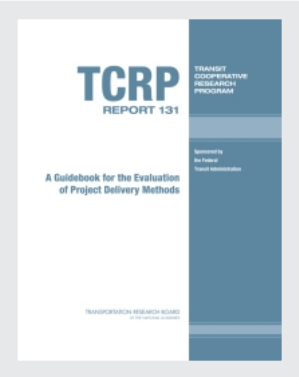


A Guidebook for the Evaluation of Project Delivery Methods

DETAILS

101 pages | | PAPERBACK
ISBN 978-0-309-11779-1 | DOI 10.17226/14238

AUTHORS

Ali Touran; Douglas D Gransberg; Keith R Molenaar; Kamran Ghavamifar; D J Mason; Lee A Fithian; Transportation Research Board

TRANSIT COOPERATIVE RESEARCH PROGRAM

TCRP REPORT 131

A Guidebook for the Evaluation of Project Delivery Methods

Ali Touran
NORTHEASTERN UNIVERSITY
Boston, MA

Douglas D. Gransberg
UNIVERSITY OF OKLAHOMA
Norman, OK

Keith R. Molenaar
University of Colorado
Boulder, CO

Kamran Ghavamifar
NORTHEASTERN UNIVERSITY
Boston, MA

D. J. Mason
KEVILLE ENTERPRISES
Marshfield, MA

Lee A. Fithian
FITHIAN ARCHITECTS
Norman, OK

Subject Areas
Public Transit

Research sponsored by the Federal Transit Administration in cooperation with the Transit Development Corporation

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.
2009
www.TRB.org

TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions,* published in 1987 and based on a study sponsored by the Urban Mass Transportation Administration—now the Federal Transit Administration (FTA). A report by the American Public Transportation Association (APTA), Transportation 2000, also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA, the National Academies, acting through the Transportation Research Board (TRB); and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at any time. It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by the Transportation Research Board. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

TCRP REPORT 131

Project G-8
ISSN 1073-4872
ISBN: 978-0-309-11779-1
Library of Congress Control Number 2009903118

COPYRIGHT PERMISSION

NOTICE

The project that is the subject of this report was a part of the Transit Cooperative Research Program conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council. Such approval reflects the Governing Board's judgment that the project concerned is appropriate with respect to both the purposes and resources of the National Research Council.

The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the National Research Council, the Transit Development Corporation, or the Federal Transit Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

The Transportation Research Board of the National Academies, the National Research Council, the Transit Development Corporation, and the Federal Transit Administration (sponsor of the Transit Cooperative Research Program) do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the clarity and completeness of the project reporting.

Published reports of the

TRANSIT COOPERATIVE RESEARCH PROGRAM

are available from:

Transportation Research Board
Business Office
500 Fifth Street, NW
Washington, DC 20001

and can be ordered through the Internet at

http://www.national-academies.org/trb/bookstore

Printed in the United States of America

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. On the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Charles M. Vest is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, on its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both the Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. Charles M. Vest are chair and vice chair, respectively, of the National Research Council.

The **Transportation Research Board** is one of six major divisions of the National Research Council. The mission of the Transportation Research Board is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. The Board's varied activities annually engage about 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. **www.TRB.org**

www.national-academies.org

CRP STAFF FOR TCRP REPORT 131

Christopher W. Jenks, *Director, Cooperative Research Programs*
Crawford F. Jencks, *Deputy Director, Cooperative Research Programs*
Gwen Chisholm Smith, *Senior Program Officer*
Eileen P. Delaney, *Director of Publications*
Ellen M. Chafee, *Editor*

TCRP PROJECT G-8 PANEL
Field of Administration

Robert I. Brownstein, *AECOM Consult, Inc., New York, NY* (Chair)
Joan Berry, *EJM Engineering, Inc., Chicago, IL*
Peter A. Cannito, *Armonk, NY*
Lee L. Davis, *Lee L. Davis & Associates, Oakland, CA*
Sergio Gonzalez, *University of Puerto Rico—Mayaguez, San Juan, PR*
Rick Smith, *Washington State DOT, Seattle, WA*
Robin C. Stevens, *Robin Stevens Consulting, Ltd., New York, NY*
Mukhtar Thakur, *Minnesota DOT, St. Paul, MN*
John Walewski, *Texas A&M University, College Station, TX*
Joel R. Washington, *Washington Metropolitan Area Transit Authority, Washington, DC*
Susan Herre, *FTA Liaison*
Venkat Pindiprolu, *FTA Liaison*
James P. LaRusch, *Other Liaison*
Frederick Hejl, *TRB Liaison*

AUTHOR ACKNOWLEDGMENTS

The research herein was performed under TCRP Project G-8 by a team consisting of Northeastern University, the University of Oklahoma, and the University of Colorado. Northeastern University was the contractor for this study. Dr. Ali Touran, Associate Professor of Civil and Environmental Engineering at Northeastern University, was the Project Director and the Principal Investigator. Dr. Douglas D. Gransberg, Professor in the Construction Science Division, University of Oklahoma, and Dr. Keith R. Molenaar, Associate Professor of Civil Engineering, University of Colorado at Boulder, were co-Principal Investigators. D. J. Mason of Keville Enterprises and Lee A. Fithian of Fithian Architects were consultants. Kamran Ghavamifar of Northeastern University was a Research Assistant.

FOREWORD

By Gwen Chisholm Smith
Staff Officer
Transportation Research Board

TCRP Report 131: A Guidebook for the Evaluation of Project Delivery Methods describes various project delivery methods for major transit capital projects. This guidebook also includes an evaluation of the impacts, advantages, and disadvantages of including operations and maintenance as a component of a contract for a project delivery method. The project delivery methods discussed are design-bid-build (DBB), construction manager at risk (CMR), design-build (DB), and design-build-operate-maintain (DBOM). The guidebook offers a three-tiered project delivery selection framework that may be used by owners of transit projects to evaluate the pros and cons of each delivery method and select the most appropriate method for their project. Tier 1 is a qualitative approach that allows the user to document the 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, a clear option does not emerge, the user then moves on 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. The selection framework may also be useful as a means to document the decision in the form of a Project Delivery Decision Report. The guidebook will be helpful to transit general managers, policymakers, procurement officers, planners, and consultants in evaluating and selecting the appropriate project delivery method for major transit capital projects.

Developers of major public and private projects in the United States and elsewhere are using a variety of project delivery methods to complete those projects. In the United States, transit projects have been traditionally carried out through a design-bid-build process. There is considerable interest on the part of transportation agencies in alternative forms of project delivery and their potential benefits. However, a comprehensive discussion of the advantages and disadvantages of these methods in the context of the U. S. transit environment has been lacking.

The objective of TCRP Project G-08 was to develop a guidebook to help transit agencies evaluate and select the most appropriate project delivery method for major capital projects and evaluate the advantages and disadvantages of including operations and maintenance as a component of a contract for the project delivery system. To accomplish the project objective, Northeastern University, in association with the University of Oklahoma, the University of Colorado, Keville Enterprises, and Fithian Architects, described and critiqued pertinent issues related to each project delivery method in terms of its application to transit in the United States. The research team also identified agencies, suppliers, and individuals with experience in using the various project delivery and contracting methods and conducted in-

depth interviews with those entities to gather lessons learned. In addition, the research team described and critiqued pertinent issues related to contracting out operations and maintenance with new construction projects. The research team included a discussion of the impacts, advantages, and disadvantages of including operations and maintenance in the project delivery contract in the guidebook. Finally, the researchers developed a decision matrix to guide decision makers in selecting the most appropriate project delivery and contracting method(s) in various transit environments.

A companion publication to this report, *TCRP Web Document 41: Evaluation of Project Delivery Methods*, reviews pertinent literature and research findings related to various project delivery methods for transit projects. It contains definitions of project delivery methods and discusses the existing selection approaches commonly used by transit agencies. *TCRP Web Document 41* may found on the TRB website at http://trb.org/news/blurb_detail.asp?id=9886.

CONTENTS

SUMMARY

A Guidebook for the Evaluation of Project Delivery Methods

Objective

Various project delivery methods are available to the developers of public projects in the United States. While the traditional design-bid-build delivery method remains the most common method, there is considerable interest on the part of transportation agencies in alternative methods of project delivery and the potential of these alternative methods to save money and time.

The objective of this guidebook is to assist transit agencies in evaluating and selecting the most appropriate project delivery method for their projects and in documenting this decision in a Project Delivery Decision Report. The guidebook is based on the fundamental premise that there is no *one* best delivery method for all projects, but that a project delivery method should be selected on the basis of each project's unique characteristics. This selection should be made by considering the benefits and disadvantages of competing delivery methods for the project under consideration.

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 changes 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, methods such as design-build may include operations and maintenance as well as multiyear warrantees in the contract.

The research approach in developing the project delivery method selection framework was to synthesize relevant literature on project delivery methods and previous work in developing decision support systems for project delivery selection. In addition, face-to-face structured interviews were conducted with several transit agencies to learn how each project delivery method had been implemented in actual transit projects. The authors traveled to five selected project sites, interviewed project directors, and collected data on nine major transit projects. On the basis of this research (i.e., review of the literature, interviews with project directors, and data collection on nine major transit projects) and discussions among the research team and TCRP Project G-08 panel, the researchers identified a set of *pertinent issues.* These pertinent issues are issues that were found to have profound effect on the choice of project delivery

method. Once the authors identified the *pertinent issues,* these issues were grouped into the following categories: project-level issues, agency-level issues, public policy/regulatory issues, lifecycle issues, and other issues. The issues were also used to develop the project delivery method selection framework.

Selection System Framework

A three-tiered project delivery selection system was developed that consists of the following:

Tier 1—Analytical Delivery Decision Approach
Tier 2—Weighted-Matrix Delivery Decision Approach
Tier 3—Optimal Risk-Based Approach

The Tier 1—Analytical Delivery Decision Approach provides a framework for agencies and their project delivery teams to define project goals and examine the advantages and disadvantages of each delivery method within the context of these goals. The aim of this approach is to help agencies to 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 whether one or more project delivery methods should be excluded from the examination.

At the completion of the Tier 1 approach, the agency may not have a single, clear, and logical choice for a project delivery method. If this is the case, the agency then moves on to the Tier 2 approach with the best delivery method options from Tier 1 and creates a more detailed analysis to select the final project delivery method. The Tier 1 approach is designed to provide a simple and straightforward selection process. It is anticipated that users will find that the Tier 1 analysis is sufficient for most transit projects.

The Tier 2—Weighted-Matrix Delivery Decision Approach provides a means for an agency to further examine delivery methods and document a project delivery decision for an individual project. The Tier 2 approach involves prioritizing project objectives and selecting the delivery method that best aligns with these objectives. In the Tier 2 approach, the user concentrates on a few key parameters affecting the choice of project delivery method, assigns appropriate weights to each parameter, and calculates a score for each competing delivery method. The process of selecting each parameter and assigning the proper weight is described in detail in this guide.

The Tier 3—Optimal Risk-Based Approach leverages current, risk-based, cost-estimating methods that have emerged in transit and highway agencies in the past few years. It is expected that the Tier 3 approach will generally be used only when the completion of the Tier 1 and Tier 2 approaches does not yield a project delivery decision and when a formal risk management process for the project is already in place. It is important to note that using the Tier 3 approach (especially the quantitative analysis) requires considerably greater effort than the effort involved in implementing either the Tier 1 or Tier 2 approaches.

It is recommended that transit agencies use industry professionals from outside the agency to facilitate the implementation of the Tier 3 approach. These professionals should have a thorough understanding of and experience with the type of project the agency is evaluating, the various project delivery methods the agency is considering, and the potential risks associated with the type of project and various project delivery methods under consideration. The use of outside professionals helps to ensure that the appropriate expertise and experience is incorporated into the process. Facilitation of the process by outside professionals helps also to foster that the selection of the most appropriate project delivery method is objective, thereby minimizing the likelihood of a predetermined outcome.

The selection system framework also provides the means to document a project delivery decision in the form of a Project Delivery Decision Report. Regardless of how many tiers of the selection system framework an agency uses to select a project delivery method, the selection system framework forces decision-makers to document their logic as they proceed through the process. The Project Delivery Decision Report will provide a transparent and defensible documentation of the decision process. This documentation is extremely important when explaining a project delivery decision to project stakeholders, particularly if an alternative delivery method is selected. Furthermore, this documentation can be consulted by agencies when they have to make project delivery decisions in the future. The Project Delivery Decision Report format was created to provide agencies with a rigorous documentation format while allowing for maximum flexibility in the choice of delivery method.

This guidebook is meant to be a comprehensive resource for transit agencies embarking on the process of project delivery selection, providing concrete guidance on how to select the most appropriate delivery method for a project and how to document the final project delivery decision in a concise and consistent format.

CHAPTER 1

Overview

Introduction and Purpose

The objective of this guidebook is to help transit agencies evaluate and choose the most appropriate project delivery method for their projects. This guidebook will also help in documenting the process of decision-making and in preparing the outcome in a Project Delivery Decision Report.

The project delivery method is a process by which a project is comprehensively designed and constructed for an owner and includes 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 (DBB) method. Due to changes 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, methods (such as design-build) may include operations and maintenance as well as multiyear warrantees.

The approach to developing a project delivery selection system presented herein was to review and analyze relevant literature on project delivery methods and previous work on 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. A list of transit projects was developed and approved by the project oversight panel (see Table 1.1). The authors traveled to the selected project sites and interviewed project directors. The results of the interviews were then analyzed and summarized. Based on the outcome of the literature search and the structured interviews, a set of pertinent issues was identified and studied. These pertinent issues were ones that were thought to have a profound effect on the choice of project delivery method. These issues, in turn, were used to develop the project delivery selection system described in this guidebook.

Selection System Framework

The selection of the project delivery method is a decision that is based on a multitude of issues. In this guidebook, these issues are called "pertinent issues" and have been categorized according to the following groups: project-level issues, agency-level issues, public policy/regulatory issues, lifecycle issues, and other issues. The research team has identified and verified these pertinent issues through a literature search, extensive interviews with various transit agencies across the United States, and discussions between the research team and the project oversight panel.

Table 1.1. List of transit projects for which project directors were 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 Authority / Salt Lake City to Ogden, UT	Construction Manager at Risk
3	University Line	Utah Transit Authority/ Salt Lake City, UT	Design-Build
4	Medical Center Extension	Utah Transit Authority/ 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 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	Construction Manager at Risk
9	I-205 Light Rail Extension Project	TriMet/ Portland, OR	Design-Build

Based on these pertinent issues, the team has developed a three-tiered project delivery selection system that consists of the following tiers:

- Tier 1—Analytical Delivery Decision Approach,
- Tier 2—Weighted-Matrix Delivery Decision Approach, and
- Tier 3—Optimal Risk-Based Approach.

The Tier 1—Analytical Delivery Decision Approach (Tier 1 approach) provides a framework for agencies to use in defining project goals and examining the advantages and disadvantages of each delivery method within the context of these project goals. The aim of this approach is to help agencies understand project delivery method attributes and determine whether 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 whether one or more project delivery methods should be excluded from the examination.

After completion of the Tier 1 approach, an agency may not have a single, clear, and logical choice for a project delivery method. If this is the case, the agency is advised to move to the Tier 2—Weighted-Matrix Delivery Decision Approach (Tier 2 approach) with the best project delivery method options and create a more detailed analysis to select the final project delivery method. The Tier 1 approach 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 approach provides a means for the agency to further examine and document a project delivery decision for an individual project. If a project delivery method was not found in the Tier 1 approach, the Tier 2 approach can be used to select a delivery method by prioritizing project objectives and selecting the delivery method that best aligns with these objectives. The Tier 2 approach is based on successful project delivery decision tools developed by academics and professionals over the past 20 years. With the Tier 2 approach, the user concentrates on a few key

parameters that affect the choice of project delivery method, assigns appropriate weights to each parameter, and calculates a score for each competing delivery method. The user can use the material presented in Appendix F for guidance in assigning weights to each parameter.

The Tier 3—Optimal Risk-Based Approach (Tier 3 approach) leverages the current, risk-based, cost-estimating methods that have emerged in transit and highway agencies in the past few years. Most project delivery method decisions will be made through completion of the Tier 1 and Tier 2 approaches. The Tier 3 approach will be applied only when a decision has not been made after completing the Tier 1 and Tier 2 approaches 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 the Tier 3 approach (especially the quantitative approach) is considerably greater than the effort required to use the Tier 1 or Tier 2 approaches.

Organization of the Guidebook

This guidebook includes seven chapters and Appendices A and B. Appendices C through H are available on the TRB website at http://trb.org/news/blurb_detail.asp?id=10054. This first chapter provides an overview of the work accomplished and a road map for the user of the guidebook. Chapter 2 describes the characteristics of transit projects, presents the results of the literature search, and provides clear definitions of various project delivery methods. Distinguishing characteristics of each delivery method, its advantages and disadvantages, and legal precedence in project delivery method use are described in Chapter 2. Also, a summary is provided of the existing methodologies for selection of appropriate project delivery methods. In addition, recommendations are made for the appropriate point in the project lifecycle to adopt various delivery methods.

Chapter 3 describes pertinent issues affecting the choice of project delivery method and the advantages and disadvantages of each project delivery method in relation to these issues. There are numerous issues that transit agencies need to consider when selecting a project delivery method. In this research, issues were identified through a literature search, personal experience, case studies, and interviews with project directors of case study transit projects. Pertinent issues are categorized as follows:

- Project-level issues,
- Agency-level issues,
- Public policy/regulatory issues,
- Lifecycle issues, and
- Other issues.

These issues and their interactions with different project delivery methods are presented in the form of a descriptive pro/con analysis. The analysis is based on the trends found in the research team's interviews with construction directors at various transit agencies and is supported by quotations from relevant literature.

Chapters 4, 5, and 6 describe the Tier 1, 2, and 3 approaches of the project delivery selection framework, respectively. In order to facilitate and streamline the application of the approaches in these tiers, blank versions of the tables from these chapters are reproduced in Appendices C, D, E, and G, which are all available on the TRB website at http://trb.org/news/blurb_detail.asp?id=10054. The idea is that the user will download/print these blank tables and use them to go through the three tiers in sequential order. Other appendices contain support material for the guidebook. Appendix A contains a list of sources referenced in this guidebook. Appendix B contains a glossary of important terms used in the guidebook. Appendix F describes various methods of assigning

numerical weights to competing parameters. This material will be useful to the guidebook user in applying the Tier 2 approach. Appendix H contains the application of the project delivery selection system to a hypothetical project.

It is the authors' belief that this guidebook is a comprehensive resource for a transit agency trying to select the most appropriate project delivery method and to document the selection process and ultimate decision in a concise and easy-to-understand format. It is recommended that transit agencies use industry professionals from outside the agency to facilitate the implementation of the methodology contained in this guidebook. These professionals should have a thorough understanding of and experience with the type of project that the agency is evaluating, the various project delivery methods that the agency is considering, the potential risks associated with the type of project the agency is evaluating, and the various project delivery methods being considered. The use of such professionals will ensure that the appropriate expertise and experience is incorporated into the process. Facilitation of the process by outside professionals should also foster an objective selection of the most appropriate project delivery method, thereby minimizing the likelihood of a predetermined outcome.

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. It is important—especially in the case of large, complicated transportation projects—to select the most appropriate project delivery method. Contractual relations, contemporary laws and regulations, owners' perceptions of risks, awarding mechanisms, and method of payment all influence the selection of a project delivery method. This guidebook 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 choosing the delivery method, from among the many project delivery methods, that is most appropriate for a particular project. In the material that follows, alternative project delivery methods will be compared with the traditional design-bid-build (DBB) project delivery method, which functions as a benchmark against which all other methods can be evaluated. The literature shows that the use of alternative project delivery methods can accrue benefits for owners. However, the benefits of alternative project delivery methods presented in the literature occur most often across a population of projects rather than on an individual project. 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 successes and failures. Selecting the wrong project delivery method is often a significant driver of project failure. Therefore, the reader should understand the results of the research reported herein as evidence that a given project delivery method may be used successfully on a specific set of projects, not as evidence that any particular project delivery method is inherently superior to all others.

Before describing various project delivery methods, it is important to note the features of major transit projects that distinguish them from other transportation projects. Transit projects are larger projects, usually in excess of $100 million. Transit projects, especially projects with fixed-guideway systems, usually consist of at least two large contracts: (1) civil and (2) systems. The nature of these two contracts and the specialization required for each are such that usually two different entities deliver these contracts. This circumstance makes coordination between these two entities of paramount importance to project success. Generally, in DBB projects, the owner hires a construction manager (CM) (this construction manager is a representative of the owner, i.e., the agency CM, as opposed to the construction manager at risk [CMR]) to coordinate these two separate contracts and manage the 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. Therefore, a major criterion in choosing a project delivery method for a transit project is the delivery method's ability to accommodate the needs of various stakeholders in a complex environment.

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 circumstance makes coordination with the railroad company owning the freight line extremely important. The importance of reaching agreements with the railroad company and clarifying the details of the work and the responsibilities of the 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 projects is that typically they incorporate features that are unusual in an engineering project, and thus transit projects may require the involvement of professionals from the fields of architecture, landscape architecture, and interior design, as well as engineering. The integration of "vertical" construction features (e.g., parking structures and transit stations) with "horizontal" construction features (e.g., track beds, bridges, and roadway elements) creates a need for a comprehensive set of design and construction services that is not normally found in transportation projects. Additionally, transit agencies' need to integrate their facilities with other transportation modes demands another comprehensive set of design and construction service providers and requires a more flexible approach to design and construction than is required by single-mode transportation projects. These characteristics of transit projects drive the need for a "toolbox" of project delivery methods that permits a transit agency to select the appropriate project delivery "tool" based on the technical demands of a given project.

Transit projects are not usually money makers (unlike some toll roads in the highway sector). Therefore, it is difficult to generate interest in potential public-private partnerships. Financial institutions, which are 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 to bringing the project into being, depends on specific steps that are 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 to the next development stage. The owner agency must meet certain requirements to advance from project planning to final design and finally to 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 federal requirements.

