D. Gransberg, and K.R. Molenaar, (2002). “Partnering Successful Design-Build Contracts in the Naval Facilities Engineering Command Southwest Division,” *The Military Engineer*, SAME, Vol., 94 (616), pp.47-48.

AASHTO (2005). “Accelerating Project Delivery: It is about Time”, American Association of State Highway and Transportation Officials (AASHTO).

Associated General Contractors (2004). *Project Delivery Systems for Construction*, Associated General Contractors of America.

This practical guide to delivery systems describes Agency CM, Program Management (both, project management approaches), DBB, DB, CM-at-risk, DBOM, PPP (project delivery systems). The book is very useful especially for clear definitions that are provided for various terms of art.

ACI-NA, ACC, and AGC (2006). “Airport Owners’ Guide to project Delivery Systems,” a white paper by Airport Council International – NA, Airport Consultants Council, and the AGC of America.

This white paper describes various delivery systems (DBB, DB, and CM-at-risk) in the context of airport projects. Has a useful section on definitions of terms-of-art. In addition to project delivery

systems, they cover *project oversight*, funding mechanisms for airport capital projects, and provide guidelines for the selection of the appropriate project delivery system.

American Institute of Architects (AIA) (2005) “Construction Manager at-Risk State Statute Compendium,” AIA Government Affairs, American Institute of Architects, Washington, DC, pp. 125-129.

AIA Minnesota (2006). “Understanding Project Delivery for the Design and Construction of Public Buildings”, AIA Minnesota.

A/E/C Training Technologies (2005). *Construction Project Delivery Systems: Evaluating the Owner's Alternatives*, Reston, VA. [WWW document] URL <http://www.aectraining.com> (Viewed March 1, 2006).

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American Consulting Engineers/council. (1997). “Proposal for ISTEA II: Improving the Delivery of Transportation Project Through Partnerships.” ACEC.

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Anderson, S. Russell J. (2001). “Guidelines for Warranty, Multi Parameter, and Best Value Contracting,” National Cooperative Highway Research Programs (NCHRP), Report 451.

Beard, J., Loulakis, M. and Wundram, E. (2001). *Design-Build: Planning Through Development*. RR Donnelley & Sons Company.

Bearup, W, Kenig, M. and O'Donnell, J. (2007), “Alternative Delivery Methods, A Primer” Proceedings, Airport Board Members and Commissioners Annual Conference, Airports Council International - North America, Chicago, Illinois.

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Born, M. and Burner, C. (2003). "Design-build contracts: Lessons learned on the Gold Line rail project for APTA," *Transportation Research Circular No.E-C058*, TRB, Washington, D.C., 575-581.

Booz Allen Hamilton Inc. (2005). "Managing Capital Costs of Major Federally Funded Public Transportation Projects," Transit Cooperative Research Program (TCRP), Washington, D.C.

This document is based on the results of a research funded by the TCRP on the issue of cost overrun and cost management on 28 transit projects in the United States. This research studies the methods useful to manage cost and prevent cost overruns. The cost and duration data in these projects is collected and analyzed.

Branca, A.J. (1988). *Cost Effective Design/Build Construction*, McGraw Hill, New York, N.Y., 1988.

C & S Companies (2005). "Construction Management At Risk" [WWW document]. URL <http://www.cscos.com/services/CMatRisk/index.cfm> (visited 2005, January 31)

Construction Industry Institute (2003). *Owner's Tool for Project Delivery and Contract Strategy Selection*, Research Summary 165, Construction Industry Institute, Austin, TX.

Clarke, R. (2003). "Early Planning and Decisions on the Southeast Corridor Project," *Leadership and Management in Engineering*, July.

This paper is about southeast corridor, a multimodal transportation project in Denver, Colorado. The paper concentrates on early decisions made in this DB project. The paper explains the activities done by the joint owners of this project to decrease the uncertainty in this project.

Chan, A., Yung, K., Lam, P., Tam, C., Cheung, S. (2001). "Application of Delphi Method in Selection of Procurement Systems for Construction Projects", *Construction Management and Economics*, Vol. 19, pp. 699-718.

Chang, K. (2004). "Multiattribute Weighting Models for Best-Value Selection in Public Sector Design-Build Projects", PhD thesis, University of Colorado.

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C & S Companies (2005). “Construction Management At Risk” [WWW document]. URL <http://www.cscos.com/services/CMatRisk/index.cfm> (visited 2005, January 31)

Dantata, N. (2003). “Cost overruns in federally funded transit projects,” M.S. Thesis, Northeastern University, Boston.

This thesis documents transit project cost overruns and quantifies cost growth during each phase of project life-cycle, *i.e.*, during A/A, PE, final design, and construction. There is in-depth analysis of seven major transit projects with their history of cost overruns.

Debella, D.C. Ries ,R. (2006). “Construction Delivery Systems: A Comparative Analysis of Their Performance within School Districts”. *Journal of Construction Engineering and Management*, 132(11).

This paper focuses on school projects delivered using a multi-prime DBB approach. Projects under consideration are 94 school projects in the Northeast. The comparison is done based on qualitative and quantitative parameters. Quantitative parameters are construction speed, unit cost, cost growth, schedule growth, percentage change order, number of litigation cases. Qualitative ones are length of punch list, difficulty of facility startup, level of call-backs after owner occupancy, level of administrative burden, project team communication, project team chemistry and litigation. The study shows that there are more change orders in the case of multi-prime with CM which increases as the size of the project increases.

Dorsey, R. (1997). *Project Delivery Systems for Building Construction*, Associated General Contractors of America, USA.

This book covers four delivery systems *i.e.* lump sum general contracting, cost-plus a fee/GMP contracting, Design-Build, and Construction Management for building projects. The book suggests using a weighting matrix for project delivery system selection. The set of criteria in this matrix includes: size/dollar, complexity, uniqueness, proximity, external approvals, goals, experience, decisions, construction liability, business risks, quality, change, schedule, cost, early cost guarantee, value, and cultural factors. The book has many figures for illustrating the contractual relations between parties involved in a project in different delivery systems. It also gives the advantages and disadvantages of each delivery system in detail.

Duncombe, T., Cartwright, E. (2005). Oakland Airport Connector: Pushing the Design-Build Envelope,[WWW document].

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Ellis, R.D. *et al* (1992). “Final Evaluation of the Florida Department of Transportation’s Pilot Design-Build Program,” *Transportation Research Record 1351*. Washington D.C.

El Wardani, M., Messner, J., Horman, M. (2006). Comparing Procurement Methods for Design-Build Projects, *Journal of Construction Engineering and Management*, 132(3).

This paper focuses on procurements used in DB projects, i.e. sole source, qualifications based, best value and low bid selection. The paper is based on 76 projects consisting of low complex and high complex projects. Cost, time and quality of the projects are studied and procurements are compared.

Faulkner, B., El-Shrafi, M. (2002). “From Rehab to First Class: Analyzing the Increase in Costs of the Old Colony Commuter Railroad Project,” Jacobs Civil Inc., Boston, USA.

Fernandez, N.I. (2000). “Design-build and design-build-operate maintain,” *Dear Colleague Letter*, No.C-00-15, 09-20-00, FTA.

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FHWA (2006). “Guide to Risk Assessment and Allocation for Highway Construction Management,” US Department of Transportation, Washington, D.C.

This guidebook helps DOTs to have a uniform and robust approach toward risk management in highway projects. It defines risk, gives examples and shows how to go through different steps of the proposed approach including identification, analysis, mitigation, allocation and monitoring of risks.

Federal Transit Administration (1997). “Lessons Learned: Turnkey Applications in the Transit Industry,” FTA, U. S. D. o. T., Washington, D.C., October.

Federal Transit Administration (2003). “Project and Construction Management Guidelines,” Federal Transit Administration, Washington, D.C.

Federal Transit Administration (2006). “Annual Report on New Starts: Proposed Allocation of Funds for Fiscal Year 2007”, FTA, U. S. D. o. T., Washington, D.C.

Flyvbjerg, B., Bruzelius, N., Rothengatter, W. (2003). *Megaprojects and Risk*, Cambridge University Press.

This book is mainly based on three major infrastructure projects in Europe (Channel Tunnel, Oresund Bridge, and Great Belt), and a number of transportation projects in the US and Europe. Based on the data gathered by the authors, underestimating the costs and overestimating incomes in transportation projects is a trend all over the world and most of the infrastructure projects face schedule delays. The book explains the reasons for cost overruns, revenue shortcomings, environmental issues, and delays, and suggests new approaches to be applied in decision making about projects and their economic and environmental impact estimates.

Garvin, M (2003). "Role of Project Delivery Systems in Infrastructure Improvement," *Proc., Construction Research Congress*, ASCE.

The paper mainly concentrates on the importance of understanding the differences between the delivery systems. The author believes that many alternative delivery systems have flaws and this underscores the importance of thorough studies before decision making. The paper talks about O&M part of the project life cycle and studies BOT contracts as well as DB and DBB.

Ghavamifar, K. and A. Touran (2008), "Alternative Project Delivery Systems: Applications and Legal Limits in Transportation Projects," *Journal of Professional Issues in Engineering Education and Practice*, ASCE, 134 (1), January, 106-111.

Part of this paper is presented in this report under Appendix C.

Gordon, C. M. (1994). "Choosing Appropriate Construction Contracting Method," *Journal of Construction Engineering and Management*, ASCE, 120(1), 196-210.

The author divides the contracting process into four parts: scope, organization, contract and award. He defines the traditional and alternative delivery methods and their advantages and disadvantages. Then the author covers owner's drivers and market drivers and gives a list of parameters for decision making in delivery system selection. The paper also provides a flowchart for method selection.

Gordon & REES LLP. (2005). "The Basics of Design Build," Construction Group Newsletter, Gordon & REES LLP.

Gannett Fleming, Inc. (2006). "Construction Project Management Handbook", Federal Transit Administration.

Gransberg, D.D., J.E. Koch and K.R. Molenaar (2006). *Preparing for Design-Build Projects: A Primer for Owners, Engineers, and Contractors*, ASCE Press, Reston Virginia.

Gransberg, D.D. and Molenaar, K.R., (2001). "Project Delivery Methods Professional Practice Guide," *Proc., AACE-International*.

Gransberg, D.D. and Molenaar, K.R. (2004). Analysis of Owner's Design and Construction Quality Management Approaches in Design/Build Projects, *Journal of Management in Engineering*, 20(4).

This paper studies the quality management approaches in 78 Design-Build projects based on their RFPs. These projects are divided in two groups and different mechanisms found in RFPs are categorized and the trends are studied. The authors found six different approaches: quality by qualification, quality by evaluated program, quality by specified program, quality by performance criteria, quality by specification, and quality by warranty. The authors believe that many DB project owners still have DBB mentality while developing their approach for quality management. Based on this study the highways have the most comprehensive approach to QM where owners ask for design QM and also qualification of the design team as well as QM for construction.

Gransberg, D.D. and Molenaar, K.R. (2004). Life Cycle Award Algorithms for Design-Build Highway Pavement Projects, *Journal of Infrastructure Systems, ASCE*, 10(4).

Gransberg, D.D. and Barton, R.F. (2007). "Analysis of Federal Design-Build Request for Proposal Evaluation Criteria," *Journal of Management in Engineering, ASCE*, Vol. 23 (2), April 2007, pp. 105-111.

This paper is based on the analysis of 110 request for proposals and intends to identify the benefits federal owners are seeking through design-build process. The analysis compares the benefits cited for DB implementation and weights given to evaluation criteria. The study shows a very heavy weight given to price while schedule is given a very low average weight in government selection process.

Gransberg, D. and Molenaar, K.R. (2007). "The Impacts of Design-Build on the Public Workforce", Research Paper 07-01, USC Keston Institute for Public Finance and Infrastructure Policy, University of Southern California, Los Angeles, CA, April 2007.

This research focuses on the effects of design-build application on the transportation agencies' staff. It shows that DB does not shift public professional engineering jobs from state agencies to private sector. It also shows that implementing DB requires a more competent and experienced workforce.

Graham, P. (2001). "Evaluation of Design-Build Practice in Colorado IR(CX) 70-4(143)," Colorado Department of Transportation, Denver, Colorado.

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Ibbs, C., and Kwak, Y. (1998). "Benchmarking project management organizations," *PMNetwork*, February, 49-53.

Ibbs, C.W., Kwak, Y., Odabasi, A. (2003). "Project Delivery System and Project Change: A Quantitative Analysis," *Journal of Construction Engineering and Management*, ASCE 129(4). 382-387.

The paper is based on a data base of 67 projects from 5 million to 1 billion USD (mostly between 25 and 75 million). The main goal is comparing DB and DBB. Some parameters were defined for this comparison like cost change, schedule change and productivity. Taking absolute value of cost changes, there is a small difference between DB and DBB: 13% vs. 15.6%. For changes in schedule the same difference was observed. DB had 7.7% changes while DBB had 8.4% changes. The changes in productivity based on the changes in schedule or cost is compared.

Irwin, D. (2003). "Developing the design and construction contracting plan for a major light rail extension project," *Transportation Research Circular No. E-C058*, TRB, Washington, D.C., 557-575.

This paper shows the complexities of transit projects due to several approvals needed, interaction with communities, coordination, property takes, *etc.* The author then highlights the advantages and disadvantages of several delivery methods and also gives data about a few Oregon transit projects and legal limitations of transit agency (TriMet) in that state. The paper provides useful information on the selection of a CM-at-risk approach for transit project delivery.

Katz, G., and Smith, S. (2003). Build-Operate-Transfer: The Future of Public Construction?, *Journal of Construction Accounting and Taxation*, March/April, 36-48.

This paper defines and explains the advantages and disadvantages of BOT and similar systems like BOO, BTO, *etc.* It concentrates on the fact that this delivery system, which is mainly developed to attract private funds to build infrastructures, has an inherent problem about risk allocation. This problem is because of the difficulties guaranteeing the revenue of the facility by the public entity. The private sector is reluctant to participate in a project in which the minimum stream of revenue is not guaranteed. These guarantees sometimes conflict with constitutional law against monopoly. The authors believe that BOT contract have some mechanisms to cover the risks of the private entity but do not have mechanisms to give enough control to the public entity on the project.

Kessler, F., Nossaman, Guthner, Knox & Elliot LLP (2005). "Managing Your Money: Project Delivery Methods," [WWW document] URL http://www.nossaman.com/db30/cgi-bin/news/FWK_MassTransit_04.05.pdf (visited March 20, 2007)

This report compares DB and DBOM in transit projects. The authors have collected information about several DB and DBOM projects and have interviewed the owners and contractors of those

projects to find out the benefits of DBOM and the reasons why some agencies use this system and why others do not.

Kluenker, C. (2001). "Risk vs. Conflict of Interest-What Every Owner Should Consider When Using Construction Management," *CMEJournal*, Construction Management Association of America.

This paper is about different ways of contracting with a construction manager in a project. It explains the level of risk and responsibility of the Agency CM in each case and shows how transfer of risks to the CM may cause conflict of interest in the project. The paper discusses the evolution of construction management.

Kopic, P.(1997). "Contract Management Techniques for Improving Construction Quality," *Publication No. FHWA-RD-97-067* http://www.tfhrc.gov/pavement/rd97_079.htm.

Konchar, M. and V. Sanvido (1998). "Comparison of U.S. Project Delivery Systems," *Journal of Construction Engineering and Management, ASCE*, 124(6), 435-444.

This paper compares DBB, DB and CMR in building projects based on three criteria: time, cost and quality. The paper is based on a research which consisted of four phases: develop an instrument for data collection and pilot test it, collect data from US projects, check the validity of data collected, testing different hypotheses. The projects are divided into six groups in order to have a better judgment about each group. In general, the paper concludes that DB is superior to DBB and CMR in terms of speed of delivery and control of cost growth.

Kumaraswamy, M. M. & Dissanayaka, S. M. (1996). "Procurement by Objectives," *Journal of Construction Procurement*, 2(2), 38-51.

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Loulakis, M. (2000). *Project Delivery Systems: Evaluating Owner's Alternatives*. A/E/C Training Technologies.

Loulakis, M. (2003). *Design-Build for the Public Sector*, Aspen Business and Law, Aspen Publishers, New York, N.Y.

Mahdi, I.M., Alreshaid, K. (2005). "Decision Support System for Selecting the Proper Project Delivery Method Using Analytical Hierarchy Process," *International Journal of Project Management*, 23, 564-572.

This paper compares three delivery systems: DBB, DB and CMR. The factors affecting this comparison are categorized in groups: owner characteristics, project characteristics, design characteristics, regulatory, risk, contractor characteristics, and claims and disputes. The authors have

used AHP to compare the delivery systems; a sensitivity analysis is performed to evaluate the effect of various parameters on the choice of delivery system.

Mahoney, S. E. (1998). “Project delivery and planning strategies for public owners,” *MS thesis*, Massachusetts Institute of Technology, Cambridge, Mass.

Miller, J.B. (2000). *Principles of Public and Private Infrastructure Delivery*. Springer. USA.

Miller, J. B., Garvin, M. J., Ibbs, C. W., Mahoney, S.E. (2000). “Toward a new paradigm: simultaneous use of multiple project delivery methods.” *J. of Eng. Mgmt.*, 16(3), 58-67.

Minchin, E., Thakkar, K., Ellis, R. (2007). “Miami Intermodal Center-Introducing CM-At-Risk to Transportation Construction”, in *Innovative Project Delivery Systems*, Molenaar, K.R. and Yakowenko, G. (Eds), ASCE Press, pp 46-59.

The paper discusses CM-at-risk delivery system as used for the Miami Airport. It gives the details of the project, distribution of risks, and method of payment to the contractor.

Mitchell, B.P. (1999). “The Applicability of the Spearin Doctrine: Do Owners Warrant Plans and Specifications?” Find Law for Legal Professionals, <http://library.findlaw.com/1999/Aug/1/128038.html> (March 24, 2007).

Molenaar, K.R. (2005). “Programmatic Cost Risk Analysis for Highway Megaprojects,” *Journal of Construction Engineering and Management*, ASCE Vol. 131(3), pp. 343-353.