Evolution of Current Alternative Delivery Methods in Transit Projects

Public procurement law has historically limited public agencies to using DBB construction project delivery only. The current wide range of project delivery methods is a relatively recent development for publicly funded transit projects in the United States. The development of the public procurement laws limiting public agencies to use of the DBB project delivery method can be traced in part 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 should be procured on the basis of qualifications only. Alternatively, numerous laws and statutes throughout the

United States 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 was the traditional transportation project delivery method until the introduction of DB and design-build-operate-maintain (DBOM) in the Intermodal Surface Transportation Efficiency Act of 1991.[1] 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 (TEA-21), Public Law 105-178, allowed state departments of transportation (DOTs) to award DB contracts if the enabling state-level legislation was in force. Subsequent to the successful use of DB in several projects, many states passed new legislation and codes to allow alternative project delivery methods, i.e., DB and CMR. Adding the responsibility of operation and maintenance to DB projects created another delivery method, DBOM. The differences among delivery methods, the unique characteristics of each project, and the vast variety of parameters affecting the selection of a project delivery method, have made selection of a project delivery method complicated for many owners. The purpose of this guidebook is to facilitate the decision-making process by clarifying the differences among the project delivery methods and proposing a structured decision-making approach that 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 from project conception to project completion for all kinds of public and private facilities. As a result, both owners and the 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. This report provides a set of standard project delivery definitions to help communicate the technical requirements for bringing a new project from the owner's conception to operation and finally to decommissioning.

Project delivery method is a term used to refer to all the contractual relations, roles, and responsibilities of the entities involved in a project. TxDOT 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, Gibson, and Jasper 2001). The Associated General Contractors of America (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, different project delivery methods are distinguished by the way the contracts among the owner, the designer, and the builder are formed and the technical relationships among parties within those contracts.*

The Construction Industry Institute maintains that there are really only three fundamental project delivery methods: DBB, DB, and CMR (Construction Industry Institute 1997). While

[1] In 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 (1) the Los Angeles Union Station Intermodal Terminal, (2) Baltimore Light Rail Transit, (3) San Juan Tren Urbano, (4) Bay Area Rapid Transit in San Francisco, and (5) Hudson-Bergen Light Rail Transit.

there are a multitude of names for project delivery methods throughout the industry, the Construction Industry Institute is essentially correct. Therefore, this report will focus its information on those three methods.

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. For example, an owner may hire an agency CM to manage a DBB, DB, or even a CMR project.

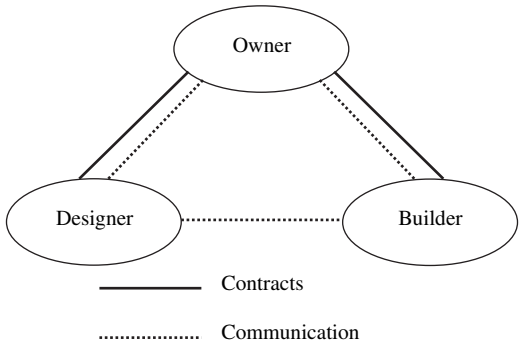
Graphics displaying the contractual relationships among the major stakeholders and their lines of communication are presented in Figures 2.1 through 2.3 to assist the reader in putting the contents of this report into proper context. Note that the lines of communication shown in the figures represent the ability to exchange information through formal and informal requests for information among the various entities in the project.

Design-Bid-Build (DBB)

DBB is the traditional project delivery method. In this method, an owner retains a designer to furnish complete design services and then advertises and awards a separate construction contract that is 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 shows that the owner is situated squarely between the designer and the builder in the DBB project delivery method. 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; this is 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 won a project by submitting the lowest possible bid may need to look to post-award changes as a means of enhancing profit on the project. One author states that the defining characteristics of DBB are as follows (Bearup, Kenig, and O'Donnell 2007):

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



(Adapted from American Institute of Architects 1996.)

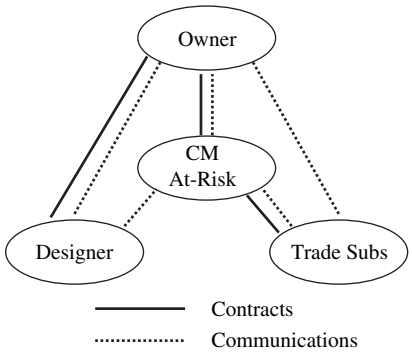
Figure 2.1. Design-bid-build.

Despite the general definition of DBB given above, DBB projects can also be awarded on a negotiated basis and a best-value basis (Scott et al. 2006); however, DBB transit projects awarded in either of these two ways usually require FTA approval and frequently violate local laws. For projects awarded on a negotiated basis or a best-value basis, the probability that the project will be awarded to a builder who has submitted a mistakenly low bid is reduced. Additionally, in both cases, the builder will be motivated to complete the project in a such a way that it be 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 involves 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 a constructability review, if there is any at all. Nonetheless, in this method the owner has full control over the details of design, which may be a requirement for some complex projects.

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

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 State Construction Office 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 (see Figure 2.2). The CMR will usually be



(Adapted from American Institute of Architects 1996.)

Figure 2.2. Construction manager at risk.

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 following:

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

According to Bearup, Kenig, and O'Donnell (2007), additional defining characteristics are the following:

- The CMR contracts directly with trades and takes on "performance risk" (cost and schedule commitments);
- The schedule allows for overlapping design and construction;
- The owner procures preconstruction services from the CMR; and
- The owner expects the CMR to provide GMP and to commit to a delivery schedule.

A final defining characteristic, noted in AIA's "Construction Manager at-Risk State Statute Compendium," is that "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, p. 1).

Constructability and speed of implementation are the major reasons that an owner would select the CMR method (3D/International, Inc. 2005). Additionally, CMR greatly facilitates phased construction when that is a requirement for a given project. Unlike DBB, CMR brings the builder into the design process at a stage in which 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." (3D/International, Inc. 2005, p. 4). In CMR, the CM essentially becomes the general contractor at the time the GMP is established. While some experts attempt to distinguish between CMR and CM/GC, due to perceived levels of risk, many agencies use these terms more or less interchangeably.[2] The CMR can and is expected to provide realistic project cost estimates early in the project lifecycle. It is anticipated that after a certain amount of the 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, Thakkar, and Ellis 2007).[3] The timing of GMP negotiations varies among different agencies. In many cases, at least 60% of the design is completed before a GMP is established. In some cases, the design is 80 to 90% complete before a GMP can be effectively negotiated with the CMR. The timing of GMP negotiations depends on project complexity, agency rules, and external conditions such as inflation and the expected level of competition among subcontractors. In general, the CMR may feel that committing to a GMP while all the details of the design are not defined may involve incurring undue risk. Also, some agency rules may hamper early GMP negotiations. For example, if an 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

[2]According to AGC (2004), there has been some confusion about the 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 "at-risk" and instead use the term CM/GC (p. 8).

[3]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 because the CM is not contractually responsible for delivering the project. The role of agency CM is purely advisory, and thus, the agency CM is usually not at risk for the cost and schedule of building the project.

14 A Guidebook for the Evaluation of Project Delivery Methods

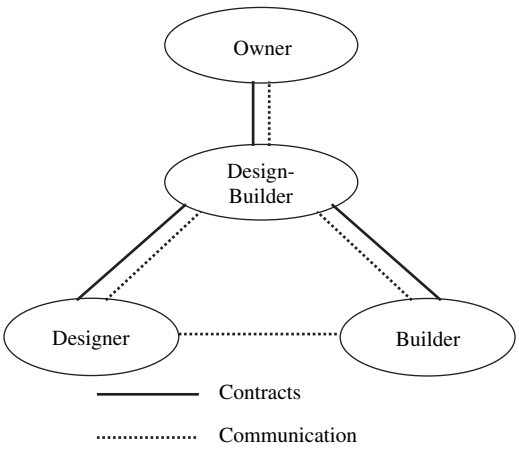
a 100%-complete design. This in turn makes the CMR hesitant to provide a reasonable GMP for fear that money will be lost if the subcontract bids come in too high.

As the design selection process in CMR virtually mirrors the design process in DBB, implementing CMR does not inherently restrict competition among designers and design subconsultants (AIA 2005). Owners, at their own discretion, occasionally require the designer in a CMR project to have previous CMR experience, which may result in fewer qualified proposers. As the constructor is selected on the 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 subcontract work packages combined with the qualifications-based selection of the GC as CMR.

Design-Build (DB)

Design-build is a project delivery method in which the owner procures 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. Common methods are the one-step and the two-step processes. 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 determination of best value is based on a combination of technical merit and price. The two-step process separates the technical proposal from the price. This method typically uses request for qualifications (RFQ)/request for proposal (RFP) procedures rather than DBB invitation-for-bid procedures. There are a number of variations on the DB process, but all involve three major components. First, the owner develops an RFQ/RFP that describes essential project requirements in performance terms. Second, proposals are evaluated. 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 must usually provide a firm, fixed price in its proposal (El Wardani, Messner, and Horman 2006; Ibbs, Kwak, and Odabasi 2003; and Graham 2001).

Figure 2.3 shows that from the owner's standpoint, DB simplifies considerably the project's chain of responsibility. As in CMR, the builder has early constructability input to the design process. As the owner no longer owns the details of design, the owner's relationship with the



(Adapted from American Institute of Architects 1996.)

Figure 2.3. Design-build.

design-builder must be based on a strong degree of mutual professional trust (Beard, Loulakis, and Wundram 2001). The design-builder literally controls this project delivery method. As a result, the DB project delivery method has proven to be highly successful in compressing the project delivery period and is therefore often used for "fast-track" projects (SAIC, AECOM Consult, and University of Colorado at Boulder 2006).

Bearup, Kenig, and O'Donnell (2007) state that the defining characteristics of DB are as follows:

- A single point of responsibility,
- A schedule that allows for overlapping design and construction,
- A design-builder that furnishes preconstruction services during the project design, and
- An owner that expects the design-builder to provide a firm, fixed price and to commit to a 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 major selection factors. Because the owner transfers responsibility for all design and construction in 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 the design is complete, DB can also create an unfavorable risk environment for subcontractors whose cost-estimating systems lack the sophistication 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), and DBOM, all require the DB contractor to remain with the project after construction is complete. DBOM is very similar to DB except that the DBOM contractor assumes the operation and maintenance risks of the project and is responsible for operating the new facility according to a set of regulations and codes for a determined duration (Wiss, Roberts, and Phraner 2000; Kessler 2005).

Statutory Authorization of Delivery Methods in Various States

DBB has traditionally been used throughout the United States, and all 50 state codes have given full authority to transit agencies to use this method in their projects. Alternative delivery methods do not have this clear statutory support. Some states do not allow transit entities to use alternative delivery methods, some have given one-time authority to use an alternative method for a special project, a group of states have put some limits on the application of alternative delivery methods, and a few states require transit agencies to obtain extra approval 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 50 states. Several relevant keywords were searched using the LexisNexis search engine. All the state codes and statutes that deal with project delivery in transportation projects were examined. The results were then compared with the existing surveys of legal codes available in the literature (e.g., see Smith and Davis 2006 and AIA Minnesota 2006). The research herein shows that 37 states permit the use of DB in their transportation projects, leaving the agencies of 13 states without the authority to do so. The application of CMR is not authorized in 31 states, and only 14 states have

fully authorized DOTs to use this delivery method. Five states allow the use of CMR with some restrictions or after obtaining extra approvals (Ghavamifar and Touran 2008). It should be noted that the laws governing the legality of alternative project delivery methods are evolving, and therefore the information given herein on the legality of alternative project delivery methods should be understood as subject to change. Also, while some state DOTs are permitted to use alternative delivery methods, it is not clear whether those states' transit agencies are allowed to use alternative delivery methods. The purpose of the literature search was to provide an overall picture of the legal status of using various project delivery methods for transportation projects in the United States at the time this report was prepared. Each public agency considering the use of a specific delivery method should check the legality of the method carefully.

FTA's requirements for third-party contracting, described in *Circular 4220.1E* (FTA 2003), are sufficiently flexible to allow the agencies to select their contractors through competitive bidding and/or competitive proposal/RFP (price and other parameters considered). For DBB, *Circular 4220.1E* 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 from undertaking such procurement.

Existing Selection Approaches for 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 for the project are ready. The decision will be made when the owner still has little information about the exact outcome of the project and the project plans are not detailed enough to be reliable grounds for judgment about the project. In this situation, 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 (Debella and Ries 2006; Garvin 2003; Gordon 1994; Ibbs, Kwak, and Odabisi 2003; Konchar and Sanvido 1998; Mahdi and Al-Reshaid 2005; Oyetunji and Anderson 2006). Several of these researchers have chosen specific projects and have based their selection methodology on the characteristics of those projects.

The relevant literature can be divided into two groups: (1) literature that compares project delivery methods on the basis of observed performance measurements collected from a group of projects and (2) literature that provides a list of criteria and a framework for decision-making.

One of the best examples of the first kind of literature is a paper by Konchar and Sanvido (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, such as cost growth, construction speed, and schedule growth. Some criteria are also defined to incorporate the quality performance of the delivery methods, such as difficulty of facility start up, number and magnitude of call backs, and operation and maintenance costs. According to Konchar and Sanvido (1998, p. 9), "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." Konchar and Sanvido (1998) divided the projects into six different groups (e.g., light industrial, complex office, and heavy industrial) in order to see clearer trends in each group. Taking this into account, the paper does not have enough data to distin-

guish between the performances of different delivery methods in transit projects. However, two studies comparing DB and DBB project performance in the federal building sector did make direct comparisons (Allen, Gransberg, and Molenaar 2002; Gransberg, Badillo-Kwiatkowski, and Molenaar 2003). One study compared 54 DBB projects with 34 DB projects and discovered that DB projects had 16.4% less cost growth and 19.0% less time growth than similar DBB projects (Gransberg, Badillo-Kwiatkowski, and Molenaar 2003). Another study, which looked at 110 Navy projects, also found that DB projects performed more efficiently, with 18.0% less cost growth and 60.0% less time growth (Allen, Gransberg, and Molenaar 2002). Additionally, a recent NCHRP study of best value contracting also furnished a direct comparison of the performance of transportation project delivery methods (Scott et al. 2006). 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. The NCHRP study found that DB projects had 4.7% less cost growth and 9.3% less time growth than DBB. Best value projects had 2.0% less cost growth and 18.5% less time growth than DBB. Other researchers, such as Debella and Ries (2006) and Ibbs, Kwak, and Odabisi (2003), have used a methodology similar to that of Konchar and Sanvido (1998), but they have narrowed down the scope of their research either to special kinds of projects or fewer performance measures.

The second kind of literature mentioned above, literature that provides a list of criteria and a framework for decision-making, has focused on the decision-making process. This literature proposes mechanisms for decision-making and defines the necessary criteria and frameworks so that the most important project parameters are identified and used in the decision-making method. The frameworks are primarily intended to be simple, rational, and comprehensive. They range from basic flowchart methods (Gordon 1994) to more sophisticated processes based on methodologies such as multiple linear regression, the Analytical Hierarchy Process (AHP) (Mahdi and Al-Reshaid 2005), or the 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 direct the owner's attention to the most important issues in project delivery method selection. A multimedia education compact disc and delivery selection tool have been developed (Loulakis 2005). 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 (1998) propose a client advisory system with an expert system front end that will gather project information and model the project profile to generate a list of delivery options. Finally, Oyetunji and 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, which gives a single rank to each delivery method. The delivery method with the highest rank should be chosen for the project.

Looking at both kinds of literature, one finds that many of the important parameters that affect the decisions early in the project fall into one of four groups: project-related parameters, agency-related parameters, legal parameters, and lifecycle issues. Project-related parameters are those parameters that pertain to project duration: estimated cost, quality level, risks, limits on schedule growth, complexity, and so forth. Agency-related parameters mainly consist of the status of the agency; the role of a project in the strategies of the agency; and the organization of the agency, i.e., availability of funds, sophistication of the agency's employees, flexibility needs in the construction phase, level of risk assumption, importance of preconstruction services, and quality level expectation. The legal parameters mainly cover legal and contracting issues, such as statutory authority to

Table 2.1. The timing of project delivery method selection.

Project delivery method	At the end of conceptual design	At the end of preliminary engineering	At the end of final design	Construction
DBB	■	■	□	NF
CMR	■	□	□	NF
DB	■	■	NF	NF
DBOM	■	■	NF	NF

■ = Desirable
□ = Feasible
NF = Not feasible

use alternative project delivery methods, the level of competition in the market, and the permits needed for the project. Lifecycle issues cover the costs of maintaining and decommissioning the facility and the ability to minimize the energy and environmental effects of the project.

In the parameters mentioned above, the ability to transfer the risks of a project to entities other than the owner is a characteristic that is related to both the project and the owner agency. This parameter includes the level of risk and uncertainty of the project and the ability of the owner to assume the risks or transfer them (risk-averse or risk-prone agency). Project delivery methods have different mechanisms for risk distribution among the entities involved. In summary, the existing body of knowledge in the area of project delivery, along with specific information collected on transit projects during interviews, provides a solid foundation for developing a new selection system for project delivery methods that is 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), and
- Full Funding Grant Agreement (FFGA).

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

In selecting a project delivery method, the owner should realize that the window of opportunity to select some methods will close as the project moves through various stages of development. Table 2.1 maps project delivery method selection with project development phase. It can be seen that selecting a project delivery method other than DBB should be done relatively early. Most of the benefits can be realized by engaging the constructor as soon as possible. The decision point for project method delivery 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 project scope and reduce the uncertainty. However, the owner should have decided on the type of delivery (e.g., DB) much earlier, so that the design documents can be developed to properly accommodate the type of delivery method.

CHAPTER 3

Advantages/Disadvantages of Each Project Delivery Method

Introduction

There are numerous issues that transit agencies need to consider when selecting a project delivery method. In this chapter, the information collected during this research on pertinent issues is synthesized for use in Tiers 1 and 2 of the selection system presented later in the guidebook. These pertinent issues and their interactions with different project delivery methods are presented in the format of a descriptive pro/con analysis. The issues were identified through a literature search, the personal experience of the research team, case studies, and interviews with the project directors of the case study transit projects. Please see the TCRP Project G-8 final report, published as *TCRP Web-Only Document 41: Evaluation of Project Delivery Methods,* for presentation and discussion of the literature search, case studies, and interviews with the project directors of the case study transit projects. *TCRP Web-Only Document 41* is available on the TRB website at http://trb.org/news/blurb_detail.asp?id=9886.

The issues are organized into the following categories:

- Project-level issues,
- Agency-level issues,
- Public policy/regulatory issues,
- Lifecycle issues, and
- Other issues.

In this chapter, each issue is first defined and then the advantages/disadvantages of each delivery method are explained. The analysis is based on the trends found in the interviews (which are cited using brackets) and is supported by quotations from relevant literature. A list of references used is provided in Appendix A. It should be noted that there are overlaps and redundancies in the issues and how they are affected by the choice of delivery method. While there was an effort to separate issues so that redundancy and double counting would be minimized, it was not possible to treat the issues completely independently.

Project-Level Issues

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

Issue 1: Project Size

Project size is determined by transit project dollar value and physical dimensions. 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. It seems that project size would strongly 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. A possible exception seems to be DBOM, which has been considered mainly for larger transit projects. Because each of the three main delivery methods (DBB, CMR, and DB) can be applied to projects of all sizes, it seems clear that project size needs to be considered in combination with other issues, such as schedule, agency staffing, and risk management in order to determine an appropriate project delivery method.

Issue 2: Cost

This issue includes several aspects of project cost, such as ability to handle budget restrictions, early and precise cost estimation, and consistent control of project costs. Below, each project delivery method is evaluated with regard to cost control and cost estimation.

DBB

This delivery method may provide a cost benefit because it includes marketplace competition, which increases the likelihood of receiving low bids when the project is bid out. Furthermore, having a complete design before awarding the project increases 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. Another cost advantage of DBB is that 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 does not have to pay for constructor 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 with regard to project cost. An advantage is that there may be cost savings because of early constructor input to the project ("CM/GC White Paper, Public Contracting Coalition" 2000) and competitive pricing through "open book" accounts (Irwin 2003). Usually, the owner can negotiate and set the GMP at about 60% of design completion (AGC 2004). If the project requires the services of major trade or specialty subcontractors, bringing them on board during the design phase is recommended. This way, the project team can benefit from their knowledge and experience and establish a more reliable budget early on. The cost drawback to this project delivery method is losing the opportunity to bid the work out. Potential schedule compression by some overlap between design and construction can be an advantage to CMR if the inflation rate will significantly escalate project cost. Also, the owner will know the estimated cost earlier in the project lifecycle than a project owner using the traditional DBB method would. At the same time, owners using the CMR delivery method need to closely monitor costs on the project because of the cost-reimbursable payment method (Walewski, Gibson, and Jasper 2001). Also, it is somewhat difficult to evaluate the validity of the GMP compared to a traditional bid process.

DB

DB performs relatively well when there is budget restriction (Gordon & Rees LLP 2005) because it reduces the potential of cost overruns due to claims and delays. *TCRP Research Results Digest 53* shows that there are fewer cost overruns in DB (Harrington-Hughes 2002). Another study shows

that DB outperforms CMR in operation and maintenance costs, unit cost, and cost growth (Konchar and Sanvido 1998). The DB method can also provide the owner with a firm, fixed price earlier in the design phase. 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, Gibson, and Jasper 2001; Gransberg and Barton 2007a). The AASHTO Procurement Guide states that DB gives earlier cost certainty and has less cost growth than traditional DBB (Molenaar et al. 2005).

DBOM

Early certainty in project costs and mainly operation and maintenance 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 operation and maintenance 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 to 30% design level. This difficulty can lead to increased contingencies, which result in higher prices if the entities submitting proposals are required to price operation and maintenance in response to the DBOM RFP because 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 allows the constructor to bring some innovations to the project in order to decrease the project costs (Kessler 2005).

Issue 3: Schedule

This issue involves two aspects of a project schedule: controlling the schedule (keeping the duration of the project within the expected timeframe) and shortening the schedule. In other words, in this section, each project delivery method is evaluated with regard to schedule control and schedule compression.

DBB

DBB has a sequential process and usually does not have room for significant schedule compression. This sequential process results in a longer schedule than is required by DB, CMR, and DBOM (Walewski, Gibson, and Jasper 2001; Gordon 1994). A longer schedule is the price that is paid for the owner to have the project designs completed prior to the project award. DBB schedule growth also tends to be larger than the schedule growth of the other delivery methods. *NCHRP Report 561* showed that DBB projects had the greatest average time growth (Scott et al. 2006). Inability to compress the schedule in DBB has been one of the main reasons that owners 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 Project]. One problem with 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 realistic schedule for the project. A study has shown that CMR has the ability to meet or exceed schedule requirements (Minchin, Thakkar, and Ellis 2007). This delivery method can also help owners with projects that are schedule sensitive (Walewski, Gibson, and Jasper 2001) and can save some time in the project because of concurrent design and construction ("CM/GC White Paper, Public Contracting Coalition" 2000).

DB

Flexibility in schedule increases in DB because designer and builder are one entity ("Design-Build White Paper, Public Contracting Coalition" 2002). Many experts believe that DB results

in a faster schedule delivery (Walewski, Gibson, and Jasper 2001; Konchar and Sanvido 1998; Gransberg and Molenaar, 2007b; Molenaar and Scott 2003) and has the least schedule growth (Konchar and Sanvido 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. 2007b). This can help agencies award a project and allocate the available funds without waiting for the project design to be complete.

DBOM

This delivery method can increase schedule certainty and early delivery of the project (Kessler 2005). It has all the characteristics of DB, so it can be used as a means of schedule compression.

Issue 4: Risk Management

Each new project has some level of uncertainty during various phases of its development. Strategies for coping with these uncertainties are built into each delivery method. The effect of each delivery method on risk identification, quantification, and mitigation is different; therefore, selection of a delivery method is dependent on the owner's risk management approach. These differences are considered under this issue. Tier 3 of the selection system presented in this guidebook 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 only to Issues 4 and 5 of the chapter.

DBB

This delivery method has a long history of application and a rich background in terms of statutory laws and standard contracts that 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 often arise over authority, responsibility, and quality (Walewski, Gibson, and Jasper 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 CMR comes from the CM holding the trade contracts and taking the performance risk of the project (AGC 2004). The use of a GMP 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, and so forth. This sharing of information is why some experts believe that CMR theoretically reduces the risk of every entity involved in the project (Minchin, Thakkar, and Ellis 2007).

DB

Risk allocation and risk management are inherently different in DB delivery than they are in DBB and CMR delivery. 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 a situation in which the designer and constructor are blaming each other for changes in the cost or the timeframe of the project (Harrington-Hughes 2002; Riley, Diller,

and Kerr 2005; Irwin 2003). From the owner's perspective, the DB approach reduces the size and frequency of change orders (Molenaar and Scott 2003; Riley, Diller, and Kerr 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 although 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 is transferred to the DB contractor, who has more of an economic incentive to manage the risk than the owner in the DBB system.

DBOM

The DBOM entity assumes the risks assumed by the constructor in DB delivery, as well as assuming the risks involved with operations and maintenance, system integration, and project start-up. Agencies expect that the DBOM entity will be more inclined to ensure quality of design and workmanship since it will be responsible for operations and maintenance. Also, the DBOM delivery method does not allow the DBOM entity to claim compensation from the agency for inadequate operation and maintenance considerations because the designer and the constructor are on the same team. As the contract includes the operation and maintenance phase, uncertainty during the operation and maintenance 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 the constructor (Kessler 2005). The DBOM constructor makes money out of the project and may accept higher levels of risk in safety or lower levels of 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 commuter satisfaction problems.

Issue 5: Risk Allocation

Research in the area of risk management has indicated that the most effective approach for risk management is risk allocation—assigning 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 selected by an owner 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 presented in this guidebook is based on an effective method of risk allocation. For example, schedule risk is sometimes addressed by choosing a DB approach (as discussed above). It is important to note that risk allocation affects many of the issues discussed in this chapter and is not limited to Issues 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, which the owner usually transfers to the design team (AGC 2004). 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 Project, Weber County Commuter Rail]. Although GMP as a means of risk allocation should decrease the owner's risks, there is always the possibility that the owner and the onboard contractor will 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 as well as taking the chance of getting bids that are higher than expected.

DB

Because the 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 the risks that the design-builder can best bear. It is unwise to allocate total risk to the DB contractor because that would drastically increase the contingency and the 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 real estate. Experience shows that the owner is in the best position to assume these risks [Greenbush Commuter Rail].

DBOM

Risk allocation in this method is similar to risk allocation in DB, but an allocation of risks is added for the operation and maintenance phase. If the owner can identify the risks of the project early enough to allocate them at the time the project is awarded, DBOM can have some advantages with regard to risk allocation. 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 cases in which the system provider does not guarantee the system if operated by another entity (Kessler 2005). One of the major risks in this approach is the owner's ability to provide clear scope and objectives; if the owner cannot provide these, the consequences of disputes in the later stages may be significant.

Issue 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 U.S. Green Building Association's Leadership in Energy and Environmental Design (LEED) certification is often used by public agencies as a means of articulating their 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 functions with regard to 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 whether or not LEED certification is sought for the project. LEED prerequisites (including selection of site and construction activity pollution prevention) can yield 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 LEED standards are evolving in an effort to accommodate a range of project types. The adoption of LEED criteria as a selection requirement may need to be phrased to indicate that the most current iteration of LEED criteria should be consulted rather than a particular, existing LEED standard.

DBB

In DBB, the owner has a clear opportunity to define sustainable design with LEED criteria. The builder's lack of input in DBB means that there will be little opportunity to take advantage

of builder knowledge of sustainable design, and the owner, in certain cases, can thereby risk losing LEED certification.

CMR

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

DB

With DB, the owner can clearly articulate its expectations regarding the use of LEED criteria by assigning weight to the LEED criteria in relation to other factors in the DB evaluation plan and by 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 define the project scope and goals clearly to ensure reasonable competition, especially if LEED certification is desired.

DBOM

While the project owner and operation and maintenance personnel may be acquainted with the LEED criteria and requirements, there may be limited ability to incorporate evolving criteria as well as restricted opportunities to "push the envelope." The addition of post-construction operation and maintenance allows the owner to hold the DBOM contractor responsible for delivering the lifecycle cost savings incorporated as a result of the design process. The DBOM contractor would thus be at risk for failing to achieve the savings associated with the approved design. Reduced lifecycle cost (both economic and environmental) is an advantage of sustainable design strategies and a fundamental LEED component. Sustainable design strategies that may produce increased initial costs are balanced and ultimately offset through reduced lifecycle 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, staff capability, agency goals and objectives, agency control of the project, and third-party agreements.

Issue 7: Agency Experience

This issue relates mainly to the level of experience of an owner's staff in application of various delivery methods—in other words the staff's 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 as their project delivery method. This experience with DBB makes it a good candidate as a project delivery method (Harrington-Hughes 2002). This experience can motivate an agency to use an alternative delivery method or deter the agency from doing so. The most experienced owners may find that some of their negative experiences with DBB (e.g., contractor's claims, erroneous designs, delays in the schedule, and cost overruns) will push them to try alternative methods. Other owners will be comfortable with DBB delivery and therefore be hesitant to try new delivery methods.

CMR

Most transit agencies have not used CMR for their projects because this is a relatively new project delivery method in transit. Agencies' experience with CM is limited mainly to hiring a construction manager as a consultant or agency CM (see Chapter 2 for a detailed discussion of the CM definition). Nonetheless, agency staff with DBB management experience should have most of the skills necessary to manage CMR because of the similarities between CMR and DBB [Portland Mall Project and Weber County Commuter Rail]. One missing skill may be negotiating the construction manager's preconstruction services fees and the GMP in CMR.

DB

Several transit projects have been executed with the DB approach. Many transit agencies, as well as other public agencies, have the managerial experience required for a DB project. Although agency staff with DBB management experience should have most of the 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 between the two approaches is in 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 the best value method instead of biding based solely on cost), the manner in which the 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 in new skills for owner employees, which may make DB more difficult to administer [Medical Center Extension, Greenbush Commuter Rail, T-REX, and I-205 Light Rail Extension Project].

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 2005). However, the loss of control that goes with this transference of responsibility can be a disadvantage if the agency does not have experience in managing responsibilities for design, construction, and maintenance that have been outsourced to a contractor.

Issue 8: Staffing Required

This issue reflects how each delivery method affects 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 dependence of project progress on the owner's involvement in decisions reflect the extent of the owner's involvement. The total number of owner employees required 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; nonetheless, this assumption has to be weighed 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 approach [Silver Line Project] (AGC 2004, Gordon 1994). The owner's responsibilities in DBB are spread throughout the project (mainly focused on dealing with the designer at the beginning of the process and

shifting to focus on 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 approach can arguably require the least number of owner 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 employees or consultants) if special expertise (e.g., GMP or construction manager's fee negotiation) in managing a CMR contract is desired.

DB

The owner should develop a comprehensive set of project specifications before advertising a DB 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. One study shows that most agencies have not changed the size of their staff after implementing DB mainly because the owner must be involved in a substantial amount of pre-advertising design and engineering (Gransberg and Molenaar 2007b). Another study shows that some public agencies have put considerable effort into 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 because the number of check-points and controls is reduced in this delivery method and the oversight procedures are usually streamlined (Harrington-Hughes 2002). Another driver with respect to the size of staff is the way quality assurance/quality control (QA/QC) is handled in DB projects. In most DB projects, the constructor is put in charge of day-to-day QC functions. The owner's role is to design and implement a QA program.

DBOM

Early decisions in this delivery method cover a wide range—from the feasibility of the project in conceptual design to safety in the operation phase. This broad range of expertise requires an owner to have a good-sized staff to handle the project at least in pre-design and preliminary phases of design [Hudson-Bergen Light Rail]. 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 2005). In most DB projects, the constructor is put in charge of day-to-day QC functions. The owner's role is limited to spot checks and QA functions.

Issue 9: Staff Capability

This issue is mainly focused on the quality and competence of the owner's employees and their ability to complete the duties that must be undertaken in each delivery method. There is a concern about the retirement of experienced employees negatively affecting the capability of an owner's staff during the project. So the availability of the experienced staff until the end of the project should be considered while evaluating staff capability.

DBB

Transit agencies have more experience with DBB than other project delivery methods. This experience helps them to gradually build up capability in their staff at all levels of the organization. An important issue to consider is the different staff expertise required to handle a design contract with the designer of the project and a construction contract with the general contractor. If an owner chooses a project delivery method other than DBB, it may end up with a longer list of required competencies [Silver Line Project].

CMR

Some professionals believe that administering CMR requires special capabilities while others think that the owner agency delegates most of its duties to the CMR. While the work can be delegated, agency staff must be capable of overseeing CMR work and notice errors or omissions [Portland Mall Project and Weber County Commuter Rail]. CMR also requires management of the relations between the onboard constructor and the designer. The owner should carefully manage the process by which the constructor gives input (constructability, value engineering, etc.) to the designer and the way these inputs are received, analyzed, and implemented. 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 with this method, the staff would need to be especially competent and versatile in dealing with these additional requirements.

DB

DB contracts require owner competency in managing the process, keeping up with the typically faster pace of the design-builder, and understanding the procedures. Recent research shows that the traditional design and construction engineering tasks performed by public agency professional engineers (e.g., design deliverable approvals and construction inspection) were performed by the same staff in design-build projects (Gransberg and Molenaar 2007b). While the required skills for DBB are similar to DB, owners tend to put their most experienced staff on DB projects because these staff members need to understand conceptual designs, conceptual estimates, and performance criteria. These skills typically reside only in the most experienced staff [Medical Center Extension, Greenbush Commuter Rail, T-REX, and I-205 Light Rail Extension Project] (Gransberg and Molenaar 2007b).

DBOM

The variety of decisions that must be made early in the main portion of the project scope demands capable employees with a high level of expertise [Hudson-Bergen Light Rail]. 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 of project viability, contract incentives, and the owner's financial security (FTA 2006).

Issue 10: Agency Goals and Objectives

Agency goals can be described in broad terms as providing service to the community or achieving its growth goals. Agency goals can align with project delivery attributes or can be in conflict with them. Agency goals are different from project goals. Agency goals 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 the one hand, and requirement of design approval for construction commencement, on the other hand, helps the owner ensure the achievement of its goals and objectives. Examples of achieving goals and objectives include specifying targets for disadvantaged business enterprise (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 RFP can help ensure that agency goals and objectives are clearly incorporated into CMR proposals. This delivery method may encourage a better owner-constructor relationship than DBB, one that can facilitate the achievement of agency goals [Portland Mall Project and Weber County Commuter Rail].

DB

In DB, an agency has less control over the details of the design than in DBB. To the extent that these details affect agency goals, DB may have a negative impact on achieving agency goals. Examples of 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 [Medical Center Extension, Greenbush Commuter Rail, T-REX, and I-205 Light Rail Extension Project] (Molenaar et al. 2005).

DBOM

A DBOM contract covers a large number of project issues. This comprehensive agreement may push the project through different decision steps and help the owner achieve its goals. Nonetheless, there is a concern that DBOM may hinder the owner in achieving its social goals. Although, according to Kessler (2005, p. 36), a "TRB study" states that decreases in quality and safety of services provided by private entities have not been proven, some experts believe that using this delivery method may limit agencies' power to serve the public (e.g., a change required in operation phase will be extremely costly in DBOM). Advocates of this method believe that a comprehensive agreement with an appropriate level of detail can address this issue; however, it should be noted that there is insufficient precedence to ensure success.

Issue 11: Agency Control of Project

Different delivery methods have different checkpoints and decision-making steps. This section is focused on an owner's control over the details of design and quality of construction; cost control and time control are examined in other sections.

DBB

The owner using this delivery method may benefit from the checks and balances provided by having separate contracts with the designer and the constructor. Having periodic decision points in DBB, primarily during the design phase, helps the owner control the project's design (Harrington-Hughes 2002, Garvin 2003, Irwin 2003). Having a specific contract based on bid plans helps the owner to control construction and material quality. The owner has objective control over the quality of the design through the design team. Also, if flexibility is required during construction, DBB can perform better than some other methods because there are established procedures for implementing changes. Nonetheless, change orders are usually accompanied by corresponding cost increases.

CMR

The owner agency benefits from the involvement of the CM in most of the decisions during the design phase. The CM can assist in controlling the details of design. The owner therefore has a similar level of control in CMR as in 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 than DB does. Furthermore, implementing changes in CMR may be more effective than implementing changes in DBB because the CM is on the team in CMR (Walewski, Gibson, and Jasper 2001; Minchin, Thakkar, and Ellis 2007).

DB

Although, according to some, DB provides the owner with the same quality of design and construction as DBB does, in DB the owner loses control over the details of the design that are not defined in the RFP (Konchar and Sanvido 1998; SAIC, AECOM Consult, and University of Colorado at Boulder 2006). Loss of control over the design (and possibly lack of checkpoints) has the potential to expose the owner to shortcomings in the quality of design and construction [Medical Center Extension, T-REX, and I-205 Light Rail Extension Project] (Gordon & Rees LLP 2005; Irwin 2003; Gransberg and Molenaar 2004).

DBOM

The owner in this delivery method loses control over the details of design and details of operation and maintenance. DBOM is not a good option for owners who want to extend their existing systems, mainly because of the integration needed in the operation phase (Kessler 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.

Issue 12: Third-Party Agreements

This issue concerns each delivery method's impact on facilitating agreements with third parties—political entities, utilities, railroads, and so forth—involved in the progress of the project.

DBB

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

CMR

The main advantage of having a CM is having constructability advice and the responsibility for that advice (e.g., 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 agencies interviewed in this research, one strongly emphasized the benefit of having a contractor on board while negotiating with third parties [Weber County Commuter Rail]. 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 to an earlier point in the delivery process, often before the design is complete. Agencies have experienced both the 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 are 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 experiences with DB show that DB contractors have been successful in obtaining responses from project stakeholders by exerting pressure on them. Constructors have different

approaches to negotiating agreements with third parties than owners do, and these approaches can often be very effective [Medical Center Extension, Greenbush Commuter Rail, T-REX, and I-205 Light Rail Extension Project].

DBOM

Since the DBOM contractor will be maintaining the project for a significant period of time after construction, it needs 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. Sometimes, in cases with fewer schedule constraints, owners may treat third-party agreements similar to the way that they are treated in a DBB project [Hudson-Bergen Light Rail].

Public Policy/Regulatory Issues

This section examines the choice of project delivery method in relation to public policy/regulatory issues such as existing laws, mandated social programs, labor unions, and so forth that establish the legal environment in which the project must be delivered.

Issue 13: Competition

The choice of delivery method may affect the level of competition. In many cases, agencies are operating under a legal requirement that 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 transportation) projects. Additionally, some 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. The effects of each delivery method on competition are evaluated below.

DBB

Compared with other delivery methods, the availability of a relatively large pool of potentially qualified bidders in DBB ensures a high level of competition (Walewski, Gibson, and Jasper 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 out separately to further increase competition. The drawback to the multi-prime approach is that the coordination among various contracts may prove difficult.

CMR

Using RFP procedures and taking into consideration qualifications-based factors when evaluating bidders can help owners weed out unqualified proposers. The issue in this method 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; however, 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 with other delivery methods and requires some extra competencies that typical construction contractors usually lack. The prime contractor usually hires operation and maintenance subcontractors 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!

Issue 14: Disadvantaged Business Enterprise (DBE) Impacts

A project delivery method can facilitate 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 in this section. In general, due to the size of most transit programs, it is unlikely that a DBE firm would serve as the lead constructor. What is more common is to set aside a certain percentage of the budget to ensure DBE participation.

DBB

With DBB, the owner has the chance to include requirements for DBE 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 percentage of contract price. On the other hand, the low-bid environment may force DBE subcontractors 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 experience is a disadvantage 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 experience and financial resources usually make it difficult for a DBE to become the main contractor for a DB project; however, 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 the RFP for a DB project and also in the project contract. This percentage 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. Because an owner has less control in this delivery approach, the enforcement of DBE participation may be harder than with DBB or CMR.

DBOM

DBOM performs very similarly to DB and has the same advantages and disadvantages. The dollar value and the size of the main contract do not work against small businesses if relevant considerations are included in the contract. For example, there were DBE goals in the Hudson-Bergen Light Rail Project that were achieved by putting a clause in the contract for outsourcing some parts of the project to local contractors [Hudson-Bergen Light Rail]. It should be noted, however, that because an 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.

Issue 15: Labor Unions

Each delivery method covers certain phases of a project lifecycle. For example, DBOM covers almost all the phases while DBB 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 the Federal Transit Act, complicate 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) see *TCRP Legal Research Digest 4* [Woodman, Starke, and Schwartz 1995]). Other acts, such as the Davis-Bacon act, should also be taken into consideration when determining laborers' minimum wages in any delivery method.

DBB

In DBB, the contractor hires the laborers directly or through a subcontractor. Union or non-union labor may be used in this method (unless local conditions and considerations limit a 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 it is unlikely that there would 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 posed by the labor union issues. Unions may support alternative delivery methods because these methods give more weight to qualifications than to cost; unions assert that their members are more qualified than non-union labor (Bearup, Kenig, and O'Donnell 2007).

DB

Design-builders are usually joint ventures and dissolve at the end of a project. This may make the process of dealing with unions a bit complicated because unions expect a reliable and established party with whom to have an agreement. Awarding the design to a design-builder in cases where state engineers have their own unions (e.g., in California) may cause conflicts and challenges for owners who want to use DB (this practice has more precedence in highway projects than in transit projects). Unions may support alternative delivery methods as these methods give more weight to qualifications than to cost; unions assert their members are more qualified than non-union labor (Bearup, Kenig, and O'Donnell 2007).

DBOM

Labor unions may affect DBOM more than DB because DBOM includes 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 operation and maintenance personnel at reasonable rates during the operation phase. Also, there may be some opposition from an agency's maintenance employees to the award of such contracts. In any case, there is already considerable experience with operation and maintenance contracting in transit.

Issue 16: Federal/State/Local Laws

Research done on federal and state laws suggests that transit agencies may not be able to use some project delivery methods. Some states require transit agencies go through several steps before being allowed to use an alternative delivery method. This section looks at how difficult it

is to use a delivery method from a legal standpoint. Constant changes in state and local laws mean that an agency researching possible delivery methods for a project should check the legality of each delivery method by checking all the relevant codes. (See 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 the use of CMR 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 CMR or any delivery method other than DBB 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 is similar to awarding a project with DB, and owners are required to comply with the same laws and regulations that in some locations make DBOM application impossible. In addition, if the DBOM arrangement calls for contractor financing, then additional regulations and laws may need to be considered.

Issue 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 the 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 1990s.

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 than with DBB. This may cause some problems or delays although the agency maintains that it can accommodate all legal delivery methods. Handling environmental issues in CMR would be similar to DBB because the owner remains involved and is in control throughout the design phase.

DB

FTA started an initiative to experiment with DB early in the 1990s. 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 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, however, can be problematic. For example, in a commuter rail project [Greenbush Commuter Rail], 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 more than a year.

DBOM

Concerns with DBOM are similar to concerns with DB in relation to FTA/EPA regulations.

Issue 18: Stakeholder/Community Input

The opportunities afforded by a particular delivery method to an owner for coping with community inputs are discussed below. A delivery method should leverage stakeholder and community input as much as possible to achieve project goals in a meaningful and transparent fashion.

DBB

The separation of design and construction phases in DBB gives an owner more time and opportunity to get stakeholders' and communities' inputs to project design and incorporate their expectations into the project scope before the commencement of the construction phase. This characteristic of DBB can lengthen the project preconstruction phase and cause delays in the project.

CMR

The CM is on board during design in CMR 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 input from stakeholders before issuing an RFP because changes in the project after that are difficult and costly. On the other hand, after the contract award, DB contractors have sometimes been able to handle community pressure more effectively than state agencies [T-REX]. 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 the project lifecycle. This characteristic makes preconstruction negotiations between owners and stakeholders more complex. The DBOM contractor may be able to push through the construction phase and handle community pressures more effectively. At this point, there is little evidence to show how this issue will be coped with in DBOM projects.

Lifecycle Issues

This section looks at the project delivery methods in a long-term, post-construction context. Lifecycle issues are those issues that impact not only the maintainability of a project and the cost

of operation 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.

Issue 19: Lifecycle Costs

The opportunities or barriers that each delivery method provides with regard to lifecycle costs are discussed below.

DBB

The owner is in control of design and quality and can tailor these to a project's long-term lifecycle goals.

CMR

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

DB

The owner needs to watch out for increasing project lifecycle costs mainly because the design-builder has a motive to decrease the initial costs of the project to 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 operation and maintenance to a private constructor creates opportunities to leverage private-sector expertise and to realize lifecycle cost reduction by integrating delivery activities and private-sector efficiencies (Garvin 2003, FTA 2006). There are usually provisions in a DBOM contract that motivate the constructor to keep the operation and maintenance cost at the lowest possible amount. The DBOM delivery method is primarily used for financial purposes in countries other than the United States and has been the most suitable delivery method for public owners when the project initial costs are beyond the available funding resources (Harrington-Hughes 2002)

Issue 20: Maintainability

Maintainability is affected by the choice of delivery method in two different areas: level of quality and ease of maintenance.