Molenaar, K. R., A.D. Songer, and M. Barash (1999), “Public-sector Design/Build Evolution and Performance,” *Journal of Management in Engineering*, ASCE, 15(2), March/April, 54-62.

Molenaar, K.R., *et al.* (2002). 2001 European Contract Administration Scan – Final Report, *Report #FHWA-PL-03-002, International Technology Program, Federal Highway Administration*, Washington, DC, October, 111 pp.

Molenaar, K.R. and Yakowenko, G. (2006). *Innovative Project Delivery, Procurement, and Contracting Methods for Highways*, Molenaar, K.R. and Yakowenko, G. (Eds.), ASCE Press.

It contains eight papers on various aspects of project delivery methods including issues of warranty, incentive/disincentives, best-value procurement methods, and quality-based contractor selection. The main emphasis is highway construction projects.

Molenaar, K.R., *et al.* (2005). “Recommended AASHTO Design-Build Procurement Guide”, NCHRP 20-7(172), National Cooperative Highway Research Program, Transportation Research Board of the National Academies, Washington, DC, June 2005, 182 pp.

This guide is intended to assist state highway agencies in the design-build procurement process including the preparation of request for qualification and requests for proposals and the selection of the successful proposer. It describes the capabilities of design-build and gives a matrix for risk allocation in this delivery method.

Molenaar, K.R., and Scott, S. (2003). Book chapter "Examining the Performance of Design-Build in the Public Sector," *Design-Build for the Public Sector*, Edited by Michael Loulakis, ISBN 0-7355-3011-4, Aspen Business and Law, Aspen Publishers, 71-112.

This chapter examines the efforts made to measure success or benchmark design-build against more traditional project delivery methods in public sector construction. It also recommends strategies that public owners should consider when implementing design-build to measure performance and improve their chances of realizing a successful outcome. It also discusses the effects that different design-build procurement and contracting strategies have on performance outcomes.

Mouritsen, J.W. (1993). "An Empirical Analysis of the Effectiveness of Design-Build Construction Contracts." Master's Thesis. Purdue University.

North Carolina State Construction Office (2005). "Construction Management-At-Risk Selection Procedures" [WWW document]. URL <http://interscope2.doa.state.nc.us/Guidelines/CM@RISK%20SELECTION%20PROCEDURES.pdf> (visited 2005, January 31)

Nossaman, Guthner, Knox & Elliott. (2006). "50 state survey of transportation agency design-build authority." {<http://www.nossaman.com>} (visited Dec. 12, 2006).

Oyetunji, A.A, Anderson, S.D., (2006). "Relative Effectiveness of Project Delivery and Contract Strategies," *Journal of Construction Engineering and Management*, ASCE, 132(1), 3-13.

The paper explains the importance of finding the most appropriate delivery method and highlights some of its difficulties. It studies some methods of decision making and suggests SMART system with pre-calculated and fixed weights. The authors give a list of 20 factors with their correspondent weights for 13 different combinations of payment and contracting in construction projects.

Oppenheim, A. N. (1992). *Questionnaire Design, Interviewing and Attitude Measurement*, Continuum, London.

Paek, J. H., Lee, Y. W. & Napier, T. R. (1992). "Selection of Design/Build Proposal using Fuzzy-Logic System", *Journal of Construction Engineering and Management*, ASCE, 118 (2), 303-317.

Pakkala, P., Jong, W., Aijo, J. (2007). "International Overview of Innovative Contracting Practices for Roads," Finnish Road Administration, Helsinki, Finland.

Pakkala, P. (2002). *Innovative Project Delivery Methods for Infrastructure—an International Perspective*. Finnish Road Enterprise, Helsinki, Finland, p. 32.

Parsons Brinckerhoff Quade & Douglas Inc. ,(2002). “Design-Build Practice Report,” New York State Department of Transportation.

Parsons, Touran, A., and Golder Assoc. (2004). “Risk Analysis Methodologies and Procedures,” Federal Transit Administration.

This report discusses the process of risk management in transit projects. The risk management process is divided into six distinct steps: scope review, risk identification, risk quantification, review, risk mitigation, and risk implementation. The emphasis is on probabilistic risk analysis. Several examples are provided.

Potter, K., Sanvido, V. (1994). “Design-Build Prequalification System,” *Management in Engineering, ASCE*, 10(2).

Potter, K., Sanvido, V. (1995). “Implementing a Design-Build Prequalification System,” *Management in Engineering, ASCE*, 11(3).

Quatman, W. (2000). *Design-Build for the Design Professional*, Aspen Publishing, Inc., New York, N.Y.

Riley, D., Diller, B., Ken, D. (2005). “Effects of Delivery Systems on Change Order Size and Frequency in Mechanical Construction,” *Journal of Construction Engineering and Management, ASCE*, 131(9).

This paper compares the effects of DB and DBB on the number and size of change orders in mechanical construction projects. 598 change orders in 120 construction projects were studied and the results show that the total number of change orders in DB and DBB are almost equal but the size of change orders is significantly smaller in DB.

SAIC Inc. (2003). “Outsourcing of State DOT Capital Program Delivery Functions”, *NCHRP Web Document 59*, TRB, Washington, D.C.

This report explains how the DOTs have outsourced their duties to the private sector. The report mainly concentrates on DB and also O&M part of DOT duties. The authors focus on “capital program delivery functions” like major facility design, major project construction supervision, etc. and study the ways of outsourcing these activities to qualified private entities.

Saaty, T.L. (1990), *Multicriteria Decision Making: the Analytical Hierarchy Process*, RWS Publications, Pittsburgh, PA.

Schaufelberger, J. (2005). “Use of Design-Build on Mass Transit Rail Projects”, *Proceedings, Construction Research Congress*, San Diego, USA.

This paper is based on eight DB transit projects in the US and has useful information about them. The author has collected information about the projects and also has sent questionnaires to all the parties involved in these projects and has obtained information about cost overruns, delays, management skills, challenges in the projects, lessons learned by the owner and necessity of early contractor's involvement in the project. The author concludes that the contractor in DB projects should come onboard when the design is 10 to 15% complete and also the federal funds should be available when they are needed.

Scott, S. Molenaar, K., Gransberg, D, Smith, N. (2006). "Best Value Procurement Methods for Highway Construction Projects", *National Cooperative Highway Research Programs (NCHRP), Report 561*, Washington, D.C.

Skitmore, R. M. & Marsden, D. E. (1988). "Which Procurement System? Towards a Universal Procurement Selection Technique", *Construction Management and Economics*, E.F. Spon, Ltd., 6, 71-89.

Stenbeck, T. (2006). "Effects of Outsourcing and Performance-Based Contracting on Innovations", *TRB 2006 Annual Meeting*, Washington, D.C.

This paper studies the difference between outsourcing the projects and doing them in-house in terms of innovations raised during the design and construction phase. The paper focuses on transportation projects in France and Sweden and also compares them with some projects in the USA.

Strang, W. (2002). "The Risk in CM at Risk," *CMEJournal*, Construction Management Association of America.

Temesi, J. (2006). "Consistency of decision maker in pairwise comparisons", *Int. J. of Management and Decision Making*, Vol. 7, No. 2/3, pp. 267-274.

Thomas, S.R., C.L. Macken, T.H. Chung, and I. Kim (2002). "Measuring the Impacts of the Delivery System on Project Performance – DB and DBB," *NIST, GCR 02-840*, November.

Tom Warne and associates, LLC (2005). "Design Build Contracting for Highway Projects: A Performance Assessment", Report prepared for California DB Coalition, Tom Warne and Associates, LLC.

This report studies 21 highway projects that have used DB as the delivery system to find out the effects of this delivery system on the success of highway projects. They have collected the data from the published reports and also some interviews with the key people in those projects. Their conclusion shows 100% owners satisfaction with using DB in their projects. Two factors have mainly driven the owners in choosing DB as a delivery method: schedule and finance.

Tomeh, O., Schneck, D., Stross, R. (1999). "Innovative Procurement Methods in Rail Transit Projects," *Paper No. 99-1551, Transportation Research Record 1677*, pp. 79-86.

This paper is based on the evaluation of two phases of Baltimore light rail. The first phase is done with a DBB method and the second phase with a DB arrangement. The authors compare these two projects and explain some clauses in DB contract and also bonding issues and at last compare the level of control of the owner in these two delivery methods.

Toussant, J. (2003). “Environmental Impacts to Design/Build Projects-A Case Study of the St. George Island Bridge Replacement”, *Leadership and Management in Engineering*, 128-132.

This paper is about replacement of a bridge in Apalachicola Bay. It is done using a DB approach. Because of the sensitivity of the environmental issues, the owner had developed a best value selection system in which environmental plan of the proposals had a high weight. This case study shows some flexibilities of DB when the environmental issues are of paramount importance.

Transit Cooperative Research Program (1995). “Transit Labor Protection-A Guide to Section 13(c)”, Legal Research Digest, number 4, Federal Transit Administration, Washington, D.C.

Transit Cooperative Research Program (2002). “Design-Build Transit Infrastructure Projects in Asia and Australia”, Federal Transit Administration, Washington, D.C.

This report was sponsored by the TCRP and covers DB application in transit projects in Asia and Australia. It was observed that many transit-related projects in Hong Kong have been done using DBOMT; in Thailand, some transit projects are done by DBOOT. They collected the experiences and lessons learned on DB application in these countries and Australia. They found that using DB would reduce the number of approval milestones and help the project go forward when approved once. The report explains different aspects of DB contract like risk, control, and quality in some detail.

Trombly, J., Luttrell, T. (2000). “Michigan Intelligent Transportation System Center: Use of Design/Build/Warranty Contract”, Federal Highway Administration.

Twomey, T.R. (1989). *Understanding the Legal Aspects of Design/Build*, R.S. Means Co., Kingston, Mass.

TRB (1999). “Report on Innovative Financing Techniques for Transit Agencies”, *TRB Report Number TL01*.

TRB (2000). “Systems Approach to Evaluating Innovations for Integration into Highway Practice”, *TRB Document Number NR442*.

Touran, A., P. Bolster, and S. Thayer (1994). “Risk assessment in fixed guide way construction,” *Report No. FTA-MA-26-0022*, Federal Transit Admin., U.S.D.o.T.

This is one of the earlier reports on probabilistic risk analysis for estimating the probability of cost and schedule overrun in transit projects. The report contains a section on risk allocation in the construction contract.

Touran, A. (2006). “Owners Risk Reduction Techniques Using a CM”, Construction Management Association of America.

This report, sponsored by CMAA, explains the methodology of risk analysis and risk management in different phases of a project and shows the role of a CM in conducting successful risk mitigation. The author divides risk analysis into five steps: validation of cost/schedule, risk identification, risk quantification, risk mitigation, and implementation of risk mitigation plan. This report has a risk catalog as an appendix.

U.S.Army Corps of Engineers (1997). “Design-Build and Military Construction Workbook”, Corps of Engineers Training Management Directorate, No.425-FY95 (PROJECT), Huntsville, Alabama.

Walewski, J. Gibson, G., Jasper, J. (2001). “Project Delivery Methods and Contracting Approaches Available for Implementation by the Texas Department of Transportation”, Texas Department of Transportation, Austin, Texas, 116 pages.

The report gives an analysis of alternative project delivery methods and provides insight on how alternative delivery methods can help achieve successful projects in Texas. It also describes the limitations of Texas laws in using various project delivery systems.

Warne, T. and Beard, J. (2005). *Project Delivery Systems Owner's Manual*. American Council on Engineering Companies, Washington, D.C.

Weber, M., Borcharding, K. (1993). “Behavioral Influences on Weight Judgments in Multiattribute Decision Making”, *European Journal of Operational Research*, Vol. 67, pp. 1-12.

Wiss, R., Roberts, R., Phraner, S. (2000). “Beyond Design-Build-Operate-Maintain,” *Transportation Research Record, Paper No. 00-0675*, 13-18.

This paper mainly discusses DBOM transit projects in the State of New Jersey. The focus of the paper is on preceding stages of DBOM and explains the development of Public-Private-Partnership. The main advantage of PPP compared to DBOM is said to be new allocation of risks in the project. A transit project starts from a need for public transportation and goes through different studies and phases by various entities, before it goes to the construction phase. In PPP, the legislators let the private sector partner with the public entity, finance the project, design it, build it and operate it for a predetermined time. NJDOT receives proposals (13 mentioned in the paper) for any kind of PPP project. Barriers to this procurement are public ignorance, environmental mandates and mistrust between the parties.

Yin, R.K. (2004). “Conducting Case Studies: Collecting the Evidence” [WWW document]. URL <http://72.14.203.104/search?q=cache:jHb6y55UFJ8J:www.idt.mdh.se/>

phd/courses/fallstudie/slides%2520-%2520seminarie%25202/Yin%2520-%2520kapitel%25204%2520Rev%25203.ppt+conducting+case+studies&hl=en&gl=us&ct=clnk&cd=1 (visited 2006, March 13).

Yin, R. K. (1994). Case Study Research: Design and Methods, Sage Publications.

APPENDIX C – LEGALITY OF ALTERNATIVE DELIVERY METHODS

This appendix includes the results of a research on the state codes to study the legality of alternative delivery methods in transportation projects in various states in the United States.

Alternative Project delivery methods: Applications and Legal Limits in Transportation Projects

Introduction

At the present time several types of project delivery methods are available to the owners of publicly funded transportation projects in the United States. An important decision, especially in the case of large complicated transportation projects is to select the best project delivery method for a specific project. In general, a construction project starts with a need and/or idea in the owner's organization. The owner needs to hire professionals for design, management and construction of the project if there is not enough expertise in-house. Contractual relations, contemporary laws and regulations, owner's perception of risks, awarding mechanism and the method of payment all contribute to project delivery method selection. Based on Public Law 92-582 (Brooks Act) passed in 1972 and similar laws passed by individual states (Little Brooks Acts), public projects in the United States should be designed by the quality-based selected designers. On the other hand the construction of the project should be awarded to the lowest responsible, responsive bidder. Combination of these two has led the public agencies towards the adoption of Design-Bid-Build (DBB) delivery method. This method was overwhelmingly dominant in transportation projects until 1996 when the Federal Acquisition Reform Act authorizing the use of Design-Build (DB) for federal projects was passed. After that the Transportation Equity Act for the 21st Century (TEA-21) allowed the states Department of Transportation (DOTs) to award a DB contract if the state code lets them do so (Molenaar et al 1999). Subsequent to the successful experience of using DB in several projects a number of states passed legislations and codes to allow alternative project delivery methods (Design-Build and Construction Management at Risk).

The laws and regulations of the state where the transportation project is being considered play an important role in the choice of project delivery method. In many states, simply there is no choice other than the traditional design-bid-build approach. The trend however, is the rapid change of laws to allow more flexibility for choosing the contractor. This appendix is based on a review of United States codes in all the 50 states and shows which states have approved using alternative project delivery methods, namely Design-Build and/or Construction Management at Risk in the transportation sector. The states are categorized in four groups based on the level of authorization as follows:

- 1) fully authorized
- 2) authorized but needs extra approvals
- 3) authorized for a pilot program and/or with some limitations
- 4) not authorized

Design-Bid-Build (DBB) is the traditional delivery method that is used in public and private projects in the United States and all the state codes authorize public agencies to use it in their projects. Design-Build (DB) and Construction Management at Risk (CMR) are considered as two alternatives to this traditional method. Some states have passed the authorization law for public agencies who want to use either of these two. Although legal authority is a yes/no criterion in decision making, only limited research is done on this issue. All of these research efforts have chosen either DB or

CMR and have shown in which states that method can be applied. As an example, a survey of states Department of Transportations authorized to do DB was done by Nossaman et al. (2006). The current report is based on a search in all the 50 state codes using LexisNexis search engine and has found the legal status of each of these two methods in each state. One important issue in this type of research is the realization that state codes in this area are constantly changing. States have made significant changes to their laws in the past 10 years with regards to alternative project delivery methods. This appendix is based on a research done at the end of December 2006 and does not reflect any updates in state codes afterwards.

Wording of statutes are different in state codes; so in order to make sure that nothing is missed, several key words were used which are listed below:

(1) Design-Build, (2) Design Build, (3) D/B, (4) design builder, (5) Construction Management at Risk, (6) Construction Management, (7) CM/GC, (8) Construction Manager at Risk, (9) construction manager/general contractor, (10) general contractor / construction manager, (11) construction manager, (12) alternative delivery system.

The focus of this appendix is transportation projects. Some states permit an alternative delivery method to be used in some other types of projects but not transportation projects. For example, state code of Florida allows using CMR for educational facilities but no statute was allowing this application for DOT projects and because of that, Florida is considered a “not authorized” state. Another point is that in some states, the lawmakers have given authority for using an alternative delivery method for some special projects. In other words there is no statute in the state code of that state authorizing DOT for using alternative delivery method but some projects are done under DB or CMR contracts. These states are still considered “not authorized” states.

The results of the search are explained in the following parts. The states are divided into four distinguishable categories. There are some states that have statutes in which all the public entities (including DOTs) can apply an alternative delivery method. There are some other states that allow DOTs to use DB and/or CMR. These states are listed under “fully authorized” states. In some states DOTs cannot choose an alternative delivery method unless they get an approval from another governmental entity like governor or legislator. These states are considered as states which are “authorized but needs extra approvals” for alternative entities. Any in-house approval does not mean extra approval. There is another group of states in which a pilot program for alternative delivery methods is defined by law and/or a limit is put on its usage. These states are listed under “authorized for a pilot program and/or with some limitations”. The rest of the states are those where no statute was found for alternative delivery method authorization in transportation projects at the time of this research. These states are listed as “not authorized” states.

Design-Build

Design-Build is arguably the oldest delivery method in the construction industry. The practice goes back in history for centuries. Many large cathedrals of Europe were built by Master Builders who were roughly equivalent to today’s DB contractors. In this method, a single entity is chosen by the owner after the completion of conceptual design or preliminary engineering and when the performance requirements are defined. This entity completes the design and constructs the project, often simultaneously with the final design phase. The design-builder assumes almost all the responsibilities of the detail design and construction and delivers to the owner the final product

which should fulfill the performance requirements previously defined. Almost all the projects in the USA have used a kind of design-build method up to the 19th Century (Miller 2000).