DBB

In DBB, the owner can check the maintainability of the finished design before awarding the project. Having checkpoints in the design phase can help the owner ensure the design quality 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 quality control is transferred to the design-builder in DB and the details of the design are not known at the time that the project is awarded, many owners have some concerns about the

maintainability and quality of the end product. This has led some owners to require multiyear warranties from DB contractors.

DBOM

This delivery method works much like DB; however, as operation and maintenance are included in the contract and the constructor is in charge of operating the facility after it is built, the owner is less concerned about ensuring the quality and maintainability of the end product.

Issue 21: Sustainable Design Goals

Sustainable design is becoming ever more important in achieving sustainability goals for projects. The effect of delivery method on the sustainability of project designs is the focus of this discussion.

DBB

In DBB, the owner has a clear opportunity to define sustainable design intent and shape social and environmental impact. This method provides 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 ultimate operation and maintenance personnel for the project could be unfamiliar with the operational requirements for sustainable systems, but this is an issue that can be resolved with careful planning.

CMR

In CMR, the owner has a unique opportunity to realize the economic returns of 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 sustainability criteria. The owner can clearly articulate expectations regarding sustainability by assigning weight to sustainability in relation to other factors in the DB evaluation plan. The design schedule could, however, impact public participation, thereby raising social equity issues. Due to the normally time-consuming processes associated with fulfilling municipal and state requirements for announcement and convening of public hearings, certain sustainability measures—such as wetlands mitigation and avoidance of undeveloped areas—raise concerns for eminent domain and brown fields redevelopment, which can impact time performance.

DBOM

DBOM can realize accelerated economic returns for sustainable systems performance since the owner/operator has an inherent bias toward minimizing operations and maintenance lifecycle costs. The compressed timeframes could, however, impact public participation, raising social equity issues. Furthermore, operation and maintenance 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.

Issue 22: Sustainable Construction Goals

Sustainable construction is an important vehicle for achieving sustainability goals for new projects. The disconnect between designer and builder in some delivery methods can restrict the means and methods available for a project. The effect of various delivery methods on facilitating sustainable construction is the focus of this discussion.

DBB

With DBB, an experienced constructor does not have the opportunity to give sustainable design features as inputs during the design phase. Sustainable materials and practices relevant to regional procurement and construction methodology may be unavailable to designers unfamiliar with the project location.

CMR

With 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 in 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 a lack of previous installations.

DBOM

In DBOM, because designer, builder, and operator are contractually united, there is an inherent coordination of design and performance with the requisite guaranteed ability to implement sustainable construction and operational features. DBOM can realize accelerated economic returns for sustainable systems performance since DBOM contractors have an inherent bias toward minimizing operations and maintenance lifecycle 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 lifecycle costs.

Other Issues

This category includes issues that are important to project success that have not been previously categorized in this chapter.

Issue 23: Construction Claims

The focus of this discussion is how each delivery method exposes the agency to potential conflicts and claims. If a delivery method can reduce exposure to construction claims, that delivery method is a favorable choice, and if it increases the possibility of construction claims, it is an unfavorable choice.

DBB

This method typically has the highest occurrence of claims and disputes. Disputes often arise over authority, responsibility, and quality (Walewski, Gibson, and Jasper 2001). Furthermore,

as the owner is responsible for design completeness, errors and omissions claims are common 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 results in the highest rate of cost growth, which could be an indication of a large number of claims (Konchar and Sanvido 1998).

CMR

Assuming a well-structured contract, there is less possibility of claims and disputes in CMR projects once a GMP is agreed upon and the contract is signed. Because the CMR is present during the design process, there is less need for information and clarification of the design documents. Some professionals think that this approach will result in very few construction claims, which is a major advantage of the CMR approach [Weber County Commuter Rail]. 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

Some research shows that the size and frequency of change orders are less in DB than in other project delivery methods (Riley, Diller, and Kerr 2005). This delivery method is less prone to claims and disputes, assuming a well-structured contract. For example, claims for design errors, a major source of DBB contractors' complaints, are 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 among 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 operation and maintenance. This will minimize the challenges of start-up claims and system integration in complex projects (Kessler 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 project will face difficulties during the design, construction, and operation phases.

Issue 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. Conversely, if the project delivery method increases the possibility of adversarial relationships, it is considered a detriment.

DBB

This delivery method can create an adversarial relationship among the parties to the contract—mainly between the owner and the construction contractor (Walewski, Gibson, and Jasper 2001; Irwin 2003; Mahdi and Al-Reshaid 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 the case of project failures or during major disputes (Halpin 2006).

CMR

The inclusion of the construction contractor during the design phase in the CMR method builds constructive team work and facilitates project team formation (Irwin 2003; Minchin, Thakkar, and Ellis 2007) although it requires extensive coordination of consultants and/or subcontractors.

DB

Having a single point of responsibility for design and construction, as in the DB method, decreases the potential for conflict between the engineer and constructor (Walewski, Gibson, and Jasper 2001; Harrington-Hughes 2002; Halpin 2006). Although in DB there should be less incentive for the designer and the constructor to blame each other for problems (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 designer and constructor (on the same DB team) were observed during the interviews for this research [Greenbush Commuter Rail and Hudson-Bergen Light Rail]. It is worth mentioning that design-builders may be deterred from submitting frivolous claims to owners who have future DB projects because with a qualifications-based selection system the design-builder will want to avoid making the owner angry with a claim.

DBOM

With the DBOM method, the owner is less vulnerable to disputes between DB and operation and maintenance personnel. This delivery method also decreases start-up challenges and system integration during the initial years of operation (Kessler 2005). Despite this, disputes between team members such as systems and civil contractors can adversely affect the project.

Conclusion

This chapter discusses the advantages and disadvantages of various project delivery methods in relation to each of the pertinent issues discussed. It should be noted that in many cases, the advantages and disadvantages listed are not absolute and should be considered in comparison with competing delivery methods. The information provided in this chapter can be used to help identify the strengths or weaknesses of each delivery method in relation to important factors that can affect a project's goals. This discussion provides a broad picture of the issues affecting project delivery methods and thereby provides a basis for the decision system that is introduced in the chapters that follow.

CHAPTER 4

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 (Tier 1 approach) provides transit agencies with a structured approach to choosing the most appropriate project delivery method for an individual project. The Tier 1 approach has three primary objectives:

- Present a structured framework to assist agencies in examining 24 pertinent issues involved in the project delivery decision,
- Assist agencies in determining whether there is a dominant or obvious choice of project delivery method, 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 use in defining project goals and examining the advantages and disadvantages of each delivery method within the context of these goals. The aim of this approach is to help agencies understand project delivery method attributes and to help them determine whether 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 whether one or more project delivery methods should be excluded from the examination.

At the completion of the Tier 1 approach, there is a possibility that an agency may not have one 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 approaches with the best delivery method options yielded in the application of the Tier 1 approach and create a more detailed analysis to select the final project delivery method.

The Tier 1 approach includes six distinct steps listed below and shown in Figure 4.1:

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

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 the key variables and provide a "snapshot" of the project scope at the time when the project delivery decision was made.

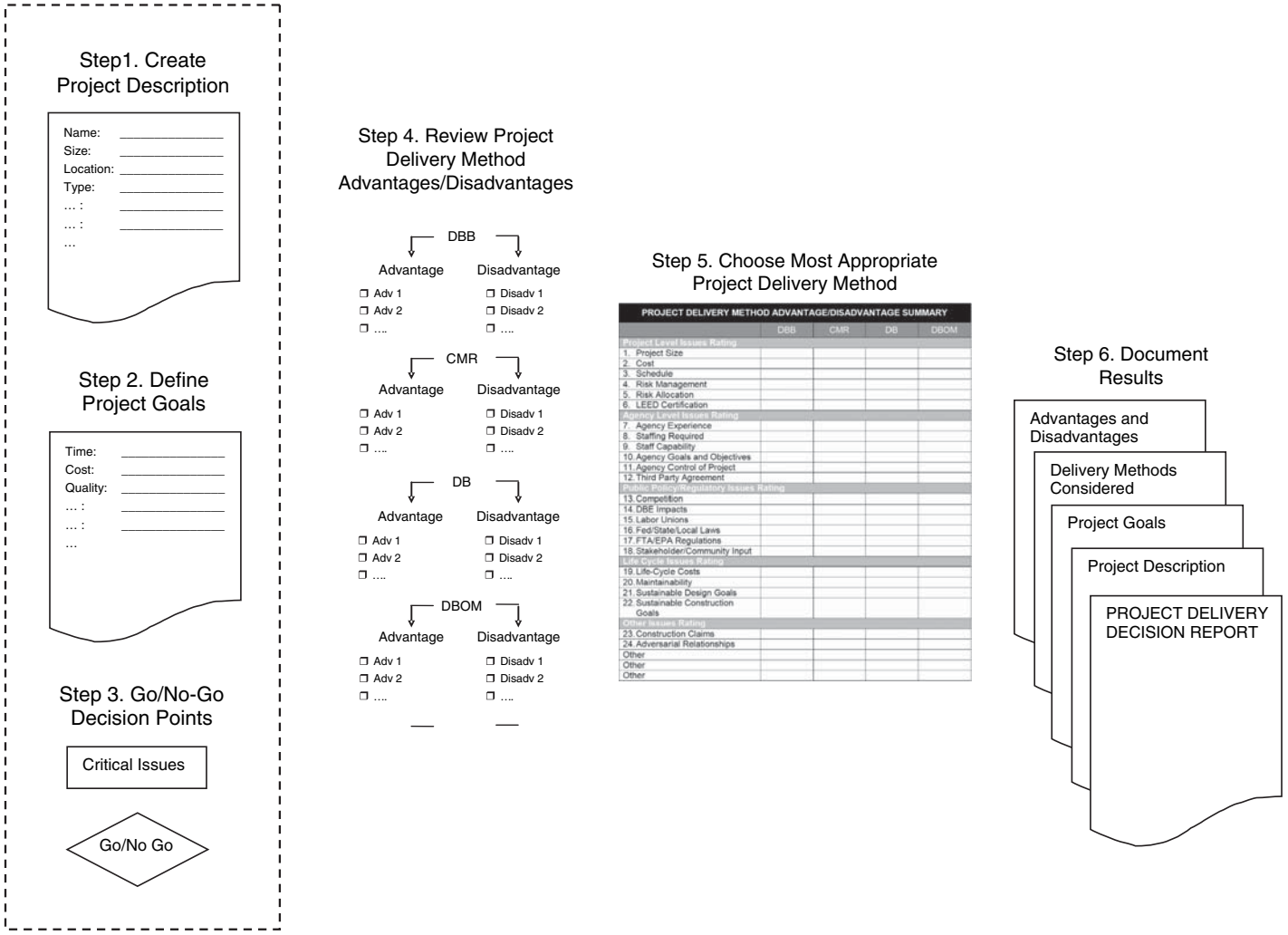


Figure 4.1. Overview of Tier 1 approach.

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. This section also provides examples of goals from transit projects across the country to show how agencies have defined their project goals for a variety of project delivery methods.

Materials for completing Steps 1 and 2 (a project description checklist and a blank form on which to document the project goals and objectives) are included in Appendix C, available on the TRB website at http://trb.org/news/blurb_detail.asp?id=10054.

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 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 whether a delivery method should be excluded from consideration.

The primary objective of Step 4 is to present a comprehensive listing of the generic *potential* advantages and disadvantages of each delivery method in 24 critical areas (forms for working through Step 4 are included in Appendix D, available on the TRB website at http://trb.org/news/blurb_detail.asp?id=10054). *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* used by an agency (the "three Ps") will determine whether the *potential* advantages or disadvantages of a project delivery method are *actual* advantages or disadvantages for a particular project. In Step 4, agencies will have to consider actual advantages and disadvantages and rate each project delivery method as "most appropriate," "appropriate," or "least appropriate or not applicable" on each of the 24 issues. A form for this rating and a structure for documenting comments are provided (see Table 4.29 and Appendix D).

The objective of Step 5 is to make the final project delivery choice if a dominant or obvious choice exists. Upon the transference of the 24 individual ratings from Step 4 into an overall summary, agencies must determine whether there is a dominant choice. In Step 5, the agencies consider the significant benefits of what appears to be the most appropriate delivery method as well as any risks or fatal flaws of that delivery method. If a dominant method is not apparent, the user will document the Tier 1 approach and move to the Tier 2 approach for further analysis of the most applicable methods emerging from the Tier 1 analysis.

The objective of the final step, Step 6, is to provide a framework for documenting the decision made on the basis of the Tier 1 approach. This is done in the form of a Project Delivery Decision Report. This 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. The framework organizes the report into sections that follow the five previous steps in the Tier 1 approach—project description, definition of project goals, go/no go decision points, advantages and disadvantages, delivery method decision, and any relevant appendices.

Step 1. Create Project Description

The first step in the Tier 1 approach involves the creation of a concise, yet comprehensive, project description that serves to communicate the important project characteristics to decision-makers and also to provide a "snapshot" of the project scope at the time in which the project delivery decision was determined. Projects differ in scope of work and major elements (e.g., people

involved, physical project characteristics, project duration, project budget, and so forth). The project description should include necessary information about the project and address all aspects of the project that may be influenced by the selected delivery method. The project description will serve to communicate the decision to interested stakeholders and to justify the decision if issues arise years later. Below is a checklist of the important project characteristics that should be covered in the project description (see Figure 4.2 for an example of a project description):

- Project Name
- Location
- Mode of Transportation
- Estimated Budget

Project Name: Weber County to Salt Lake City Commuter Rail Project.
Location: Utah.
Mode of Transportation: Commuter Rail.
Estimated Budget: $196 million for the main contract (total program is estimated at $611 million).
Estimated Project Delivery Period: 6 years (including design phase).
Required Delivery Date: September 2008.
Source(s) of Project Funding: FTA and Local Sales Tax.
Project Corridor: From Pleasant View through the new Ogden Transit Center at 2349 Wall Street, in Downtown Ogden, and terminating at the Salt Lake City Intermodal Center at 600 West 200 South Street, just west of the central business district.
Project Corridor Dimensions: 43 miles with 8 stations, starting from Pleasant View, Ogden, Roy, Clearfield, Layton, Farmington, Woods Cross, and North Temple in Salt Lake City (Future) and finishing at the Salt Lake Intermodal Center. Additionally, the project has 6 parking lots in its design.
Major Features of Work: Track, at-grade stations, platforms, and parking lots.
Ridership Forecast: 11,800 average weekday boarding.
Major Schedule Milestones: Project completion date—September 2008.
Major Project Stakeholders: Utah Transit Authority (UTA), Union Pacific-Santa Fe Railroad, FTA, and local jurisdictions.
Labor Union Status: No labor union issues anticipated.
Major Challenges:
- UTA entered into an interlocal agreement to build in the existing freight rail corridor with the jurisdictions that it passed through to be able to build without the need to procure building permits from every single local entity.
- The entire project requires working within 25 feet of the active mainline Union Pacific Railroad corridor from Salt Lake City to Ogden, which has up to 35 trains a day passing through at speeds up to 70 mph. The project runs through 14 different municipalities and intersects at 42 road crossings.

Main Identified Sources of Risk: Storm drainage system, safety of construction (narrow corridor), coordination with Union Pacific for the work that Union Pacific has to do, unsuitable soil conditions, incomplete design on some aspects of the work such as station design.
Sustainable Design and Construction Requirements: Enhance the environment through less traffic congestion and pollution.

Figure 4.2. Project description example.

- 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 (if 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

Step 2. Define Project Goals

Defining 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. The definition of project goals is a key success factor not only in the project delivery decision, but also in 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, and so forth) and will also have performance goals regarding time, cost, quality, maintainability, and sustainability that must be met. The performance goals typically drive the project delivery decision.

At project inception, the agency must identify the various performance aspects of the project that must meet its requirements. Generally, these performance aspects will fall into the categories of cost, schedule, and quality as defined by the technical design. Of these three factors, one factor will be the most important for the project's ultimate success—the preeminent factor. In order to achieve goals related to this preeminent factor, an agency would be willing to sacrifice pieces of the other two factors. For example, for its University Line, the Utah Transit Authority (UTA) in Salt Lake City had a fixed budget and certain quality standards to maintain; however, schedule was the preeminent factor because the project had to be finished before the start of the 2002 Winter Olympics. The primary importance of schedule was a major reason that UTA selected DB project delivery. In this case, the owner could not complete the necessary work using the traditional process (DBB) in time to meet the deadline.

A clear and concise definition of project goals not only assists with selecting an appropriate project delivery method, it also provides a clear measure for project success and clear directions for the CM or design-builder to complete the project. Project goals set the stage for decision-makers throughout the project lifecycle and keep the project priorities before decision-makers as they analyze different delivery methods. Project goals influence choice of procurement method, risk-allocation strategies, contracting, progress monitoring, and, at the end of the project, evaluation of project outcome.

To define project goals, thinking in terms of performance categories can be helpful. Schedule, cost, quality, and sustainability are common categories. Table 4.1 provides some examples of generic goals in these categories.

46 A Guidebook for the Evaluation of Project Delivery Methods

Table 4.1. Examples of generic project goals.

Schedule • Minimize project delivery time • Complete the project on schedule • Accelerate start of project revenue	Quality • Meet or exceed project requirements • Select the best team
Cost • Minimize project cost • Maximize project budget • Complete the project on budget	Sustainability • Minimize impact on the environment • Achieve LEED certification

Choosing the goals that apply to a specific project is the second step in an agency's selection of a delivery method. The third, and equally important step, is the ranking of the goals. Table 4.2 provides examples of goals from transit projects in which alternative delivery methods were used.

The project goals in Table 4.2 vary in style and emphasis due to the unique needs of each project, but the goals all clearly link to the benefits of the project's delivery method. For example, CMR was selected for the Portland Mall project in Oregon because there was a project goal of minimizing disruption to business and minimizing traffic control issues during construction. CMR helps with both of these goals through the contractor's early involvement in design (something that is absent from the DBB method). Likewise, in the T-REX project, the design-builder's involvement in design helped to meet the agency's primary goal of minimizing inconvenience. Additionally, the ability to confirm a fixed price and schedule early in design in the DB method facilitates the goals of meeting or beating the total program budget and schedule.

Although not all the ranking of goals in Table 4.2 was provided by the project owners, ranking of the project goals is important. On every project there are tradeoffs among schedule, cost, and quality. It is to the project's benefit if the agency, designers, and constructors are aware of, understand, and are in agreement with these project goals. For example, the Rail Runner's first project goal is not to exceed the program budget and the third project goal 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 clearer. Defining and ranking project goals will also help to define and communicate the criteria for determining overall project success, thereby informing designers and constructors of 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 union agreements. These issues and how they relate to the four primary delivery methods are shown in Table 4.3. 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 that are not available for further consideration. The flowchart in Figure 4.3 depicts a step-by-step approach to the decision; a description of the approach follows.

Table 4.2. Examples of project goals.

Project	Delivery Method	Project Goals*
Portland Mall Project, Oregon	CMR	1. Work with builder to minimize disruption to businesses along right-of-way; 2. Minimize traffic control issues during construction; 3. Add auto and bike access routes in multimodal approach; and 4. Enhance commitment to public art program by furnishing space for expanded sculpture.
Weber County to Salt Lake City Commuter Rail, Utah	CMR	1. Maximize cost-effectiveness by using 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 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 (T-REX), Colorado	DB	1. Minimize inconvenience to the community, motorists, and the 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	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 DB delivery system.
Hudson-Bergen Light Rail, New Jersey	DBOM	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 from the T-REX and Rail Runner projects were published in the RFP. 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.

As depicted in the flowchart in Figure 4.3, the agency should first conduct research into the pertinent issues of federal, state, and local laws; project schedule constraints; third-party agreements; and labor union agreements. 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 with a law that requires award of

Table 4.3. Go/no-go issue summary.

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

Note. Shaded areas do not need to be considered by the user.
✓ / X = Go/no-go decision point

48 A Guidebook for the Evaluation of Project Delivery Methods

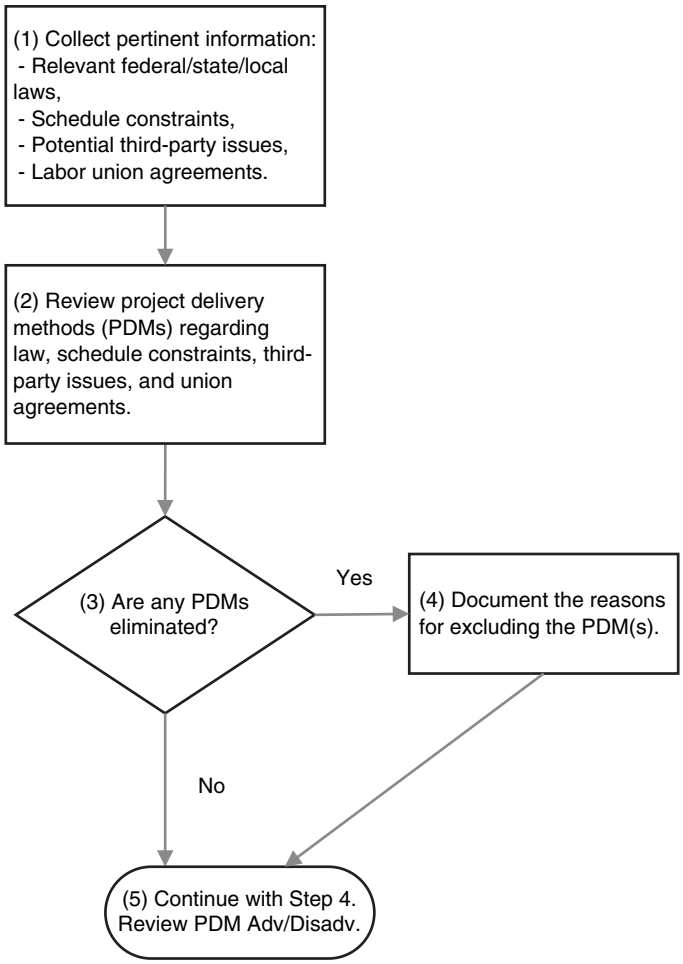


Figure 4.3. Go/no-go decision points.

construction contracts to the low bidder may have to adopt the low-bid DB award method in order to use DB project delivery. Next, the agency should review any major milestones that could create schedule constraints that would prohibit a traditional DBB delivery (e.g., an aggressive fixed end date, funding availability windows, and so forth). The agency then needs to determine the third-party agreements that will be required (e.g., railroad, utility, permitting, and so forth). Finally, 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 results of their review of pertinent issues in relation to the constraints of each delivery method. As depicted in Table 4.3, an issue 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 first priority among competing project goals. Agencies most frequently cite shortening project duration as the reason for using delivery methods other than DBB.