Based on the current laws, 17 states have fully authorized DOTs to apply DB in their projects. For example, in Colorado, C.R.S. § 43-1-1401 says that the department of transportation is authorized to enter into design-build contracts and to use an adjusted score design-build selection and procurement process for particular transportation projects regardless of the minimum or maximum cost of such projects.

Two states need extra approval from an entity outside of the DOT, like the house or senate. As an example, in Louisiana, La. R.S. 48:250.2-4 mentions that the secretary of the DOT, with approval of the House and Senate Transportation, Highways and Public Works Committees, may use the design-build method on any transportation infrastructure project in an area impacted by a hurricane.

In 18 states, lawmakers have decided to define a pilot program for using DB or have put some limitations (either the number or cost of projects in a period of time) on using this delivery method. For example, in Ohio (ORC Ann. 5517.011) there is a limit of \$250 million for the total dollar value of the contracts made under DB delivery method. Another example is the state of Montana (Mont. Code Anno., § 60-2-135) where the DOT is authorized to establish and implement a design-build contracting pilot program (2003-2008) for highway construction.

Based on the aforementioned data, 37 states use DB in their transportation projects while 13 state DOTs still do not have the authority to do so. The states are categorized in the table below.

Table C-1 - Legal status of states regarding the use of Design-Build in transportation projects

Fully authorized (1)	Authorized but needs extra approvals (2)	Authorized for a pilot program and/or with some limitations (3)	Not authorized (4)
AK, AZ, AR, CO, DE, FL, HI, ID, IL, IN, KY, ME, MD, NJ, SD, TN, VA	LA, OR	CA, GA, MA, MN, MS, MO, MT, NV, NH, NM, NC, OH, SC, TX, UT, WA, WV, WI	AL, CT, IA, KS, MI, NE, NY, ND, OK, PA, RI, VT, WY

Figure C.1 illustrates the same results schematically.

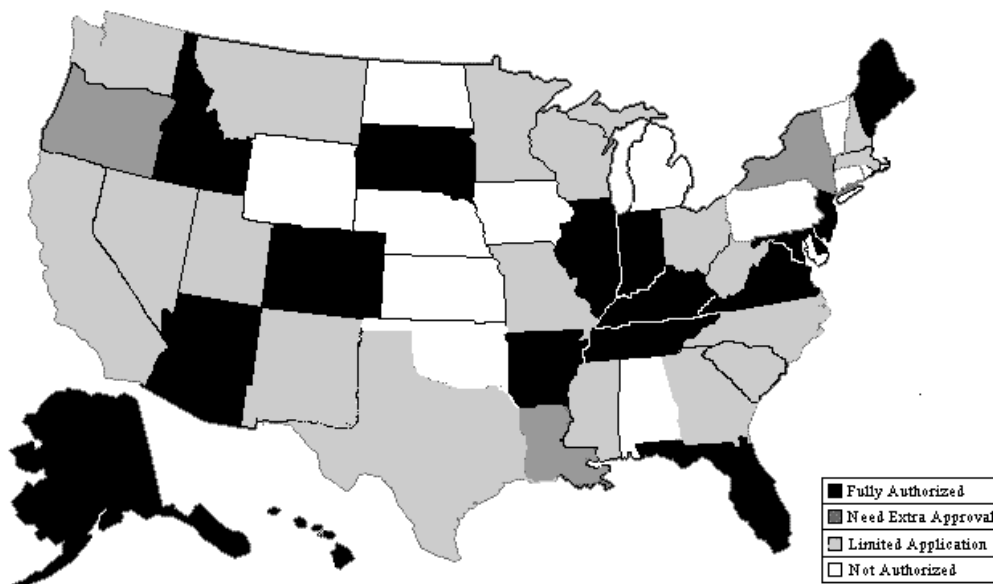


Figure C-1 - Design-Build statutory status of all the states in December 2006

Construction Manager at Risk (and/or CM/GC)

Construction Management-at-Risk (sometimes referred to as Construction Manager/General Contractor (CM/GC)) is a delivery method in which a contractor comes on board early during the project design phase to help the owner with managerial duties and also to increase the feasibility and constructability of the design. While some experts distinguish between CM-at-risk and CM/GC due to perceived levels of risk, many agencies use these terms more or less interchangeably (Associated General Contractors of America). CM-at-risk can and is expected to provide realistic project cost estimates early in the project life cycle. It is anticipated that after a certain amount of design is complete and the project is sufficiently defined, the owner will enter into a contract with the CM-at-risk for providing construction services. States agencies usually reserve the right to go out for bid if they think that the CM-at-risk price is not competitive. But if they come to an agreement the construction manager will be obligated to deliver the project with a guaranteed maximum price (GMP).

In general, Construction Management is mainly divided into two categories: construction manager at risk, and construction management agency. The main difference between these two is about their role and responsibility in the project. CM agent is simply an advisor to the owner; the CM is not responsible for any delay or cost overrun as long as he does his duties according to the contract. CM agent will be paid based on a fee and because of that some specialists refer to this method as CM for Fee. CM at risk on the other hand takes many of the general contractor's responsibilities. It should choose subs and award different parts of the project. CM performs the general conditions and maybe some small parts of the project. All the terms mentioned above can be found in state codes and two types of CM have almost the same definition. The main issue is to differentiate between Agency CM and CM at Risk based on the wordings of statutes.

Based on the search done in the 50 state codes, 14 states have authorized their DOTs to use CMR in their projects. For example, in North Carolina (N.C. Gen. Stat. § 143-128.1) the construction manager at risk shall contract directly with the public entity for all construction; shall publicly

advertise; and shall prequalify and accept bids from first-tier subcontractors for all construction work under this section.

Construction Management at Risk is allowed to be used in DOT projects in two states only after obtaining an extra approval. For example, in Massachusetts (ALM GL ch. 149A, § 1) it is mentioned that “prior to using the construction management at risk delivery method, the public agency shall obtain a notice to proceed from inspector general.”

It is possible to use Construction Management at Risk in three states but with limitations in each fiscal year. For example based on the Minnesota legislation, (Minn. Stat. § 16C.34), construction manager at risk contracts may be used but not for “more than five percent of its total projects let, by number, in each of the fiscal years 2006 and 2007, and ten percent of its total projects let, by number, in each fiscal year thereafter.”

Most of the states have not passed a law which allows DOTs or even other public entities to use CMR in their projects. This research shows that 31 states have not accepted CMR as a legal project delivery in public projects. All the 50 states are categorized in Table C-2, as to the legality of the CMR.

Table C-2 - Legal status of states regarding the use of CM-at-Risk in transportation projects

Fully authorized	Authorized but needs extra approvals	Authorized for a pilot program and/or with some limitations	Not authorized
(1)	(2)	(3)	(4)
AZ, AR, CT, GA, KY, ME, NH, NC, SD, TN, UT, VA, WV, WY	MA, OR	MN, TX, WA	AL, AK, CA, CO, DE, FL, HI, ID, IL, IN, IA, KS, LA, MD, MI, MS, MO, MT, NE, NV, NJ, NM, NY, ND, OH, OK, PA, RI, SC, VT, WI

Figure C.2 illustrates the same results for Construction Management at Risk.

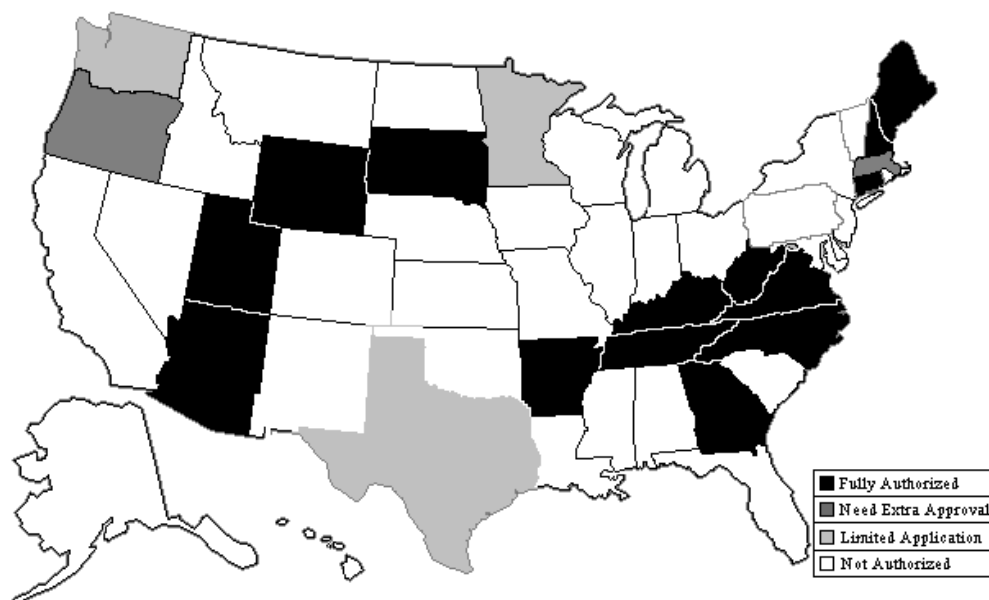


Figure C-2 - Construction Management at Risk statutory status of all the states in December 2006

Regulatory and statutory limitations

Public agencies have found that the traditional way of awarding and executing a project is not necessarily the best way of delivering all the projects; not using other methods of project delivery in public construction is actually foregoing some opportunities of adding value to the money spent on these projects. The best value for the money may not always be achieved by using a traditional design-bid-build project delivery method. This has been the main motive for states to pass various laws which allow other methods of procuring construction projects. Some potential issues include conflicts between lowest cost based bids of contractors *vs* quality based selection of engineers in Design-Build, and the fear of favoritism and added unnecessary cost in Construction Management at risk. These issues have played a negative role in this transition phase and the lawmakers have been hesitant to authorize public agencies in using these new methods. Because of this, there has often been a transition phase between the “only DBB authorized” and “all methods authorized” in states.

In the transition phase some limitations are put in for using a method. For example, only a few pilot projects are allowed to use the method and these projects should be first selected by a board mentioned in the law. In Virginia for example, a “review board” defined in the state code has the duty of deciding on project delivery methods. In other words, this board studies each project suggested for utilizing Design-Build or Construction Management at Risk and approves or rejects the proposal. (Va. Code Ann. § 2.2-2405 (2006)).

SUMMARY

The results of a comprehensive survey to identify the legality of using alternative project delivery methods in state-funded transportation projects were explained in this appendix. The survey covered design build and CM-at-risk (and/or CM/GC) project delivery methods. It was found that dividing

the states into authorized or non-authorized would not provide the full picture. There are many cases where authorization is provided on a case-by-case basis or comes with various limitations. In order to respond to this, four different levels of authorization were considered in the survey: (1) fully authorized, (2) authorized but needed extra approvals, (3) authorized only within pilot programs or other types of limitations, and (4) not authorized. Comparing the results of this survey with previously done surveys on the legality of alternative delivery methods shows that more states are moving towards authorizing various alternative delivery methods for transportation projects. The history of current authorizing statutes and the succession of major changes in state codes confirm this trend.

List of codes found in the survey for each alternative delivery method

Design Build:

Alaska in Alaska Stat. § 36.30.200
 Arizona in A.R.S. § 28-7363
 Arkansas in A.C.A. §27-65-107
 California in Cal Pub Contract Code § 20209.6
 Colorado in C.R.S. § 43-1-1401
 Delaware in 2 Del. C. § 2003
 Florida in Fla. Stat. § 337.11
 Georgia in O.C.G.A. § 32-2-81
 Hawaii in HRS § 103D-303
 Idaho in Idaho Code § 67-2309
 Illinois in 30 ILCS 535/75 and 70 ILCS 3615/4.06
 Indiana in Ind. Code Ann. § 5-30-2-2
 Kentucky in KRS § 45A.180 and KRS § 65.025
 Louisiana in La. R.S. 48:250.2-4
 Maine in 23 M.R.S. § 753-A
 Maryland in Ann. § 3-602
 Massachusetts in ALM GL ch. 149A, § 14
 Minnesota in Minn. Stat. § 161.3410-12
 Mississippi in Miss. Code Ann. § 65-1-85
 Missouri in R.S.Mo. § 227.107
 Montana in Mont. Code Anno. § 60-2-135
 Nevada in Nev. Rev. Stat. Ann. § 338.1711 and Nev. Rev. Stat. Ann. § 408.388
 New Hampshire in RSA 228:4
 New Mexico in N.M. Stat. Ann. § 13-1-119.1
 North Carolina in N.C. Gen. Stat. § 136-28.11
 New Jersey in N.J. Stat. § 27:25-11
 Ohio in ORC Ann. 5543.22 and ORC Ann. 5517.011
 Oklahoma in 61 Okl. St. § 202.1
 Oregon in ORS § 383.005 and ORS § 279B.085
 South Carolina in S.C. Code Ann. § 57-5-1625
 South Dakota in S.D. Codified Laws § 5-18-26
 Tennessee in Tenn. Code Ann. 12.10.124
 Texas in Tex. Transp. Code § 223.203 and Tex. Local Gov't Code § 271.119
 Utah in Utah Code Ann. § 63-56-502
 Virginia in Va. Code Ann. § 2.2-4303 and Va. Code Ann. § 33.1-12
 Washington in Rev. Code Wash. (ARCW) § 47.20.785
 West Virginia in W. Va. Code § 17-2D-2

Wisconsin in Wis. Stat. § 84.11

Construction Management at Risk:

Arizona in A.R.S. § 41-2579

Arkansas in A.C.A. § 19-11-801

Connecticut in PUBLIC ACT NO. 06-134 Sec. 21

Georgia in O.C.G.A. § 36-91-20

Kentucky in KRS § 45A.045

Maine in 5 M.R.S. § 1743

Massachusetts in ALM GL ch. 149A, § 1

Minnesota in Minn. Stat. § 16C.34

New Hampshire in RSA 21-I:78 and RSA 21-I:80

North Carolina in N.C. Gen. Stat. § 143-128.1

Oklahoma in 61 Okl. St. § 202.1

Oregon in ORS § 279B.085

South Dakota in S.D. Codified Laws § 5-18-47 and S.D. Codified Laws § 5-18-51

Tennessee in Tenn. Code Ann. 12.10.124

Texas in Tex. Local Gov't Code § 271.118

Virginia in Va. Code Ann. § 2.2-4301 and Va. Code Ann. § 2.2-4306

Washington in Rev. Code Wash. (ARCW) § 39.04.220 and Rev. Code Wash. (ARCW) § 39.10.061

West Virginia in W. Va. Code § 11-15-2

Wyoming in Wyo. Stat. § 16-6-701 and Wyo. Stat. § 16-6-702

APPENDIX D – INTERVIEW BLANK FORM

The research team conducted extensive interviews with five transit agencies as part of this research. This appendix includes the cover letter and the DB questionnaire used by the research team in conducting those interviews. Questionnaires for the DBB and CMR projects were slightly different but collected the same type of information.

Dear Mr. ...:

I am leading a research effort sponsored by Transit Cooperative Research Program (TCRP) for developing a guidebook for the evaluation of project delivery methods. Specifically, the main objective of the research is to prepare a guide for transit agencies that help them choose among one of the following delivery methods for procuring transit construction services: 1) Design-bid-build, 2) Design-build, 3) Construction manager at risk, and 4) Design-build-operate-maintain.

As part of this research we plan to identify a number of major U.S. transit projects utilizing one of the project delivery methods mentioned above, and conduct interviews with individuals in those transit agencies with expert knowledge and experience with project delivery methods who were involved in the selection process. The results of the interviews should form the basis of a knowledge base for our selection system.

You have been identified as an expert in this field and we value and appreciate your participation in this process. **We understand that your time is limited and will try our best to make the process as smooth and convenient as possible.** We are sending you a copy of the questionnaire that will be the basis for the face-to-face interview. While the questionnaire appears rather comprehensive, we believe the interview format will allow us to expedite the process and gain crucial information in a most effective way. Because of this we urge you to review the questionnaire before the interview and let us know if there are any ambiguities. We welcome your sharing the questionnaire with whoever is best suited to answer the questions.

We expect the duration of the interview to be between two to three hours and we welcome your inviting others who might be able to discuss issues relevant to the topic of our research. We will prepare a report of the interview and email you the report so that you will have a chance to ensure the information was summarized accurately. Needless to say, you are at complete liberty of answering only the questions that you feel comfortable with.

We understand that this is a burden on your busy schedule and we appreciate your willingness to help in this important endeavor. I look forward to meet with you in the near future. Meanwhile please feel free to call me at (617)373-5508 or send me an email at atouran@coe.neu.edu if you have any questions or concerns.

Very truly yours,

Ali Touran
Associate Professor
Northeastern University

TCRP G-08

Structured Interview Questionnaire

CONDITIONS: This interview can either be conducted in person or via telephone. The following protocol shall be followed during its administration:

1. The questionnaire shall be sent to the respondent at least 2 weeks prior to the interview via email.
2. Two days prior to the interview, a follow-up message with the questionnaire attached will be sent to confirm the date and time of the interview.
3. To maximize the quality and quantity of information collected, the primary respondent should be encouraged to invite other members of his/her organization to be present during the interview. Thus, a single “agency” response can be formulated and recorded.
4. The interviewer will set the stage with a brief introduction that emphasizes the purpose of the research, the type of information expected to be collected, and the ground rules for the interview.
5. Once the interviewees indicate that they understand the process at hand, the interview will commence.
6. The interviewer will read each question verbatim and then ask if the interviewee understood the question before asking the interviewee to respond.
7. Each question contains a specific response that must be obtained before moving to the next question. Once that response is obtained, the interviewer can record as text additional cogent information that may have been discussed by the interviewees in working their way to the specific response.
8. Upon conclusion of the interview, the interviewer will ask the interviewees if they have additional information that they would like to contribute and record those answers as text.
9. The interviewer will assemble a clean copy of the final interview results and return them to the interviewee for verification.