Another case of schedule constraint is an agency that would like to award construction before the design is complete. The DBB method will not accommodate this constraint. This kind of schedule constraint may arise when the agency has a fiscal year budget for construction and needs to award the project before the design is finished or when the agency has an opportunity to complete a portion of the project before the design is complete (e.g., beginning construction before the end of the construction season).

Federal/State/Local Laws

Under TCRP Project G-08, a comprehensive survey was conducted of federal and state laws as they pertain to alternative delivery methods. While some states have fully authorized transit agencies to use CMR, DB, and DBOM, there are still some states that prohibit the use of one or all alternative methods. Along with states that allow full use of alternative delivery methods and those that prohibit the use of all or some of the alternative delivery methods, there are states that allow alternative project delivery methods as long as certain conditions are met (e.g., requiring extra approvals for projects with alternative delivery methods, putting dollar value limits on the volume of DB or CMR contracts that a state may authorize, or putting limits on the number of projects using an alternative delivery method that a state may authorize each year). Although the results of the survey (based on state laws in December 2006) are included in this report for reference, state laws often change, and it would therefore be prudent for transit agencies to check relevant state and local laws at the time that a particular project delivery method is under consideration.

If the federal, state, or local laws prohibit an agency from using an alternative delivery method, generally speaking, it should not be considered further. However, in some cases agencies have determined that the use of a particular alternative delivery method was essential for project success and have been successful in drafting legislation to permit an alternative delivery method for a particular project or for general use. For example, DB was not permitted in the State of Colorado when the T-REX project was envisioned. The Regional Transportation District, in concert with the Colorado Department of Transportation, helped to pass legislation permitting use of DB as a project delivery method. 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 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 the benefits of using the alternative delivery method. Local laws may also place barriers on the use of a specific delivery method, so they should be checked along with the state laws.

Third-Party Agreements

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 by 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.

50 A Guidebook for the Evaluation of Project Delivery Methods

Table 4.4. Go/no-go summary form.

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

Note. Shaded areas do not need to be considered by the user.
✓ = Applicable for further study
X = Not applicable (discontinue evaluation of this method)

Comments _____
_____
_____
_____
_____

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 in places 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 private 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 4.4 provides a form for summarizing this go/no-go analysis.

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 critical examination of the advantages and disadvantages of the delivery methods is to determine how well each method aligns with project goals, project characteristics, agency characteristics, policy/regulatory issues, and lifecycle requirements.

In Step 4, agencies examine 24 separate issues that affect project delivery method selection (see Chapter 3 for a discussion of these issues) and rate the appropriateness of each delivery method in relation to each issue. For each issue, an Advantages/Disadvantages Form listing the general advantages/disadvantages of each project delivery method for that issue and an Issue Summary Table are provided. To determine the appropriateness of each project delivery method in relation to a particular issue, agencies should understand the issue, analyze the delivery methods, and complete the Issue Summary Table.

These three actions are described in more detail in the following:

- **Understand the issue.** Read the brief description of each issue. Refer to Chapter 3 for an expanded description of the issue if needed.
- **Analyze the delivery methods.** Using the Advantages/Disadvantages Form provided, review the advantages and/or disadvantages of each delivery method in relation to the issue. Please

note that the advantages and disadvantages listed in the Advantages/Disadvantages Form are based on general experience with that issue; a specific project may have characteristics that will affect how knowledge gained from general experience applies. Users are urged to consider these general advantages and disadvantages as they apply *to the specific project in question.* Refer to Chapter 3 for an expanded description of the issue if needed.

- **Complete the Issue Summary Table.** Upon reviewing the advantages and disadvantages of each delivery method in relation to the issue and analyzing the implications for the specific project in question, rate the appropriateness of each delivery method in the Issue Summary Table using the following symbols:
  ● – Most appropriate
  O – Appropriate
  ○ – Least appropriate
  X – Not applicable

The 24 issues to be considered are presented below grouped into the five categories in which they were introduced in Chapter 3:

- Project-level issues,
- Agency-level issues,
- Public policy/regulatory issues,
- Lifecycle issues, and
- Other issues.

Project-Level Issues

Issue 1: Project Size

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

Advantages/Disadvantages Form—Project Size

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ DBB has been shown to work on projects of all sizes.	❒ As projects grow in size, the amount of owner staffing required to oversee DBB can become very large.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ CMR has been shown to work on projects of all sizes.	❒ If not managed well, the use of multiple bid packages to facilitate CMR can be difficult.

Design-Build (DB)	
Advantages	Disadvantages
❒ DB has been shown to work on projects of all sizes. ❒ Some owners have noted that DB can facilitate better management of large projects due to the single source of responsibility.	❒ 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 (DBOM)	
Advantages	Disadvantages
❒ DBOM is appropriate for large projects. ❒ Similar to DB, DBOM can facilitate better management of large projects due to the single source of responsibility.	❒ DBOM is not appropriate for smaller projects due to the overhead costs (e.g., for maintenance etc.) ❒ Similar to DB, DBOM can necessitate large peaks in owner staffing requirements.

52 A Guidebook for the Evaluation of Project Delivery Methods

Table 4.5. Project size advantages/disadvantages summary.

Issue	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 _____
_____
_____
_____
_____

Issue 2: Cost

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

Advantages/Disadvantages Form—Cost

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ Costs are known at bid time, before construction begins. ❒ Project can benefit from low bid procurement. ❒ Project can benefit from unit price bidding because quantities are defined prior to procurement.	❒ Construction costs are not fixed (or locked in) until design is 100% complete. ❒ Constructability advice and contractor innovations are not available to lower cost until post bid. ❒ The DBB process is prone to change orders and cost growth after award.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ CMR can be used in conjunction with a GMP pricing structure, which can be useful in negotiating and controlling costs. ❒ If open book pricing can be used, all costs will be known by the owner. ❒ Costs will be known earlier when compared to DBB. ❒ Early constructor involvement or construction advice can lead to cost savings through value engineering and constructability reviews.	❒ If multiple bid packages are used, the overall project cost could grow if later bid packages cost more than estimated. ❒ If a GMP pricing structure is used, owners may have some difficulty in negotiation.

Design-Build (DB)	
Advantages	Disadvantages
❒ If a lump sum pricing structure is used, costs will be fixed early in the project development process. ❒ DB has been shown to have lower average cost growth than DBB or CMR.	❒ 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 (DBOM)	
Advantages	Disadvantages
❒ Owner is provided with fixed cost for design, construction, and maintenance very early in the process.	❒ 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. ❒ DBOM pricing may be hard to negotiate due to the complexity and timeframe of maintenance contracts.

Table 4.6. Cost advantages/disadvantages summary.

Issue	DBB	CMR	DB	DBOM
2. Cost				

Key: ● Most appropriate delivery method
◘ Appropriate delivery method
○ Least appropriate delivery method
X Not applicable (discontinue evaluation of this method)

Comments _____
_____
_____
_____
_____

Issue 3: Schedule

This issue includes two aspects of project schedule—the ability to shorten the schedule and the opportunity to control and prevent time growth.

Advantages/Disadvantages Form—Schedule

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ None.	❒ Likely to yield longest delivery schedule. ❒ Likely to yield the largest schedule growth. ❒ There is no opportunity to compress schedule due to the linear nature of DBB.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ Facilitates fast-tracking, or the ability to bid multiple design packages. ❒ Studies have shown that CMR is faster on average than DBB, but slower than DB.	❒ Risk that overlapping design and construction packages may create delays if not properly coordinated. ❒ Fast-tracking schedule will require owner effort in design and construction reviews.

Design-Build (DB)	
Advantages	Disadvantages
❒ Provides a single point of responsibility (DB contractor) for schedule control. ❒ Provides early schedule certainty. ❒ Historically, provides the least schedule growth. ❒ Provides opportunities for flexibility in schedule compression. ❒ Studies have shown that DB is faster on average than DBB or CMR.	❒ Owner will sacrifice the checks and balances of having a 100%-complete design prior to start of construction. ❒ Rapid schedule will require owner effort in design and construction reviews.

54 A Guidebook for the Evaluation of Project Delivery Methods

Design-Build-Operate-Maintain (DBOM)	
Advantages	Disadvantages
❒ Provides a single point of responsibility (DB contractor) for schedule control. ❒ Provides early schedule certainty. ❒ Historically provides the least schedule growth. ❒ Provides opportunities for flexibility in schedule compression. ❒ Will facilitate start-up process due to a single point of responsibility for design, construction, and operation. ❒ Historically faster than DBB or CMR.	❒ Owner will sacrifice the advantage of having complete design prior to start of construction. ❒ Rapid schedule will require owner effort in design and construction reviews.

Table 4.7. Schedule advantages/disadvantage summary.

Issue	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 _____
_____
_____
_____
_____

Issue 4: Risk Management

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

Advantages/Disadvantages Form—Risk Management

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ Provides historically well-defined and well-understood risk-management processes. ❒ Prescriptive designs and specifications allow for greater detail in risk allocation.	❒ Constructor cannot participate in risk management during design. ❒ Constructor's ability to manage risk is constrained by low-bid procurement.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ Construction manager understands and participates in risk-management process during design.	❒ Risk-management process can be more complex due to separate design, construction, and construction management contracts.

Design-Build (DB)	
Advantages	Disadvantages
❒ Single point of responsibility for risk management in design and construction.	❒ Owner may lose some ability to participate in the risk-management process.

Design-Build-Operate-Maintain (DBOM)	
Advantages	Disadvantages
❒ Single point of responsibility for risk allocation in design, construction, operation, and maintenance.	❒ Owner may lose some ability to participate in the risk-management process for design, construction, operation, and maintenance.

Table 4.8. Risk-management advantages/disadvantages summary.

Issue	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 _____
_____
_____
_____
_____

Issue 5: Risk Allocation

Each project delivery method has characteristics that affect risk allocation. The overarching goal should be to select the project delivery method that assigns project risks to the parties in the best position to manage them.

Advantages/Disadvantages Form—Risk Allocation

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ A clear risk allocation has been established due to history of use and statutory case law.	❒ Constructor cannot participate in risk-allocation discussions during design. ❒ Conflicts can exist in risk allocation between separate design and construction contracts.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ Construction manager understands and participates in risk allocation during design. ❒ Prescriptive designs and specifications allow for greater detail in risk allocation.	❒ Conflicts can exist in risk allocation among the separate design, construction, and construction management contracts.

Design-Build (DB)	
Advantages	Disadvantages
❒ Provides a single party for risk allocation in both design and construction. ❒ Design-builder owns risk for design errors and omissions.	❒ Risks must be allocated through conceptual design and performance specifications.

Design-Build-Operate-Maintain (DBOM)	
Advantages	Disadvantages
❒ Provides single-party risk allocation in design, construction, and maintenance. ❒ Constructor owns risk for design errors and omissions in construction, operations, and maintenance.	❒ Risks must be allocated through conceptual design and performance specifications for design, construction, operation, and maintenance.

56 A Guidebook for the Evaluation of Project Delivery Methods

Table 4.9. Risk-allocation advantages/disadvantages summary.

Issue	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 _____
_____
_____
_____
_____

Issue 6: LEED Certification

This issue concerns obtaining LEED certification for a project. Each project delivery method needs to be examined to discover its ability to include features that will facilitate obtaining LEED certification in accordance with the owner's needs.

Advantages/Disadvantages Form—LEED Certification

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ LEED certification can be established in more detail during design period.	❒ Provides the least opportunity for constructor to participate in LEED process during design. ❒ Separate design packages can create difficulty in coordinating LEED elements in construction.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ Construction manager can offer its construction expertise during design decisions that involve LEED issues.	❒ Separate design packages can create difficulty in coordinating LEED elements in construction.

Design-Build (DB)	
Advantages	Disadvantages
❒ Owner can use some LEED certification elements to select constructor. ❒ Single point of responsibility is provided for LEED certification in design and construction.	❒ Owner may not be involved in all LEED decisions.

Design-Build-Operate-Maintain (DBOM)	
Advantages	Disadvantages
❒ Owner can use some LEED certification elements to select constructor. ❒ 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.	❒ Owner may not be involved in all LEED decisions.

Table 4.10. LEED Certification Advantages/Disadvantages Summary.

Issue	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

Issue 7: Agency Experience

The level of experience of an owner's staff can affect the success of an alternative project delivery method application.

Advantages/Disadvantages Form—Agency Experience

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ Since this is the traditional method of project delivery, owners will likely have the most experience with this method.	❒ None.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ CMR is similar to DBB in many key aspects where agencies have experience (e.g., separation of design and construction).	❒ Agencies may not have experience with GMP pricing or the negotiation that can be involved. ❒ Agencies may not have experience in the use of multiple bid packages to facilitate fast-track construction.

Design-Build (DB)	
Advantages	Disadvantages
❒ Agencies can take advantage of the sole point of responsibility for design and construction to leverage their experience.	❒ Agencies may not have experience authoring DB RFPs and conducting procurements. ❒ Agencies may not have experience administering DB contracts, particularly in the area of design review and administration. ❒ DB necessitates experienced staff to manage design and construction under one contract.

Design-Build-Operate-Maintain (DBOM)	
Advantages	Disadvantages
❒ Similar to DB, agencies can take advantage of the sole point of contact for design, construction, and maintenance to leverage their experience.	❒ Agencies may not have experience authoring DBOM RFPs and conducting procurements. ❒ Agencies may not have experience administering DBOM contracts, particularly in the area of design review and administration. ❒ DBOM necessitates the most experienced staff to manage design, construction, and maintenance under one contract.

58 A Guidebook for the Evaluation of Project Delivery Methods

Table 4.11. Agency experience advantages/disadvantages summary.

Issue	DBB	CMR	DB	DBOM
7. Agency Experience				

Key: ● Most appropriate delivery method
◎ Appropriate delivery method
○ Least appropriate delivery method
X Not applicable (discontinue evaluation of this method)

Comments _____
_____
_____
_____
_____

Issue 8: Staffing Required

This issue ultimately concerns the amount of owner involvement required by each delivery method. The total number of owner employees 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.

Advantages/Disadvantages Form—Staffing Required

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ The separation of design and construction phases provides less variation in owner staffing levels.	❒ DBB typically requires a larger owner staff than the other delivery methods. ❒ DBB typically requires a higher level of owner involvement.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ The CMR alternative can use the least number of owner employees if the CMR is allowed to take on the traditional owner tasks.	❒ The owner will need to have a number of staff members with the ability to oversee and negotiate with the CMR during the process.

Design-Build (DB)	
Advantages	Disadvantages
❒ DB can greatly reduce the number of required owner employees ❒ Design and construction reviews can be done in shorter periods of time.	❒ DB creates peaks in owner staffing needs, particularly during procurement and design review periods. ❒ While fewer owner staff members are needed, more experienced staff members are required.

Design-Build-Operate-Maintain (DBOM)	
Advantages	Disadvantages
❒ Similar to DB, DBOM can greatly reduce the number of required owner staff members. ❒ Design and construction reviews can be done in shorter periods of time.	❒ DBOM can create larger peaks in owner staffing needs during procurement and design review due to the inclusion of maintenance and finance issues in the process. ❒ While fewer owner staff members are needed, more experienced staff members are required.

Table 4.12. Staff required advantages/disadvantages summary.

Issue	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 _____
_____
_____
_____
_____

Issue 9: Staff Capability

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

Advantages/Disadvantages Form—Staff Capability

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ DBB is traditionally aligned with owner staff capabilities.	❒ As projects grow in size, a more experienced staff is required. ❒ Owners typically have different staff members to oversee design and construction processes.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ The CMR can augment an owner's capabilities with his own staff.	❒ Owners must have experienced staff to oversee the CMR. ❒ Owners may lack some capability in negotiating prices, developing designs, and managing the constructor's inputs during the design phase.

Design-Build (DB)	
Advantages	Disadvantages
❒ One entity will be responsible for both design and construction.	❒ Similar to CMR, DB is an alternative delivery method, and it is advisable to have staff members with DB oversight experience. ❒ Owners will need staff capabilities in developing procurement documents and performance criteria. ❒ Owners will need staff capabilities in reviewing design under a DB contract.

Design-Build-Operate-Maintain (DBOM)	
Advantages	Disadvantages
❒ One entity will be responsible for design, construction, operations, and maintenance.	❒ Similar to DB, DBOM is an alternative delivery method, and it is advisable to have staff members with DBOM oversight experience. ❒ Owners will need staff capabilities in developing procurement documents and performance criteria. ❒ Owners will need staff capabilities in analyzing complex financial proposals. ❒ Owners will need staff capabilities in reviewing design under a DB contract.

60 A Guidebook for the Evaluation of Project Delivery Methods

Table 4.13. Staff capability advantages/disadvantages summary.

Issue	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 _____
_____
_____
_____
_____

Issue 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.

Advantages/Disadvantages Form—Agency Goals and Objectives

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ The DBB process allows for goals to be defined through the design process.	❒ Separate design and construction contracts can make goals more difficult to align and manage. ❒ If not developed correctly, detailed designs and prescriptive specifications can conflict with agency goals.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ Agency can involve the CMR in refinement of goals while working together to refine the scope and the GMP. ❒ Qualifications-based construction manager selection can align the team with the project goals.	❒ The agency must have the goals substantially developed when the construction manager contract is awarded. ❒ The negotiation of a GMP may inhibit the alignment of project goals between the agency and the construction manager.

Design-Build (DB)	
Advantages	Disadvantages
❒ Best-value design-builder selection can align the team with the project goals. ❒ Properly written procurement performance criteria can help design-builders innovate to achieve project goals.	❒ To ensure success, agencies must completely understand goals prior to awarding the DB contract.

Design-Build-Operate-Maintain (DBOM)	
Advantages	Disadvantages
❒ In addition to the DB advantages, DBOM allows owners to include lifecycle and maintenance goals in the contract.	❒ Similar to DB, agencies must completely understand goals prior to awarding the DBOM contract.

Table 4.14. Agency goals and objectives advantages/disadvantages summary.

Issue	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 _____
_____
_____
_____
_____

Issue 11: Agency Control of Project

The owner's ability to control the details of design and construction varies with each project delivery method. (Note that discussion of cost control and time control is included in other issue descriptions.)

Advantages/Disadvantages Form—Agency Control of Project

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ The use of prescriptive specifications and complete designs at the time of award provides agencies with the most control over the project. ❒ Separate design and construction contracts provide clear checks and balances.	❒ With additional control come added activities and responsibility for agency staff. ❒ The DBB method can be prone to change orders if any design conflicts or constructability issues are found.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ The CMR method benefits from early constructor involvement, but still has the benefit of separate design and construction contracts.	❒ 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 (DB)	
Advantages	Disadvantages
❒ The transfer of design liability lessens the need for agency control over design.	❒ Award at a conceptual design level means that the agency will lose control over the details of the final design.

Design-Build-Operate-Maintain (DBOM)	
Advantages	Disadvantages
❒ The transfer of design liability lessens the need for agency control over design and maintenance decisions.	❒ Award at a conceptual design level means that the agency will lose control over the details of the final design. ❒ Since the DBOM will be responsible for maintaining the project, the agency could lose control over the detail of some maintenance decisions.

62 A Guidebook for the Evaluation of Project Delivery Methods

Table 4.15. Agency control of project advantages/disadvantages summary.

Issue	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 _____
_____
_____
_____
_____

Issue 12: Third-Party Agreements

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.

Advantages/Disadvantages Form—Third-Party Agreement

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ The use of complete plans and prescriptive specifications facilitates third-party agreements.	❒ Expediting third-party agreements in the DBB process can be cumbersome if it is required.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ Construction managers can help facilitate third-party agreements.	❒ Construction managers typically do not guarantee costs that stem from problems with third-party agreements.

Design-Build (DB)	
Advantages	Disadvantages
❒ Design-builders can use innovative methods to assist in obtaining third-party agreements.	❒ 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). ❒ Design-builders typically do not guarantee costs that stem from problems with third-party agreements.

Design-Build-Operate-Maintain (DBOM)	
Advantages	Disadvantages
❒ Design-builders can use innovative methods to assist in obtaining third-party agreements.	❒ 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). ❒ Design-builders typically do not guarantee costs that stem from problems with third-party agreements.

Table 4.16. Third-party agreement advantages/disadvantages summary.

Issue	DBB	CMR	DB	DBOM
12. Third-Party Agreement				

Key: ● Most appropriate delivery method
◘ Appropriate delivery method
○ Least appropriate delivery method
X Not applicable (discontinue evaluation of this method)

Comments _____
_____
_____
_____
_____

Public Policy/Regulatory Issues

Issue 13: Competition

Each delivery method may affect the level of competition, and thus the effect of each delivery method on competition must be evaluated. Alternative project delivery methods allow agencies to package projects in sizes that can effectively enhance or reduce competition.

Advantages/Disadvantages Form—Competition

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ Owner benefits from large pool of potential bidders and high level of competition.	❒ There are issues that follow low-bid procurement, such as a higher probability of requests for change orders, disputes, and claims.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ Qualifications-based selection factors can be applied to select only the most highly qualified construction managers.	❒ Presence of a constructor early in the project may give the owner less competitive leverage when pricing construction.

Design-Build (DB)	
Advantages	Disadvantages
❒ Qualifications-based selection factors can be applied to select only the most highly qualified design-builders.	❒ Proposal package size and bid preparation costs can decrease the number of qualified bidders. ❒ 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).

64 A Guidebook for the Evaluation of Project Delivery Methods

Design-Build-Operate-Maintain (DBOM)	
Advantages	Disadvantages
❒ Qualifications-based selection factors can be applied to select only the most highly qualified design-builders.	❒ Proposal package size and bid preparation costs can decrease the number of qualified bidders. ❒ Lengthy contract duration and extra competencies required for the operation and maintenance part of the contract decrease the number of bidders. ❒ 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 4.17. Competition advantages/disadvantages summary.