STRUCTURED INTERVIEW:

I. General Information:

1. US state in which the respondent is employed:
 2. Name of Agency:
 3. What type of organization do you work for?
- Public Transit Agency Other public transportation agency Other; Please describe:

Project Delivery Method Experience

Project Delivery Experience	Design-Bid-Build	Design-Bid-Build w/OM	CM-at-Risk	CM-at-Risk w/OM	Design-Build	Design-Build w/OM
<p>1 <i>Has your agency awarded a project under one of these project delivery methods?</i></p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p><input type="checkbox"/> A. If yes, how many projects?</p> <p><input type="checkbox"/> B. If yes, what percentage of your total construction budget?</p>	<p><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>A. <input type="checkbox"/> 1-5 <input type="checkbox"/> 6-10 <input type="checkbox"/> >10</p> <p>B. <input type="checkbox"/> <10% <input type="checkbox"/> 11-25% <input type="checkbox"/> 26-50% <input type="checkbox"/> >50%</p>	<p><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>A. <input type="checkbox"/> 1-5 <input type="checkbox"/> 6-10 <input type="checkbox"/> >10</p> <p>B. <input type="checkbox"/> <10% <input type="checkbox"/> 11-25% <input type="checkbox"/> 26-50% <input type="checkbox"/> >50%</p>	<p><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>A. <input type="checkbox"/> 1-5 <input type="checkbox"/> 6-10 <input type="checkbox"/> >10</p> <p>B. <input type="checkbox"/> <10% <input type="checkbox"/> 11-25% <input type="checkbox"/> 26-50% <input type="checkbox"/> >50%</p>	<p><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>A. <input type="checkbox"/> 1-5 <input type="checkbox"/> 6-10 <input type="checkbox"/> >10</p> <p>B. <input type="checkbox"/> <10% <input type="checkbox"/> 11-25% <input type="checkbox"/> 26-50% <input type="checkbox"/> >50%</p>	<p><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>A. <input type="checkbox"/> 1-5 <input type="checkbox"/> 6-10 <input type="checkbox"/> >10</p> <p>B. <input type="checkbox"/> <10% <input type="checkbox"/> 11-25% <input type="checkbox"/> 26-50% <input type="checkbox"/> >50%</p>	<p><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>A. <input type="checkbox"/> 1-5 <input type="checkbox"/> 6-10 <input type="checkbox"/> >10</p> <p>B. <input type="checkbox"/> <10% <input type="checkbox"/> 11-25% <input type="checkbox"/> 26-50% <input type="checkbox"/> >50%</p>

Project Delivery Experience	Design-Bid-Build	Design-Bid-Build w/OM	CM-at-Risk	CM-at-Risk w/OM	Design-Build	Design-Build w/OM
<p>2 <i>Does your agency use alternative project delivery methods for one of these workforce-oriented reasons?</i></p> <p><input type="checkbox"/> A. To augment existing workforce during program funding spikes?</p> <p><input type="checkbox"/> B. To reduce the number of professional engineers on the agency’s staff?</p> <p><input type="checkbox"/> C. To reduce the size of the agency’s full-time staff?</p>	<p>A.</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>B.</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>C.</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p>	<p>A.</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>B.</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>C.</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p>	<p>A.</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>B.</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>C.</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p>	<p>A.</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>B.</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>C.</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p>	<p>A.</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>B.</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>C.</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p>	<p>A.</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>B.</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>C.</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p>

II. Case Study Project Information

1. Project Name and location:
2. Project scope of work:
3. Original Total Awarded Value of project: \$ Final Total Value of project: \$
4. Date preliminary design contract awarded: Date project advertised:

Date final design contract awarded: Date construction contract awarded: [Note: same if DB]

Original Project Delivery Period (including design) Final Project Delivery Period (including design)

Explanatory notes:

5. Project delivery method used on this project:

Design-Bid-Build <input type="checkbox"/>	Design-Bid-Build w/OM <input type="checkbox"/>	CM-at-Risk <input type="checkbox"/>	CM-at-Risk w/OM <input type="checkbox"/>	Design-Build <input type="checkbox"/>	Design-Build w/OM <input type="checkbox"/>
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6. Which of the following were reasons why your agency selected the delivery method used for this project? Check all that apply.
 - Reduce/compress/accelerate project delivery period
 - Establish project budget at an early stage of design development
 - Get early construction contractor involvement
 - Encourage innovation
 - Facilitate Value Engineering
 - Encourage price competition (bidding process)
 - Compete different design solutions through the proposal process

- Redistribute risk
- Complex project requirements
- Flexibility needs during construction phase
- Reduce life cycle costs
- Provide mechanism for follow-on operations and/or maintenance
- Innovative financing
- Other: Explain

7. Which of the above was the single most significant reason for the delivery method decision on this project?
8. Please explain the process that led you to the choice of the project delivery system for this project .
9. Did you consider OM for this project?
 Yes No; Explain if necessary:

10. Case Study Project Issues: Of the following types of issues, indicate whether the issue was considered a benefit or a constraint when this project’s delivery method was selected.

Issue Type	Case Study Project Delivery Method:	DBB	DB	CMR	DBOM (circle one)
		Benefit	Constraint	Comments	
Project-level Issues	<ul style="list-style-type: none"> • Project Size • Risk management • Risk allocation • Schedule • Cost • LEED certification • Other 	<input type="checkbox"/>	<input type="checkbox"/>		
Agency-level Issues	<ul style="list-style-type: none"> • Agency experience • Staffing required • Staff capability • Agency goals & objectives • Agency control of project • Third party agreements • Other 	<input type="checkbox"/>	<input type="checkbox"/>		
Public Policy/ Regulatory Issues	<ul style="list-style-type: none"> • Competition • DBE/small business impact • Labor Unions • Fed/State/ Local laws • FTA/EPA regulations. • Other • Stakeholder/community input 	<input type="checkbox"/>	<input type="checkbox"/>		
Life Cycle Issues	<ul style="list-style-type: none"> • Life cycle cost • Maintainability • Sustainable design/goals • Sustainable construction/ goals • Other 	<input type="checkbox"/>	<input type="checkbox"/>		

Issue Type	Case Study Project Delivery Method:	DBB		DB	CMR	DBOM (circle one)
		Benefit	Constraint	Comments		
Other Issues	• .Construction claims	<input type="checkbox"/>	<input type="checkbox"/>			
	• .Adversarial relationship between project participants	<input type="checkbox"/>	<input type="checkbox"/>			
	• .	<input type="checkbox"/>	<input type="checkbox"/>			
	• .	<input type="checkbox"/>	<input type="checkbox"/>			

11. Was a formal risk analysis conducted on the project in any of the following areas?

- Project Scope
- Project Schedule
- Project Cost
- Contracting Risk

12. Did the project cost estimate involve an analysis of uncertainty (i.e. was a range cost estimate developed)?

- Yes No

13. Did the project employ any of the following risk identification techniques? Check all that apply.

- Brainstorming
- Scenario planning
- Expert interviews
- Delphi methods
- Influence or risk diagramming
- Other risk identification techniques Explain:

14. Did the project employ either of the following?

Qualitative risk assessment techniques - If yes, please describe.

Quantitative risk analysis techniques - If yes, please describe.
Examples include: Monte Carlo simulation, expected values, etc.

15. Did the project use any of the following risk management techniques?

- Risk register or risk charter

- Risk management plan

- Risk mitigation plan

- Other risk tracking techniques Explain:

16. Did the project employ any formalized risk allocation techniques to draft the contract provisions?

Yes

No

If yes, please describe:

III. Case Study Project Delivery Process Information:

The following questions will break up the alternative project delivery process for the case study project into the following three phases:

- ◆ Procurement phase: Actions taken regarding the project award and management processes that are reflected in solicitation documentation such as in the Request for Qualifications (RFQ) and the Request for Proposals (RFP).
- ◆ Design Phase: Actions taken regarding the development of design deliverables as well as those used to determine that the final design complies with contractual requirements.
- ◆ Construction Phase: Actions taken regarding the management of construction including those specifically related to ensuring the final constructed product complies with both the completed design and other contractual requirements

Procurement phase: Design-Build Project Interviewer—use appropriate form for the case study project delivery method

Do either the RFQ or the RFP require the following to be submitted as part of the design-build proposal?	Required proposal submittal?		Is it evaluated to make the DB award decision?	
	Yes	No	Yes	No
Qualifications of the Project Manager	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Qualifications of the Designer-of-Record	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Past performance record on similar projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Proposed schedule	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Proposed schedule milestones	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lump sum price	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Schedule of values	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Unit prices	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Qualifications of the Design Quality Manager	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Qualifications of the Construction Quality Manager	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Design quality management plan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Construction quality assurance plan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Construction quality control plan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Independent quality assurance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Design submittals	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Proposed sustainable design/construction	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Outline specifications	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do either your RFQ or your RFP contain the following?				
Design criteria checklists	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Standard design details	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Standard guide specifications	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Standards for sustainability				
Construction testing matrix	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Design Phase: Design-build project

Who performs the following design management tasks? (Check all that apply)	Does not apply	Agency personnel	Design-builder's design staff	Design-builder's construction staff	Agency-hired consultant
Technical review of design deliverables	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Checking of design calculations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Checking of quantities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Acceptance of design deliverables	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Review of specifications	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Approval of construction documents	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Approval of payments for design progress	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Approval of post-award design QA/QC plans	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Construction Phase: Design-build project

Who performs the following construction management tasks? (Check all that apply)	Does not apply	Agency personnel	Design-builder's design staff	Design-builder's construction staff	Agency-hired consultant
Technical review of construction shop drawings	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Technical review of construction material submittals	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Review of construction schedule	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Checking of pay quantities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Routine construction inspection	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Quality control testing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Establishment of horizontal and vertical control on site	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Verification/acceptance testing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Approval of progress payments for construction progress	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Approval of construction post-award QA/QC plans	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Procurement Phase: Construction Manager-at-Risk project

Do either the RFQ or the RFP require the following to be submitted as part of the construction manager-at-risk proposal?	Required proposal submittal?		Is it evaluated to make the CMR award decision?	
	Yes	No	Yes	No
Qualifications of the Project Quality Manager	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Qualifications of the Construction Quality Manager	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Past performance record on similar projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Design constructability review plan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Design cost engineering review plan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Construction quality management plan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Construction quality assurance plan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Construction quality control plan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do either your RFQ or your RFP contain the following?				
Design constructability checklists	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cost engineering review checklists	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Standards for sustainability	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Construction testing matrix	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Quality management roles and responsibilities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Design Phase: Construction Manager-at-Risk project

Who performs the following design management tasks? (Check all that apply)	Does not apply	Agency personnel	A/E design staff	CM's pre-construction staff	Agency-hired consultant
Technical review of design deliverables	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Checking of design calculations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Checking of quantities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cost engineering reviews by CMR	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Constructability reviews by CMR	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Acceptance of design deliverables	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Review of specifications	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Approval of construction documents	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Approval of progress payments for design progress	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Approval of post-award design QA/QC plans	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Construction Phase: Construction Manager-at-Risk project

Who performs the following construction management tasks? (Check all that apply)	Does not apply	Agency personnel	A/E design staff	CM's construction staff	Agency-hired consultant
Technical review of construction shop drawings	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Technical review of construction material submittals	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Review of construction schedule	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Checking of pay quantities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Routine construction inspection	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Quality control testing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Establishment of horizontal and vertical control on site	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Verification/acceptance testing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Approval of progress payments for construction progress	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Approval of construction post-award QA/QC plans	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Procurement phase: Design-bid-build Interviewer—use appropriate form for the case study project delivery method

Do either the RFQ or the RFP for the DESIGN contract require the following to be submitted as part of the design- bid-build proposal?	Required proposal submittal?		Is it evaluated to make the Design award decision?	
	Yes	No	Yes	No
Does not apply – Design was done using agency engineers <input type="checkbox"/>				
Qualifications of the Project Manager	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Qualifications of the Designer-of-Record	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Past performance record on similar projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Proposed schedule	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Proposed schedule milestones	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lump sum price	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Schedule of values	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Unit prices	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Qualifications of the Project Quality Manager	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Qualifications of the Design Quality Manager	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Qualifications of the Construction Quality Manager	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Design quality management plan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Construction quality assurance plan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Independent quality assurance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Design submittals	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Proposed sustainable design/construction	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Outline specifications	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do either your RFQ or your RFP contain the following?				
Design criteria checklists	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Standard design details	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Standard guide specifications	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Standards for sustainability				
Construction testing matrix	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Design Phase: Design-bid-build project

Who performs the following design management tasks? (Check all that apply)	Does not apply	Agency personnel	A/E's design staff	Agency-hired consultant
Technical review of design deliverables	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Checking of design calculations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Checking of quantities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Acceptance of design deliverables	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Review of specifications	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Approval of construction documents	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Approval of payments for design progress	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Approval of post-award design QA/QC plans	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Construction Phase: Design- bid-build project

Who performs the following construction management tasks? (Check all that apply)	Does not apply	Agency personnel	A/E's design staff	Contractor's staff	Agency-hired consultant
Technical review of construction shop drawings	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Technical review of construction material submittals	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Review of construction schedule	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Checking of pay quantities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Routine construction inspection	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Quality control testing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Establishment of horizontal and vertical control on site	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Verification/acceptance testing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Approval of progress payments for construction progress	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Approval of construction post-award QA/QC plans	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

IV. Quality Management Planning:

Please answer the following questions from a general perspective based on your experience. If you there are differences between project delivery methods, please answer the question with what you believe to be the most prevalent practice.

1. Is the design-build or CMR construction QA/QC plan significantly different from the QA/QC plan used on traditional design-bid-build construction projects?
 Yes No
If yes, what is the major difference?
2. Is the design-build or CMR design QA/QC plan significantly different from the QA/QC plan used on traditional design projects?
 Yes No
If yes, what is the major difference?
3. Does the agency specify what must be included in the design-builder's or construction manager's QA/QC plans?
 Yes No
4. Does the agency mandate the use of its own standard QA/QC plans?
 Yes No
5. Does the agency mandate the use of standard agency specifications?
 Yes No
6. Does the agency mandate the use of standard agency design details?
 Yes No
7. Does the agency mandate the use of standard agency construction means and/or methods?
 Yes No

8. Does the agency mandate a specific set of qualifications for the design-builder's or construction manager's quality management staff?
 Yes No
If yes, what are those qualifications?
9. Does the agency mandate a specific set of qualifications for the design-builder's or consulting engineer's (A/E) design quality assurance staff?
 Yes No
If yes, what are those qualifications?
10. Does the agency mandate a specific set of qualifications for the design-builder's or construction manager's construction quality control staff?
 Yes No
If yes, what are those qualifications?
11. Does the agency mandate a separate set of quality management documentation for projects that have follow-on maintenance and/or operations features?
 Yes No
If yes, what is different?

V. Project Delivery Issues:

This section is not project-specific and should be filled out for all project delivery systems. This provides us with an expert opinion on the impact of each parameter on the choice of project delivery system. The purpose of this section is to identify pertinent issues that impact the project delivery method selection decision. Mark with a check whether the given issue is considered “pro” (not considered a potential problem in the given project delivery method) or “con” (considered a potential problem in the given project delivery method)

Issue Type	Project Delivery Method	DBB		DBB w/OM		CMR		CMR w/OM		DB		DB w/OM	
		Pro	Con	Pro	Con	Pro	Con	Pro	Con	Pro	Con	Pro	Con
Project-level Issues	<ul style="list-style-type: none"> • Project Size • Risk management • Risk allocation • Schedule • Cost • LEED certification • Other 												

Issue Type	Project Delivery Method	DBB		DBB w/OM		CMR		CMR w/OM		DB		DB w/OM	
		Pro	Con	Pro	Con	Pro	Con	Pro	Con	Pro	Con	Pro	Con
	Notes on above												

Issue Type	Project Delivery Method	DBB		DBB w/OM		CMR		CMR w/OM		DB		DB w/OM	
		Pro	Con	Pro	Con	Pro	Con	Pro	Con	Pro	Con	Pro	Con
Agency-level Issues	• Agency experience												
	• Staffing required												
	• Staff capability												
	• Agency goals & objectives												
	• Agency control of project												
	• Other												
	Notes on above												

Issue Type	Project Delivery Method	DBB		DBB w/OM		CMR		CMR w/OM		DB		DB w/OM	
		Pro	Con	Pro	Con	Pro	Con	Pro	Con	Pro	Con	Pro	Con
Public Policy/Regulatory Issues	• Competition												
	• DBE/small business impact												
	• Labor												
	• Fed/State/Local laws												
	• FTA/EPA regs												
	• Other												
	Notes on above												

Issue Type	Project Delivery Method	DBB		DBB w/OM		CMR		CMR w/OM		DB		DB w/OM	
		Pro	Con	Pro	Con	Pro	Con	Pro	Con	Pro	Con	Pro	Con
Life Cycle Issues	<ul style="list-style-type: none"> • Life cycle cost • Maintainability • Sustainable design goals • Sustainable construction goals • Other 												
	Notes on above												
Other Issues	<ul style="list-style-type: none"> • . • . • . • . 												

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Evaluation of Project Delivery Methods

APPENDIX E – PROJECT DELIVERY METHOD SELECTION SYSTEM ASSESSMENT QUESTIONNAIRE

The research team used an assessment form during the validation phase. This appendix presents the form sent to the agencies that applied the decision tool developed in this research and evaluated its performance.

OVERALL ASSESSMENT OF THE PROJECT DELIVERY SELECTION SYSTEM

Agency:

Evaluator:

Evaluator's Expertise:

In the table below, please rate the two-tiered project delivery selection system introduced:

	For each statement, assign one of the following ratings based on 1 = poor to 5 = excellent .	1	2	3	4	5
1	Comprehensiveness of the overall selection system and the factors considered	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Clarity of presentation and the intent of the selection system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Applicability to real-life projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	Contribution of the system to documenting a transparent and defensible decision regarding project delivery method	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	Overall satisfaction with the results obtained from applying the selection system to your project (is the outcome realistic?)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

The proposed selection system is based on several pertinent factors as elaborated in Tier 1. Would you add any other factors to the current system?

Would you consider any of the factors redundant or superfluous? Would you consider deleting some of the factors? Which ones?

Any overall comments about the selection system?