Issue	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 _____
_____
_____
_____
_____

Issue 14: DBE 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.

Advantages/Disadvantages Form—DBE Impacts

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ Agencies can include DBE requirements in both design and construction requirements. ❒ DBE involvement is known at time of award for design and construction.	❒ Low-bidding environment may harm future viability of DBE companies.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ Agencies can include DBE requirements in both design and construction requirements. ❒ DBE involvement is known at time of award for design and construction.	❒ Due to the phased nature of CMR contracts, the final DBE involvement may not be known until the project is ultimately completed.

Design-Build (DB)	
Advantages	Disadvantages
❒ Agencies can include DBE requirements in the RFP for design and construction requirements.	❒ 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 that they specify in their proposals.

Design-Build-Operate-Maintain (DBOM)	
Advantages	Disadvantages
❒ Agencies can include DBE requirements in the RFP for design, construction, and maintenance requirements.	❒ 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 that they specify in their proposals.

Table 4.18. DBE impacts advantages/disadvantages summary.

Issue	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 _____
_____
_____
_____
_____

Issue 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.

Advantages/Disadvantages Form—Labor Unions

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ The DBB process is well established, so there is generally no fundamental opposition from unions.	❒ None.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ Similar to DBB, there is generally no fundamental opposition from unions.	❒ Construction managers do not generally guarantee prices if there are issues with labor unions.

Design-Build (DB)	
Advantages	Disadvantages
❒ None.	❒ Opposition from public design unions can exclude the DB method from consideration (see Step 3-Review Go/No-Go Decision Points). ❒ Design-builders do not generally guarantee prices if there are issues with labor unions.

Design-Build-Operate-Maintain (DBOM)	
Advantages	Disadvantages
❒ None	❒ Opposition from public design unions can exclude the DBOM method from consideration (see Step 3-Review Go/No-Go Decision Points). ❒ Opposition from public maintenance unions can exclude the DB method from consideration (see Step 3-Review Go/No-Go Decision Points). ❒ Design-builders do not generally guarantee prices if there are issues with labor unions.

Table 4.19. Labor unions advantages/disadvantages summary.

Issue	DBB	CMR	DB	DBOM
15. Labor Unions				

Key: ● Most appropriate delivery method
◘ Appropriate delivery method
○ Least appropriate delivery method
X Not applicable (discontinue evaluation of this method)

Comments _____
_____
_____
_____
_____

Issue 16: Federal/State/Local Laws

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

Advantages/Disadvantages Form—Federal/State/Local Laws

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ All states are authorized to use DBB.	❒ None.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ Some states allow more flexible procurement regulations with CMR, which can be advantageous in appropriate situations to expedite project development.	❒ 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 (DB)	
Advantages	Disadvantages
❒ Some states allow more flexible procurement regulations with DB, which can be advantageous in appropriate situations to expedite project development.	❒ 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 (DBOM)	
Advantages	Disadvantages
❒ Some states allow more flexible procurement regulations with DBOM, which can be advantageous in appropriate situations to expedite project development.	❒ State laws and regulations for DBOM are similar to DB (see Step 3-Review Go/No-Go Decision Points).

Table 4.20. Federal/state/local laws advantages/disadvantages summary.

Issue	DBB	CMR	DB	DBOM
16. Federal/State/Local Laws				

Key: ● Most appropriate delivery method
◘ Appropriate delivery method
○ Least appropriate delivery method
X Not applicable (discontinue evaluation of this method)

Comments _____
_____
_____
_____
_____

Issue 17: FTA/EPA Regulations

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

Advantages/Disadvantages Form—FTA/EPA Regulations

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ Familiarity of agencies with this method facilitates permit and funding process.	❒ 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 Manager at Risk (CMR)	
Advantages	Disadvantages
❒ Construction managers can help facilitate the environmental process.	❒ 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 (DB)	
Advantages	Disadvantages
❒ FTA has gained some experience and has modified its procedures to use DB. ❒ Cost and schedule are fixed near the FFGA.	❒ 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 (DBOM)	
Advantages	Disadvantages
❒ FTA has gained some experience and has modified its procedures. ❒ Cost and schedule are fixed near the FFGA.	❒ 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.

68 A Guidebook for the Evaluation of Project Delivery Methods

Table 4.21. FTA/EPA regulations advantages/disadvantages summary.

Issue	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 _____
_____
_____
_____
_____

Issue 18: Stakeholder/Community Input

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

Advantages/Disadvantages Form—Stakeholder/Community Input

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ Separate design and construction phases provide an opportunity to get stakeholders' inputs before the commencement of construction.	❒ The opportunity for stakeholder changes in design can cause delay in the project and add to the costs in the form of change orders.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ The construction experience of the construction manager can help facilitate stakeholder input.	❒ Stakeholder input can make GMP negotiation troublesome if not managed correctly.

Design-Build (DB)	
Advantages	Disadvantages
❒ The owner can require the DB contractor to include a public information and outreach program to facilitate communities' inputs. ❒ Design-builders can be innovative in helping gain community involvement.	❒ Any change because of community inputs after the issuance of an RFP can be costly.

Design-Build-Operate-Maintain (DBOM)	
Advantages	Disadvantages
❒ The owner can require the DB contractor to include a public information and outreach program to facilitate communities' inputs. ❒ Design-builders can be innovative in helping gain community involvement.	❒ Any change because of community inputs after the issuance of an RFP can be costly.

Table 4.22. Stakeholder/community input advantages/disadvantages summary.

Issue	DBB	CMR	DB	DBOM
18. Stakeholder/Community Input				

Key: ● Most appropriate delivery method
◘ Appropriate delivery method
○ Least appropriate delivery method
X Not applicable (discontinue evaluation of this method)

Comments _____
_____
_____
_____
_____

Lifecycle Issues

Issue 19: Lifecycle Costs

Delivery methods can influence costs in the operation and maintenance phase. This issue concerns the opportunities or challenges that each delivery method provides with regard to lifecycle costs.

Advantages/Disadvantages Form—Lifecycle Costs

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ The agency can control lifecycle costs through completed design and performance specifications.	❒ The DBB system allows for little constructor input into lifecycle costs.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ CMR has all benefits of DBB, plus the agency can leverage the construction manager's input into lifecycle costs.	❒ If lifecycle performance criteria are not well understood during the development of the GMP, lifecycle issues may be difficult to incorporate into the final product.

Design-Build (DB)	
Advantages	Disadvantages
❒ The agency can use performance criteria to set lifecycle performance standards and rely on design-builder innovation to achieve these standards.	❒ If lifecycle performance criteria are not well understood at the procurement stage, they will not be incorporated into the DB contract.

Design-Build-Operate-Maintain (DBOM)	
Advantages	Disadvantages
❒ The design-builder is responsible for maintenance in the DBOM contract and will be highly motivated to provide optimal lifecycle designs. ❒ The agency can use performance criteria to set lifecycle performance standards and rely on design-builder innovation to achieve these standards.	❒ The agency will not have complete control over all lifecycle issues that are not included as performance criteria in the contract.

70 A Guidebook for the Evaluation of Project Delivery Methods

Table 4.23. Lifecycle costs advantages/disadvantages summary.

Issue	DBB	CMR	DB	DBOM
19. Lifecycle Costs				

Key: ● Most appropriate delivery method
◘ Appropriate delivery method
○ Least appropriate delivery method
X Not applicable (discontinue evaluation of this method)

Comments _____
_____
_____
_____
_____

Issue 20: Maintainability

The issue of maintainability involves the owner's ability to specify quality and ease of maintenance. There are advantages and disadvantages to each delivery method with regard to how maintainability is achieved.

Advantages/Disadvantages Form—Maintainability

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ The opportunity to view completed plans before award allows agencies to review maintenance issues in designs.	❒ There is little opportunity for constructors to have input into maintenance issues.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ CMR has all the benefits of DBB, plus the agency can leverage a construction manager's input into maintenance issues.	❒ 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 (DB)	
Advantages	Disadvantages
❒ The agency can emphasize maintainability issues through performance criteria and best-value award factors.	❒ If maintainability issues are not well understood at the procurement stage, they will not be incorporated into the DB contract.

Design-Build-Operate-Maintain (DBOM)	
Advantages	Disadvantages
❒ The design-builder is responsible for maintenance in the DBOM contract and will be highly motivated to provide optimal lifecycle designs. ❒ The agency can emphasize maintainability issues through performance criteria and best-value award factors.	❒ The agency will not have complete control over all maintainability issues that are not included as performance criteria in the contract.

Table 4.24. Maintainability advantages/disadvantages summary.

Issue	DBB	CMR	DB	DBOM
20. Maintainability				

Key: ● Most appropriate delivery method
◘ Appropriate delivery method
○ Least appropriate delivery method
X Not applicable (discontinue evaluation of this method)

Comments _____
_____
_____
_____
_____

Issue 21: Sustainable Design Goals

Sustainable design is becoming ever more important in achieving overall sustainability goals for projects. There are advantages and disadvantages to each delivery method in terms of addressing sustainability issues and incorporating sustainable design in a project.

Advantages/Disadvantages Form—Sustainable Design Goals

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ Agencies can work with designers to incorporate sustainable designs into complete designs.	❒ The process provides little opportunity for constructability reviews to ensure that sustainable designs can be constructed efficiently and are not cost prohibitive.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ CMR has all the benefits of DBB, plus the agency can leverage the construction manager's input into sustainable design issues.	❒ The use of separate bid packages can create barriers in the integration of sustainable solutions if not approached correctly.

Design-Build (DB)	
Advantages	Disadvantages
❒ The agency can emphasize sustainable design issues through performance criteria and best-value award factors. ❒ Integration of the design and construction team can enhance constructability of designs.	❒ 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 (DBOM)	
Advantages	Disadvantages
❒ The agency can emphasize sustainable design issues through performance criteria and best-value award factors. ❒ Integration of the design and construction team can enhance constructability of designs. ❒ DBOM contractors can realize economic returns for sustainable designs since they have an inherent bias toward minimizing operations and maintenance lifecycle costs.	❒ If sustainable design issues are not well understood at the procurement stage, they will not be incorporated into the DB contract.

72 A Guidebook for the Evaluation of Project Delivery Methods

Table 4.25. Sustainable design goals advantages/disadvantages summary.

Issue	DBB	CMR	DB	DBOM
21. Sustainable Design Goals				

Key: ● Most appropriate delivery method
◘ Appropriate delivery method
○ Least appropriate delivery method
X Not applicable (discontinue evaluation of this method)

Comments _____
_____
_____
_____
_____

Issue 22: Sustainable Construction Goals

In addition to sustainable design, sustainable construction is an important vehicle for achieving overall sustainability goals. There are advantages and disadvantages to each project delivery method with regard to facilitating sustainable construction.

Advantages/Disadvantages Form—Sustainable Construction Goals

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ Prescriptive specifications can be used to define sustainable construction practices prior to construction.	❒ There is little opportunity or incentive for constructor to do more than what is specified in terms of sustainable construction practices. ❒ Agencies can assume liability when prescribing construction methods.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ The agency can leverage the construction manager's input into sustainable construction issues.	❒ The use of separate bid packages can create barriers in the integration of sustainable solutions if not approached correctly.

Design-Build (DB)	
Advantages	Disadvantages
❒ The agency can emphasize sustainable construction issues through performance criteria and best-value award factors. ❒ Integration of the design and construction team can enhance the use of sustainable construction practices.	❒ 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 (DBOM)	
Advantages	Disadvantages
❒ DBOM contractors can realize economic returns for sustainable designs since they have an inherent bias toward minimizing operations and maintenance lifecycle costs.	❒ If sustainable construction issues are not well understood at the procurement stage, they will not be incorporated into the DBOM contract.

Table 4.26. Sustainable construction goals advantages/disadvantages summary.

Issue	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

Issue 23: Construction Claims

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

Advantages/Disadvantages Form—Construction Claims

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ DBB has a well-understood legal precedent for construction claims.	❒ DBB historically has the highest occurrence of claims and disputes, which often occur in the areas of authority, responsibility and quality. ❒ The low-bid environment can provide incentives for a constructor to file claims—particularly if there is any ambiguity in the plans.

Construction Manager At Risk (CMR)	
Advantages	Disadvantages
❒ Having the constructor on the team early during design can lessen the likelihood for disputes and claims regarding designs.	❒ Since design and construction contracts are separate, the potential for disputes and claims regarding design still exist. ❒ If multiple bid packages are not managed correctly, the coordination of these bid packages can result in claims.

Design-Build (DB)	
Advantages	Disadvantages
❒ The single source for design and construction eliminates claims for design errors or omissions from the agency's perspective.	❒ There is potential for claims with regard to scope definition if the form of the DB contract is not well understood.

Design-Build-Operate-Maintain (DBOM)	
Advantages	Disadvantages
❒ DBOM has similar advantages to DB and additionally eliminates claims regarding operating performance due to the integration of the operator.	❒ There is potential for claims with regard to scope definition if the form of the DBOM contract is not well understood.

74 A Guidebook for the Evaluation of Project Delivery Methods

Table 4.27. Construction claims advantages/disadvantages summary.

Issue	DBB	CMR	DB	DBOM
23. Construction Claims				

Key: ● Most appropriate delivery method
◘ Appropriate delivery method
○ Least appropriate delivery method
X Not applicable (discontinue evaluation of this method)

Comments _____
_____
_____
_____
_____

Issue 24: Adversarial Relationship

There are advantages and disadvantages to each project delivery method with regard to avoiding adversarial relationships on the project team. These advantages and disadvantages will vary depending on the nature of the project and the owner's experience with the delivery methods.

Advantages/Disadvantages Form—Adversarial Relationship

Design-Bid-Build (DBB)	
Advantages	Disadvantages
❒ Roles and responsibilities in DBB contract are very well understood in the industry.	❒ DBB can create an adversarial relationship between the parties; primarily between the owner and construction contractor.

Construction Manager at Risk (CMR)	
Advantages	Disadvantages
❒ Inclusion of the construction manager in the design process can align team members and lessen adversarial relationships.	❒ Negotiation of GMP can create an adversarial situation if the process is not well understood.

Design-Build (DB)	
Advantages	Disadvantages
❒ Inclusion of the designer and constructor on the same team can lessen adversarial relationships.	❒ 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 (DBOM)	
Advantages	Disadvantages
❒ Inclusion of the designer, constructor, and maintenance contractor on the same team can lessen adversarial relationships.	❒ Similar to DB, a DBOM delivery requires a high level of trust to succeed.

Table 4.28. Adversarial relationship advantages/disadvantages summary.

Issue	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 through 4 of the selection process provide all the individual pieces of information needed to make a project delivery decision. The final step involves combining this information into a final comprehensive format that will aid in making the decision. Table 4.29 presents a form in which to summarize the advantages and disadvantages of each project delivery method with regard to each of the 24 issues. Following the table is an outline for use in documenting the final decision. Step 5 requires the following actions:

- **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.
- **Transfer individual issue summary ratings.** Transfer the 24 individual issue summary ratings (documented in the Issue Summary Table at the end of each issue analysis) to Table 4.29 to provide a complete picture of the analysis.
- **Review Table 4.29 to determine the dominant delivery method.** Upon completion of Table 4.29, a delivery method may emerge as 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 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 a delivery choice and move to Step 6.
- **Review "least appropriate" ratings.** Review any "least appropriate" ratings to determine whether any of the issues raised red flags or problems that would make a delivery method significantly less desirable.
- **Choose the 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.

Step 6. Document Results

The final step in the Tier 1 decision process is to document the results in a Project Delivery Decision Report. Whether one delivery method emerges as 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.

76 A Guidebook for the Evaluation of Project Delivery Methods

Table 4.29. 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. Federal/State/Local Laws				
17. FTA/EPA Regulations				
18. Stakeholder/Community Input				
Lifecycle Issues Rating				
19. Lifecycle Costs				
20. Maintainability				
21. Sustainable Design Goals				
22. Sustainable Construction Goals				
Other Issues Rating				
23. Construction Claims				
24. Adversarial Relationship				
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

_____
_____
_____
_____
_____

The six-step process forms the basis for the Project Delivery Decision Report. Steps 1 through 5 can be combined for a complete report. The advantage/disadvantage checklist and the related comments will be important components for 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, and so forth) should be added as appendices. A suggested Project Delivery Decision Report outline is the following:

1. Executive Summary
2. Project Description
3. Project Goals

4. Delivery Methods Considered
5. Advantages and Disadvantages
6. Delivery Method Decision
7. Appendices

Conclusion

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, that delivery method should be selected and the decision documented in a Project Delivery Decision Report. If, at the end of this stage, a dominant choice has not emerged, the agency should document the results and move to the Tier 2 approach for a more detailed analysis of the remaining delivery methods.

CHAPTER 5

Tier 2—Weighted-Matrix Delivery Decision Approach

Introduction

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

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

Forms for the Tier 2 approach are provided in Appendix E, which is available on the TRB website at http://trb.org/news/blurb_detail.asp?id=10054.

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 use in prioritizing their project goals and selecting the project delivery method that best aligns with these goals. Priorities for project goals and critical selection issues are unique to each project. Likewise, project delivery methods vary in their ability to achieve these goals and their suitability with regard to various 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 an agency will not have a single, clear, and logical choice for a project delivery method. If this is the case, the agency is advised to move to the Tier 3 approach with the short list of delivery methods emerging from completion of the

Tier 2 approach and make the final decision based upon a detailed risk analysis of the issues involved with each delivery method.

The Tier 2 approach is composed of five distinct steps listed below and shown in Figure 5.1.

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

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 of the 24 pertinent issues examined in Tier 1 that were deemed critical (see Chapter 4 for Tier 1). The Tier 1 approach asks owners to establish their project goals at the very beginning of the process. The first step in Tier 2 is for owners to develop a concise set of selection factors by combining their project goals with the most relevant of the 24 pertinent issues examined in Tier 1. These selection factors will be used throughout the Tier 2 approach.

In Step 2, owners rank and then weight selection factors. Some selection factors may overlap with others, in which case they can be combined. Other selection factors may stand alone for analysis. Completion of Step 2 results in a list of up to seven selection factors for further analysis.

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

Step 4 involves a determination of the most appropriate delivery method through the completion of a weighted-decision matrix (see the weighted-matrix template in Table 5.3). Owners will make the determination by multiplying the selection factor weights by the project delivery scores and then summing the values for each delivery method. The highest score will indicate the

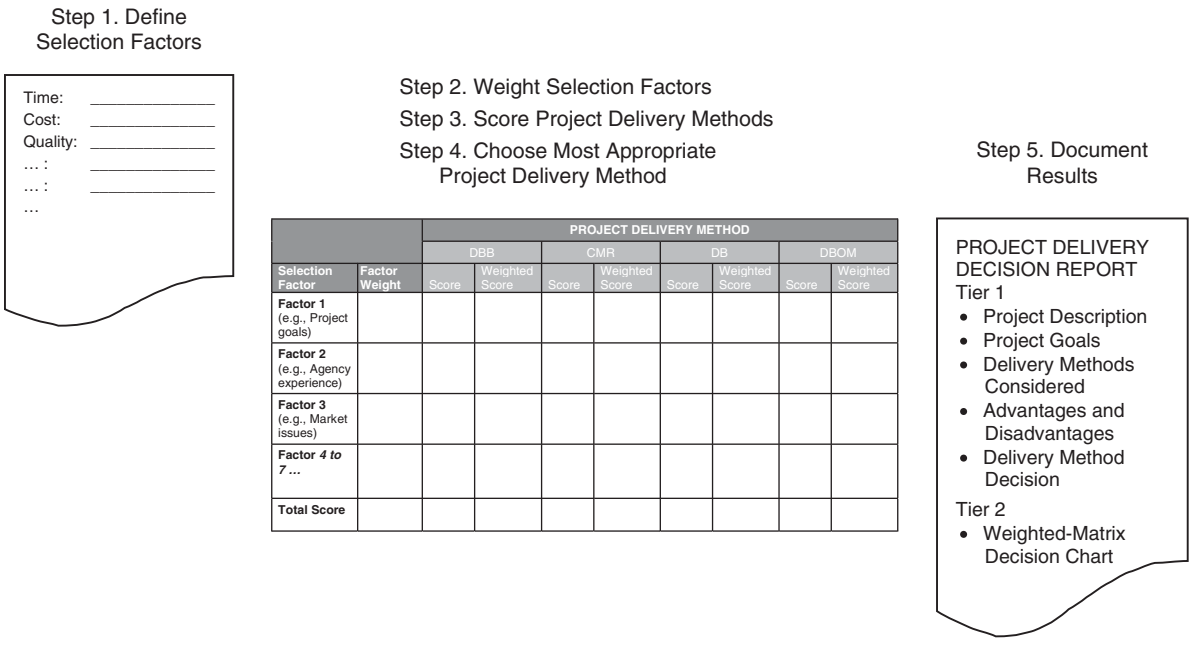


Figure 5.1. Tier 2 approach overview.

80 A Guidebook for the Evaluation of Project Delivery Methods

best choice. However, since the scores will be subjective, owners are encouraged to review the totals to determine whether the values are logical and defensible.

The objective of Step 5 is to supplement the Project Delivery Decision Report developed in Tier 1. The Tier 1 report will provide a project description, project goals, delivery methods considered, advantages and disadvantages, delivery method decision, and any relevant appendices. The Tier 2 documentation will add to this documentation of the weighted-matrix decision to supplement the archival record of the project delivery decision. The Project Delivery Decision Report 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 five steps of the Tier 2 approach are discussed in more detail below. In this report, to better illustrate how the Tier 2 approach works, the selection of a delivery method for an example project is followed through the first three steps of the Tier 2 analysis. Following the description of Steps 1, 2, and 3 in the Tier 2 approach is an illustration of how each step was handled in the delivery selection process for the example project.

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 not only in the project delivery decision, but also in the development of procurement documents and the administration of a project. It is the project 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 pertinent issues into a set of selection factors for use in a weighted-decision matrix. This step requires a review and filtering of the project goals and pertinent issues for use as selection factors. Figure 5.2 depicts this process.

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 proj-

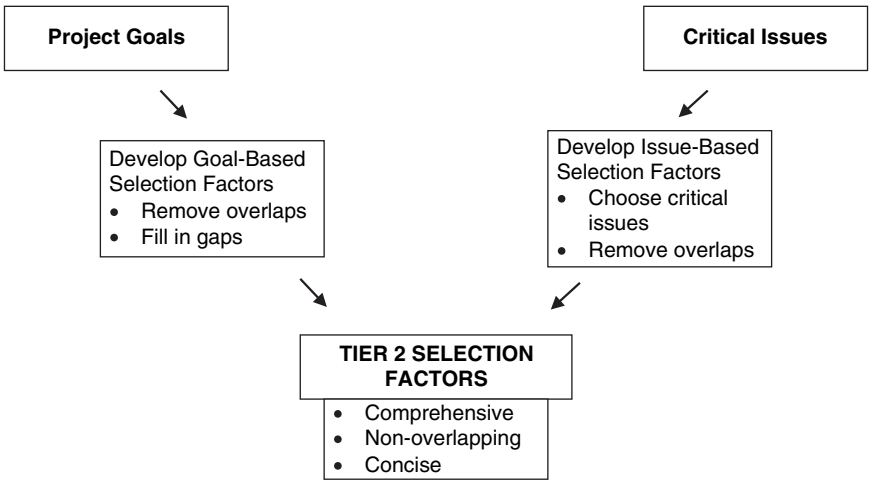


Figure 5.2. Tier 2 selection factor development.

ect goals should not change, these overlaps and gaps will need to be removed for the development of selection factors. Step 1 in the Tier 2 approach allows and encourages editing of these goals as they are rewritten into selection factors. In developing 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 goal statements missing that are needed to define the ultimate project success?
- Can any of the goals be stated more concisely?

The Tier 1 approach provides an opportunity to review 24 pertinent project delivery issues. However, in the Tier 1 approach all of the issues are treated as equally important. Upon reviewing the issues, owners will certainly find that some issues are more important than others. A small number of issues are likely to be important to the final project delivery decision.

The next task in Step 1 is to select up to 7 of the 24 pertinent project delivery issues to examine and develop into selection factors. The owner should select the pertinent issues according to the following:

- The pertinent issues should be independent of the project goals,
- The pertinent issues should be independent of each other, and
- No more than seven pertinent issues should be chosen.

The final task of Step 1 is to consolidate the goals-based and issues-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.

Delivery Selection Process for the Example Project—Step 1. The selection factors for the example project were determined to be the following:

- Project complete by November 1, 20XX.
- Cost not to exceed $1.5 billion.
- Environment enhanced through less traffic congestion and pollution.
- Staffing requirements minimized during design and construction.

This list of selection factors includes project goals relating to time, cost, and sustainability and a pertinent issue regarding agency staffing. While other issues, such as technical quality, maintainability, third-party agreements, and so forth undoubtedly exist for the project, the list of selection factors includes the goals and issues by which the success of the project will be primarily measured at its completion.

Step 2. Weight Selection Factors

The Tier 2 approach is based on the premise that owners can establish a unique hierarchy of selection factors. In other words, success will be defined differently for each project 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 first ranking and then weighting the selection factors. There are numerous methods that can be used to achieve a weighted ranking of the factors. The most straightforward method is developing a ranking and weighting through discussion among project decision makers. The decision will by nature be somewhat subjective, so a diligently documented group decision is preferable.

82 A Guidebook for the Evaluation of Project Delivery Methods

To achieve the weighted ranking, owners should do the following:

- Rank the selection factors in order from highest to lowest with regard to their influence on project success.
- Include a minimum of four and a maximum of seven factors.
  - Remove factors not ranked in the top seven.
- 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 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. Appendix F (available on the TRB website at http://trb.org/news/blurb_detail.asp?id=10054) provides descriptions of the following methods to achieve more precise weighted rankings:

- The Delphi Method,
- Rank Order Centroid,
- The Ratio Method, and
- Pairwise Comparison.

The result of Step 2 will be a weighted ranking of up to seven selection factors. The weightings should total 100 points. Equal factor weightings are not recommended because distinguishing the importance between factors (goals and pertinent issues) is necessary for the decision process. Additionally, no single factor should have a point value of less than five because a point value that low will not influence the final decision and may in fact make the selection more difficult.

Steps 3, 4, and 5 involve combining the weighted ranking of the selection factors with a scoring of the project delivery methods to arrive at the selection of the most appropriate delivery method.

Delivery Selection for the Example Project—Step 2. Table 5.1 shows how weighted ranking worked in the example project. In Table 5.1, selection factors for the example project have been weighted to reflect their influence on the success of the example project's delivery. These weightings are project dependent and should be agreed upon by key owner team members.

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 pertinent 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 do the following:

Table 5.1. Weighted ranking of selection factors for the example project.

Weight	Selection Factor
50	Project complete by November 1, 20XX.
25	Cost not to exceed $1.5 billion.
15	Environment enhanced through less traffic congestion and pollution.
10	Staffing requirements minimized during design and construction.
100	**Total**

- Using the scale given in Table 5.2, assign a score to each delivery method that represents its influence or bearing on each selection factor. Score all delivery methods for each factor before moving to the next factor.
- Repeat the previous step for each selection factor.
- When all of the delivery methods have been scored, multiply each delivery method's factor weight by its score to achieve a weighted score for each delivery method.
- Sum all of the weighted scores to arrive at a total score for each delivery method.

Table 5.2 provides a scale for scoring each delivery method's bearing on each 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 1,000. The scores are subjective, so a detailed definition for each numerical score is provided adjacent to the score in Table 5.2. When scoring the delivery methods, owners should discuss the advantages and disadvantages of each delivery method (see Chapter 3 and Step 4 of Tier 1). 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 to come to a decision by consensus. The reasons for each individual score should also be carefully documented. Consideration should also be given to the relative scores for each delivery method to ensure consistency.

Like the development of factor weights, scoring project delivery methods can be done most simply through a group discussion among key decision makers from the owner's team. If a more precise scoring is desired, one of the decision techniques described in Appendix F can be used.

Table 5.3 provides a weighted decision matrix template. The matrix can contain up to four delivery methods, depending upon the results of Tier 1. The matrix can also contain up to seven selection factors for each project. 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, making a decision, and creating a Project Delivery Selection Report.

Delivery Selection for the Example Project—Step 3. Table 5.4 shows how an owner might score the project delivery methods for the example 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 are project dependent and will certainly change from project to project.

Table 5.2. 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 point slightly 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.

84 A Guidebook for the Evaluation of Project Delivery Methods

Table 5.3. 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)									
Factors 4 to 7 …									
Total Score									

Explanations of the scores for the project delivery methods for the example project are the following:

- **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, so CMR = 6 (in this case). 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. According to what has been demonstrated in practice, the owner is confident that the end date can be achieved through a DB delivery, so DB = 8 (in this case).
- **Cost containment factor.** The cost containment factor relates to a project goal. The project has a maximum budget of $1.5 billion. Practice has shown that with DB a fixed price can be set early in the project development process. It has also been demonstrated that DB provides the lowest average cost growth of the two methods in question, so 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 GMP contract structure. The owner also feels that there is more risk with CMR of not achieving the schedule than with DB, so CMR = 6 (in this case).

Table 5.4. Weighted matrix for example project.

		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
Environment enhanced through less traffic congestion and pollution	15	10	150	6	90
Staffing requirements minimized during design and construction	10	8	80	6	60
Total Score	100		**680**		**750**

- **Environmental enhancement factor.** This factor relates to a project goal. The owner wants the project to enhance the environment through less traffic congestion and pollution. In this case, the owner has met with designers who can help define sustainability goals that can be achieved through their independent designs if they are hired directly by the owner. The CMR delivery method will provide for a direct contract between the owner and the designer to ensure that the goals are achieved, so CMR = 10 (in this case). While the owner can develop DB performance criteria related to sustainability, the owner is not as confident that it can accurately articulate its goals in the performance criteria, and it believes that there is a risk that the goals will not be fully achieved, so DB = 6 (in this case).
- **Staffing requirements factor.** The staffing requirements factor relates to a pertinent issue examined in Tier 1. The owner does not have a large staff and wants to minimize staffing requirements during design and construction. The CMR option will allow the owner to supplement its staff during both design and construction, either with the designer or with the CMR. The owner is confident that qualified professionals exist to meet its staffing needs, but is slightly concerned about exactly how the working relationship between the CMR and the owner will be executed, so CMR = 8 (in this case). The DB option will require the owner to mass its resources (or build up for a short time) during the procurement and design review process. The owner believes that it can supplement its staff with a general engineering consultant, but the owner is not confident that the DB option will be as effective as the CMR option, so DB = 6 (in this case).

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 to 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 about a particular weight or score, the owner can conduct more research about a particular delivery method and revisit the scoring after gathering more information. If the owner is not confident about the scoring method, the owner may choose to use one of the more rigorous scoring methods presented in Appendix F, available on the TRB website at http://trb.org/news/blurb_detail.asp?id=10054.

If, at this point, a "most appropriate" delivery method has not emerged, the owner should document the results of the Tier 2 analysis (see Step 5) and move to the Tier 3 approach (see Chapter 6).

Step 5. Document Results

As in Tier 1, documentation of the delivery decision is a key part 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. Documentation 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 a detailed documentation of the reasoning on which criterion weights and project delivery scores are based.

Conclusion

The Tier 2—Weighted-Matrix Delivery Decision Approach extends the Tier 1 approach by providing an examination of how project delivery methods align with project goals and pertinent issues as these are consolidated into selection factors. The weighted ranking of project selection factors requires decision makers to define their priorities and more closely examine the attributes of the delivery methods remaining after the Tier 1 analysis. 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 in the Project Delivery Decision Report. If a dominant choice does not appear, the agency should document the results and move to the Tier 3 approach, which focuses on how delivery methods relate to project risks.

CHAPTER 6

Tier 3—Optimal Risk-Based Approach

Introduction

The Tier 3—Optimal Risk-based Approach leverages risk-based cost-estimating methods that have emerged in transit and highway agencies in the past few years (Touran, Bolster, and Thayer 1994; Parsons, Touran, and Golder 2004). Tier 1 and Tier 2 approaches should be completed before the Tier 3 approach is introduced. Most of the time, it will be possible to make the delivery method decision by completing Tiers 1 and 2. Even if a clear choice cannot be established after going through the first two tiers, at least the completion of the first two tiers will yield a short list of viable choices. It is expected that by the time decision-makers get to Tier 3, they are looking at only two delivery method candidates. It is important that there are only two delivery method candidates because the effort involved in using Tier 3 (especially the quantitative approach) is considerably larger than effort involved in either Tier 1 or Tier 2.

The Tier 3 approach consists of two phases. The first phase involves a qualitative analysis: developing a risk-allocation matrix that clearly portrays an owner's risk under competing delivery methods. Through review of these risks, the owner (in this context, mostly transit agencies) will have an opportunity to decide whether a specific delivery method is more appropriate than others. If the qualitative analysis does not provide a definitive answer to the delivery selection question, the second phase—a quantitative analysis—should be considered. The quantitative approach emphasizes the effect of the project delivery method on project cost and schedule. The two-phase process (depicted in Figure 6.1) should be repeated for each project delivery method that survives the Tier 2 process.

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 documents such as "PMO Operating Procedures No. 40, Risk Management Products and Procedures" (2007). A risk-based cost estimate generates a range of possible project costs rather than a single point estimate, as shown in Figure 6.2. 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 a sufficient contingency budget to keep the probability of cost overrun or schedule delay below a specified threshold.

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 research effort) was the apparent effect of a rigorous risk analysis on project success. It

88 A Guidebook for the Evaluation of Project Delivery Methods

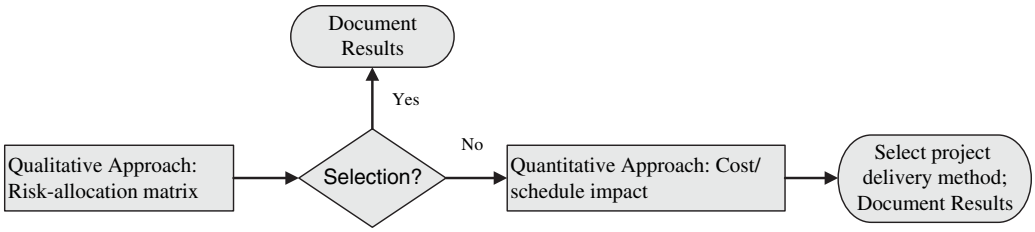


Figure 6.1. Overview of the risk-based qualitative and quantitative approaches.

was found that projects in which more attention was paid to risk analysis fared better than other projects in terms of meeting budget and schedule goals.

The following sections describe the qualitative and quantitative phases of the Tier 3 approach in more detail.

Qualitative Analysis

Figure 6.3 shows the risk-based approach superimposed on the project lifecycle. The most likely times to decide on the project delivery method are at the end of the Conceptual Design Phase or during the Preliminary Engineering Phase. If a project goes into the Final Design Phase without a decision on a project delivery method, 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 Phase, the agency usually has not done a detailed risk analysis. If an agency is unable to select a project delivery method upon completion of the Tier 1 and Tier 2 approaches, it would need to conduct a preliminary risk analysis in order to make an informed choice of project delivery method.

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. For example, a risk-allocation matrix was a first step in creating the contract for the T-REX multimodal DB project in Colorado. Table G-1 in Appendix G (available on the TRB website at http://trb.org/news/blurb_detail.asp?id=10054) presents a generic risk-allocation matrix that can be used for accomplishing the qualitative analysis. It should be noted that the matrix of Table G-1 will most likely consist of only two (and in rare cases maybe three) delivery methods because the completion of the Tier 1 and Tier 2 approaches should

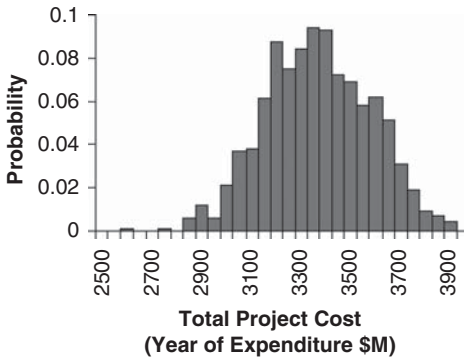


Figure 6.2. Distribution of project costs.

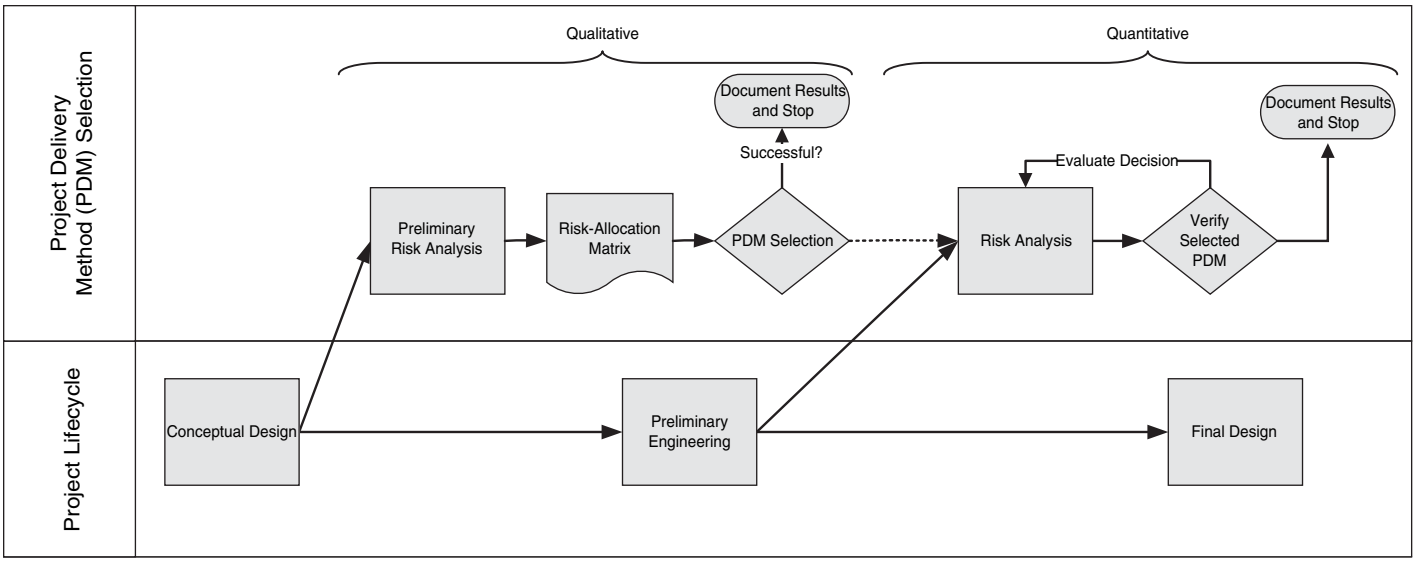


Figure 6.3. Risk-based approach superimposed on project lifecycle.

reduce the number of possible alternatives. Table 6.1 shows a risk-allocation matrix for a hypothetical project. A description of the development of this risk-allocation matrix is given below.

Risk factors (shown the first column in Table 6.1 and typically arranged in a matrix according to either their impact [rank] or chronology) are major events or conditions that can affect a project in a negative way (the events that can affect the project in a positive way are called "opportunities," and traditionally there are far fewer opportunities than risks). Only significant risks should be considered because identifying and measuring all project risks would be a major effort. Under each project delivery method listed in the matrix, a main responsible party should be identified for each risk factor. For example, in the matrix shown in Table 6.1, the party responsible for design defects in a DBB contract is the owner, whereas in the DB contract, the responsible party is the constructor.

Risk factors are rated, always from the perspective of the owner agency, according to the effect of a particular project delivery method on that risk factor. In the hypothetical case shown in Table 6.1, from the agency perspective, DBB is seen as having a favorable effect on the risk factor of "permits/approvals." The agency thinks that it is the best party to obtain permits/approvals and that it can most effectively do this using a DBB approach. Therefore, the risk factor of

Table 6.1. Risk-allocation matrix for a hypothetical project.

Risk Factor	DBB		DB	
	Responsible Party	Rating	Responsible Party	Rating
Permits/Approval	Owner	+	Constructor/Owner	–
Different Site Conditions	Owner	0	Constructor/Owner	+
Design Defects	Owner	–	Constructor	+
Quality Assurance/ Quality Control	Constructor/Owner	0	Constructor	+
Exchange Rate Risk	Owner	–	Owner	–
Other Risk Factors				

90 A Guidebook for the Evaluation of Project Delivery Methods

permits/approvals has received a rating of **+.** The same risk factor, under a DB delivery method, is seen as unfavorable from the agency's point of view because the agency thinks that the DB constructor is not the best party to obtain various permits and approvals (such as environmental permits). Therefore, a rating of **–** is assigned. Another risk factor in the hypothetical example, "design defects," has a rating of **–** 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, is rated **+** because it transfers this risk to the constructor.

If the choice of a project delivery method 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 the advantages and disadvantages of various project delivery methods in relation to 24 pertinent issues are documented.

No attempt is made at this stage of the Tier 3 analysis to quantify the impact of these risk factors (in terms of $ value or project delay). After the matrix is developed and the risk factors rated, the evaluation team can review the outcome and see if any project delivery method seems superior in terms of its capacity in dealing with these risk factors. For example, a review of the matrix in Table 6.1 may suggest that DB is the better choice for the owner agency because of the number of favorable ratings that it obtained.

Preparation of the risk-allocation matrix and rating the risk factors can be accomplished in a reasonable amount of time. If the outcome suggests a "most appropriate" project delivery method, then the decision is finalized and the results, along with justification, are documented. If, after going through the process, the choice is still not clear, then the Tier 3 process should continue on to the second phase—the quantitative analysis.

Quantitative Analysis

The quantitative approach should be attempted only if the qualitative approach does not result in a clear delivery method choice for a project. As shown in Figure 6.3, it is suggested that the Tier 3 quantitative analysis occur at the conclusion of the preliminary engineering phase, after the agency has conducted the FTA-mandated probabilistic risk analysis of project cost and schedule. The risk analysis is a major undertaking that requires hundreds of person-hours over the course of several weeks. Also, the outcome of the risk analysis can inform the project delivery method selection process (see Figure 6.4). 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 proj-

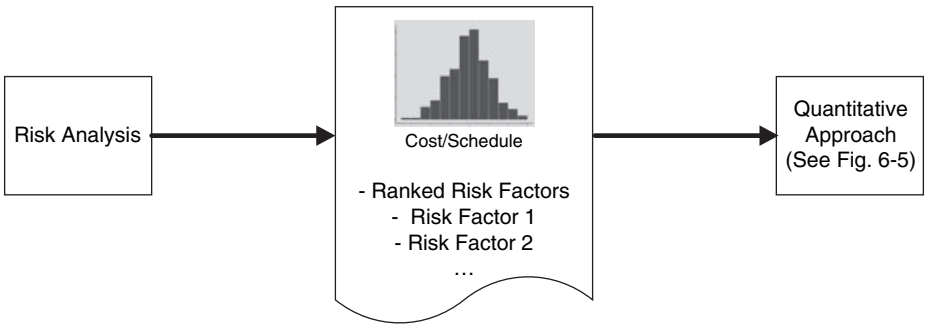


Figure 6.4. Risk analysis outcome as an input to project delivery method selection.

ect delivery method selection decision be made without this phase as the cost of this phase could be prohibitive.

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 (e.g., in several risk assessments conducted by the project management oversight (PMO) consultants on behalf of the FTA, the list of significant risk factors included 10 to 15 risk factors). The FTA analysis follows the logic of Pareto's law (also known as the 80-20 rule and 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 serve as inputs to the process of selecting the best project delivery method. 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 in 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, given a specific delivery method. The process starts by reviewing all the risk factors and selecting the risk factors whose value will be affected by the choice of project delivery method. 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 a given project delivery method. This estimation can best be accomplished by some of the same experts involved in the risk analysis. Figure 6.5 provides an example of a hypothetical project in which four major risk factors have been identified as the risk factors that are affected by the choice of project delivery method and the two remaining candidates for delivery method are DBB and DB. The risk factors are the following: *permits, utility relocation, differing site conditions (DSC),* and *third-party issues.* 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.[4] The sum of these risk costs will give the distribution for the total risk costs. There are statistical methods that can be used 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 project cost. A similar approach can be used to assess the effect of risks on project schedule. If the purpose of the risk analysis is to examine the effect of delivery method on project duration, all the distributions depicted in Figure 6.5 would have durations on the X-axis and the total effect will be the total impact on project schedule instead of on project cost.

The quantitative analysis is a powerful tool for comparing competing project delivery methods. It focuses on those differences between project delivery methods that affect cost and schedule and provides a consistent way of evaluating each project delivery method vis-à-vis major risk factors affecting the project. This analysis allows the decision-maker to document the reasons for the selection of a specific project delivery method. The drawback of this analysis is its dependency on the availability of expensive risk analysis results and the higher skill level required for pricing out each risk under various project delivery methods. However, the choice of the project delivery method 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 project delivery method is an effective risk mitigation instrument that can help keep project costs low and minimize project delays.

[4] 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.

92 A Guidebook for the Evaluation of Project Delivery Methods

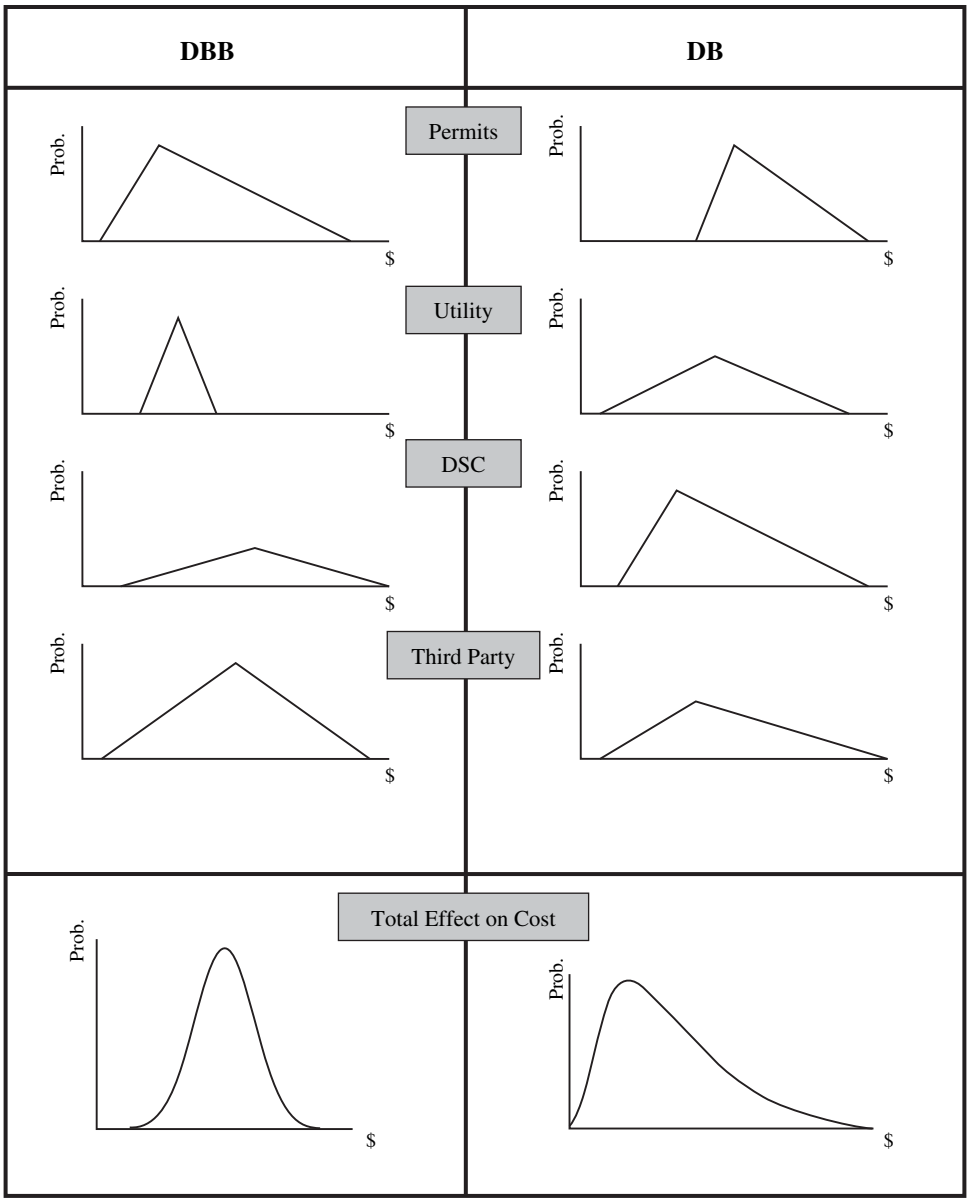


Figure 6.5. Overview of the quantitative analysis.

Conclusion

The Tier 3 approach may be needed in cases where the Tier 1 and Tier 2 approaches cannot provide a clear best choice for the project delivery method. In such a case, the Tier 3 provides a two-phased approach: first, a qualitative analysis and then, if necessary, a quantitative one. Both analyses are based on a risk-allocation exercise that will determine major risks to the agency under various project delivery methods. In the qualitative approach, the decision-makers carefully examine each risk factor and deliberate 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 the qualitative analysis does not yield a final choice of delivery method, the agency can then proceed with the quantitative analysis. In this analysis, the cost and schedule effect of each risk factor is estimated within 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 7

Summary

This guidebook was prepared with the objective of providing a systematic and logical approach for selecting the most appropriate delivery method for a transit project. Furthermore, this guidebook aims to help the user in documenting the process of decision-making in a Project Delivery Decision Report. It is recommended that transit agencies use industry professionals from outside the agency to facilitate the implementation of this methodology. These professionals should have a thorough understanding of and experience with the type of project the agency is evaluating, the various project delivery methods the agency is considering, and the potential risks associated with the type of project and various project delivery methods under consideration. The use of such professionals will ensure that the appropriate expertise and experience is incorporated into the process. Facilitation of the process by outside professionals will also foster an objective selection of the most appropriate project delivery method, and minimize the likelihood of a predetermined outcome.

The delivery methods considered in this guidebook are the traditional design-bid-build (DBB), CM-at-risk (CMR) or CM/GC, design-build (DB), and design-build-operate-maintain (DBOM). Until recently, the traditional DBB approach was transit agencies' most common choice of the project delivery method mainly because of legal limitations and because agencies had experience with this delivery method. Legal limitations on using other delivery methods have mostly been removed, and this has provided more flexibility in the choice of project delivery method.

Transit agencies have different motivations in selecting a delivery method other than DBB. The research team found that no single project delivery method was superior to all others and that transit agencies need to carefully analyze the characteristics of each project to find the project delivery method most suitable for meeting a project's requirements. The most common reasons for choosing an alternative project delivery method given by project directors interviewed for this research were the following:

1. Reducing/compressing/accelerating the project delivery period,
2. Encouraging innovation,
3. Establishing a budget and involving a contractor early in the process, and
4. Meeting flexibility needs during the construction phase.

Transit agencies should carefully study the risks, costs, and benefits associated with each project delivery method in relation to a particular project under consideration and select the project delivery method that best suits the legal, technical, and business environment in which the project must be built. This guidebook strives to facilitate this process by providing a three-tiered delivery selection system that covers all these factors. In this system, the user works through the three tiers sequentially and narrows down the viable delivery methods through a process of eliminating the inferior choices.

In the Tier 1 approach, users evaluate the viability of each delivery method against 24 pertinent issues that can be of vital importance to a project's success in achieving its goals and objectives. Among the 24 pertinent issues that affect the project delivery decision, there are 4 issues that may render one or more delivery methods inappropriate. These four issues are project schedule constraints; federal, state, and local laws; third-party agreements; and labor union agreements. The transit agency needs to review project delivery methods in relation to these four issues to determine whether any of the delivery methods should be eliminated. In other words, the agency should make a go/no-go decision on each delivery method based on how these four pertinent issues are affected by the delivery method.

Following the go/no-go decision, the user examines the remaining project delivery choices against the larger list of pertinent issues and rates each delivery method based on its advantages and disadvantages in relation to each pertinent issue. The summary of these ratings is compiled in a table and analyzed to determine whether a decision on a delivery method can be made based on the ratings. If a clear choice emerges at this point, a Project Delivery Decision Report can be generated that describes the reasons for the choice of delivery method.

If more than one delivery method remains viable after completing the Tier 1 approach, the user should move on to the Tier 2 approach. In Tier 2, a select subset of goals and pertinent issues are identified as "selection factors" that are of profound importance to the transit agency. Each selection factor is weighted according to instructions provided in this guide (see Chapter 5), and an overall score is computed for each delivery method. Again, a report documenting the decision-making process can be generated.

If more than one delivery method remains viable after completion of the Tier 1 and Tier 2 approaches, the user moves on to the Tier 3 approach. In Tier 3, the user reviews and identifies project risks and prepares a risk-allocation matrix that provides a clear comparison among the remaining delivery methods in terms of risks that are inherent to them. This matrix should help the user 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 costs of the risks associated with each delivery method. However, the quantitative approach requires significant effort and depends on the willingness of the owner agency to embark on this analysis and the availability of a risk assessment report for input into this process.

This guidebook was tested by several transit project directors. The users found the process easy to follow and informative, and their overall assessment was very positive. Their comments and feedback were carefully reviewed and incorporated in the current guidebook. The guidebook in its current form is a valuable tool for transit agencies, especially those with limited experience with alternative project delivery methods.

APPENDIX A

References

The papers, books, reports, and websites referred to in the guidebook and its appendices are listed here. An annotated bibliography is also developed in this research which can be found in *TCRP Web-Only Document 41,* available at http://trb.org/news/blurb_detail.asp?id=9886.

(2000). "CM/GC White Paper, Public Contracting Coalition." OR.

(2002). "Design-Build White Paper, Public Contracting Coalition." OR.

3D/International, Inc. (2005). *CM at Risk.* Available at http://www.3di.com/toolbox/cmatrisk.pdf (accessed April 1, 2005).

AIA Minnesota (2006). "Understanding Project Delivery for the Design and Construction of Public Buildings." AIA Minnesota, Minneapolis, MN.

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,* Vol. 94 (616), 47–48.

American Institute of Architects (AIA) (2005). *Construction Manager at-Risk State Statute Compendium.* AIA Government Affairs, American Institute of Architects, Washington, DC, 125–129.

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

Associated General Contractors (2004). *Project Delivery Systems for Construction.* Associated General Contractors of America, Arlington, VA.

Beard, J., Loulakis, M., and Wundram, E. (2001). *Design-Build: Planning Through Development.* RR Donnelley, Chicago, IL.

Bearup, W., Kenig, M., and O'Donnell, J. (2007). "Alternative Delivery Methods, A Primer." *Proceedings,* ACI-NA Project Delivery Summit II, Airport Board Members and Commissioners Annual Conference. Airports Council International-North America, Chicago, IL.

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, 699–718.

Chang, K. (2004). "Multiattribute Weighting Models for Best-Value Selection in Public Sector Design-Build Projects." Ph.D. dissertation, University of Colorado.

Construction Industry Institute (CII) (1997). "Project Delivery Systems: CM at Risk, Design-Build, Design-Bid-Build." *Research Summary RS 133-1,* CII, Austin, TX.

Construction Industry Institute (CII) (2003). "Owner's Tool for Project Delivery and Contract Strategy Selection." *Research Summary RS 165-1,* CII, Austin, TX.

Debella, D. C., and Ries, R. (2006). "Construction Delivery Systems: A Comparative Analysis of Their Performance within School Districts." *Journal of Construction Engineering and Management,* Vol. 132, No. 11, 1131–1138.

El Wardani, M., Messner, J., Horman, M. (2006). "Comparing Procurement Methods for Design-Build Projects." *Journal of Construction Engineering and Management,* Vol. 132, No. 3, 230–238.

FTA (2003). *Third Party Contracting Requirements—Circular 4220.1E.* FTA, U.S. DOT, Washington, D.C.

FTA (2006). *Annual Report on New Starts: Proposed Allocation of Funds for Fiscal Year 2007—Report of the Secretary of Transportation to the United States Congress Pursuant to 49 U.S.C. 5309(k)(1).* FTA, U.S. DOT, Washington, DC.

FTA (2007). "PMO Operating Procedures No. 40, Risk Management Products and Procedures" (internal document). FTA, U.S. DOT.

Garvin, M. (2003). "Role of Project Delivery Systems in Infrastructure Improvement," in *Winds of Change: Integration and Innovation in Construction—Proceedings of Construction Research Congress, March 19–21, 2003, Honolulu, HI.* Eds. Keith R. Molenaar and Paul S. Chinowsky (CD-ROM). ASCE, Reston, VA.

Ghavamifar, K., and Touran, A. (2008). "Alternative Project Delivery Systems: Applications and Legal Limits in Transportation Projects." *Journal of Professional Issues in Engineering Education and Practice,* Vol. 134, No. 1, 106–111.

Gordon, C. M. (1994). "Choosing Appropriate Construction Contracting Method," *Journal of Construction Engineering and Management,* Vol. 120, No. 1, 196–210.

Gordon & Rees LLP (2005). "The Basics of Design Build," *Construction Group Newsletter,* Gordon & Rees LLP, San Francisco, CA.

Graham, P. (2001). "Evaluation of Design-Build Practice in Colorado IR IM(CX) 025-3(113)." Colorado Department of Transportation, Denver, CO.

Gransberg, D. D., and Barton, R. F. (2007a). "Analysis of Federal Design-Build Request for Proposal Evaluation Criteria," *Journal of Management in Engineering,* ASCE, Vol. 23 (2), April 2007, pp. 105–111.

Gransberg, D. D., Badillo-Kwiatkowski, G. M., and Molenaar, K. R. (2003). "Project Delivery Comparison Using Performance Metrics." Presentation at 2003 Transactions, AACE International, Orlando, FL, pp. DRM 02.01–02.06.

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).

Gransberg, D. D. and Molenaar, K. R. (2007b). *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.

Halpin, D. W. (2006). *Construction Management,* 3rd ed. John Wiley and Sons, Inc., New York, New York.

Harrington-Hughes, K. (2002). *TCRP Research Results Digest 53: International Transit Studies Program Report on the Spring 2001 Mission—Design-Build Transit Infrastructure Projects in Asia and Australia.* Transportation Research Board of the National Academies, Washington, DC.

Ibbs, C. W., Kwak, Y., Odabasi, A. (2003). "Project Delivery System and Project Change: A Quantitative Analysis." *Journal of Construction Engineering and Management,* Vol. 129, No. 4, 382–387.

Irwin, D. (2003). "Developing the Design and Construction Contracting Plan for a Major Light Rail Extension Project." *Transportation Research Circular E-C058: The 9th Annual National Light Rail Conference—Experience, Economics, and Evolution—From Starter Lines to Growing Systems.* Transportation Research Board of the National Academies, Washington, D.C., 557–575. http://onlinepubs.trb.org/Onlinepubs/circulars/ec058/ec058.pdf.

Kessler, F. (2005). "Managing Your Money: Project Delivery Methods." *MassTransit,* April 2005, 26–39. http://www.nossaman.com/showarticle.aspx?show=913 (accessed March 20, 2007).

Kumaraswamy, M. M., and Dissanayaka, S. M. (1998). "Linking Procurement Systems to Project Priorities," *Building Research and Information,* Vol. 26, No. 4, 223–238.

Konchar, M., and V. Sanvido (1998). "Comparison of U.S. Project Delivery Systems." *Journal of Construction Engineering and Management,* Vol. 124, No. 6, 435–444.

Loulakis, M. (2000). *Project Delivery Systems: Evaluating Owner's Alternatives.* A/E/C Training Technologies, Reston, VA.

Loulakis, M. (2005). *Construction Project Delivery Systems: Evaluating the Owner's Alternatives.* (CD-ROM). A/E/C Training Technologies, Reston, VA.

Mahdi, I. M., and Al-Reshaid, K. (2005). "Decision Support System for Selecting the Proper Project Delivery Method Using Analytical Hierarchy Process." *International Journal of Project Management,* 23, 564–572.

Minchin, E., Thakkar, K., Ellis, R. (2007). "Miami Intermodal Center—Introducing 'CM-At-Risk' to Transportation Construction." In Molenaar, K. R., and Yakowenko, G., Eds., *Alternative Project Delivery, Procurement, and Contracting Methods for Highways,* 46–59. ASCE Press, Reston, VA.

Mitchell, B. P. (1999). "The Applicability of the Spearin Doctrine: Do Owners Warrant Plans and Specifications?" *FindLaw for Legal Professionals.* http://library.findlaw.com/1999/Aug/1/128038.html (accessed March 24, 2007).

Molenaar, K. R. (2005). "Programmatic Cost Risk Analysis for Highway Megaprojects." *Journal of Construction Engineering and Management,* Vol. 131, No. 3, 343–353.

Molenaar, K. R., and Scott, S. (2003). "Examining the Performance of Design-Build in the Public Sector." In Loulakis, M., Ed., *Design-Build for the Public Sector,* 71–112. Aspen Business and Law, Aspen Publishers, New York, NY.

Molenaar, K. R., Gransberg, D. D., Scott, S., Downs, D., and Ellis, R. (2005). "Recommended AASHTO Design-Build Procurement Guide." Final Report for NCHRP Project 20-7(172). Transportation Research Board of the National Academies, Washington, DC.

North Carolina State Construction Office (2005). "Construction Management-At-Risk Selection Procedures." http://interscope2.doa.state.nc.us/Guidelines/CM@RISK%20SELECTION%20PROCEDURES.pdf (accessed January 31, 2005).

Oyetunji, A. A, Anderson, S. D., (2006). "Relative Effectiveness of Project Delivery and Contract Strategies." *Journal of Construction Engineering and Management,* Vol. 132, No. 1, 3–13.

Parsons, Inc., Touran, A., and Golder Associates. (2004). "Risk Analysis Methodologies and Procedures." Prepared for the FTA.

Riley, D. R., Diller, B. E., Kerr, D. (2005). "Effects of Delivery Systems on Change Order Size and Frequency in Mechanical Construction." *Journal of Construction Engineering and Management,* Vol. 131, No. 9, 953–962.

Saaty, T. L. (1990). *Multicriteria Decision Making: The Analytical Hierarchy Process.* RWS Publications, Pittsburgh, PA.

Science Applications International Corporation (SAIC), AECOM Consult, and the University of Colorado at Boulder (2006). Design-Build Effectiveness Study—As Required by TEA-21 Section 1307(f). FHWA, U.S. DOT, Washington, DC. www.fhwa.dot.gov/reports/designbuild/designbuild0.htm (accessed August 30, 2006).

Scott, S. Molenaar, K. R., Gransberg, D. D., Smith, N. C. (2006). *NCHRP Report 561: Best Value Procurement Methods for Highway Construction Projects.* Transportation Research Board of the National Academies, Washington, DC.

Skitmore, R. M., and Marsden, D. E. (1988). "Which Procurement System? Towards a Universal Procurement Selection Technique." *Construction Management and Economics,* 6, 71–89.

Smith, N. and Davis, B. J. (2006). "50-State Survey of Transportation Agency Design-Build Authority." Nossaman, Guthner, Knox & Elliot LLP. www.nossaman.com/showArticle.aspx?show=925 (accessed December 12, 2006).

Temesi, J. (2006). "Consistency of Decision Maker in Pairwise Comparisons." *International Journal of Management and Decision Making,* Vol. 7, No. 2/3, 267–274.

Touran, A., Bolster, P. J., and Thayer, S. W. (1994). *Risk Assessment in Fixed Guideway Construction.* DOT-T-95-01, FTA, U.S. DOT, Washington, D.C.

Walewski, J. Gibson, Jr., G. E., Jasper, J. (2001). *Project Delivery Methods and Contracting Approaches Available for Implementation by the Texas Department of Transportation.* FHWA/TX-0-2129-1. Texas Department of Transportation, Austin, TX.

Weber, M., and Borcherding, K. (1993). "Behavioral Influences on Weight Judgments in Multi-attribute Decision Making," *European Journal of Operational Research,* Vol. 67, 1–12.

Wiss, R. A., Roberts, R. T., Phraner, S. D. (2000). "Beyond Design-Build-Operate-Maintain: New Partnership Approach Toward Fixed Guideway Transit Projects." In *Transportation Research Record: Journal of the Transportation Research Board, No. 1704,* Transportation Research Board, National Research Council, Washington, DC, 13–18.

Woodman, G. K., Starke, J. S., and Schwartz, L. D. (1995). *TCRP Legal Research Digest 4: Transit Labor Protection-A Guide to Section 13(c) Federal Transit Act.* Transportation Research Board, National Research Council, Washington, DC.

APPENDIX B

Definitions

Agency CM: Agency CM is a professional service where the CM acts as the owner's agent in managing the construction project. Its role is consultative and the CM is usually not at risk for the cost and schedule of building the project.

Analytical Delivery Decision Approach: It is a method of project delivery selection that examines the advantages and disadvantages of various project delivery methods to arrive at an appropriate method for an individual project. In this guidebook, this method is Tier 1 of the proposed Project Delivery Selection System.

Best-value Procurement System: A procurement process where price and other key factors are considered in the evaluation and selection process to minimize impacts and enhance the long-term performance and value of construction.

Construction Manager-at-Risk (CMR) or CM/GC: In this guidebook, CMR and CM/GC are equivalent terms. The owner holds two separate contracts with the construction manager (sometimes referred to as *General Contractor*) and the designer of the project. The CMR is chosen based on criteria other than just the lowest construction cost, such as qualifications and past performance. In this delivery method, the CMR is held to a *guaranteed maximum price* (GMP). The CMR typically provides constructability, cost, schedule, and value engineering input during the project design phase.

Constructor: The constructor is the entity that contracts with the project owner to execute the construction phase of the project. In the Design-Build approach, the constructor is also responsible for the final design.

Design-Bid-Build (DBB): This is the traditional method of delivering a project in which design and construction are contracted with two separate entities.

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.

Design-Build-Operate-Maintain (DBOM): In this delivery method the owner contracts out the design and construction as well as the operation and maintenance of the project to a single entity.

Decision Factor: A variable in the Weighted Decision Matrix (Tier 2 of the proposed Project Delivery Selection System) that is derived from the project goals and pertinent issues to aid in the project delivery method decision is referred to as a *decision factor.*

Go/No-Go Decision Points: A pertinent issue or decision point that excludes a project delivery method from further consideration is called a Go/No-Go Decision Point.

Guaranteed Maximum Price (GMP): A price mechanism in which the owner is committed to reimburse the project costs up to a predetermined ceiling. Any cost overrun above that ceiling is a risk that the constructor takes.

Pertinent Issues: The term *pertinent issue* refers to 24 pertinent issues identified and explained in this guidebook that influence the selection of the project delivery method.

Probabilistic Risk Analysis: This is a systematic approach for evaluating the severity and likelihood of project risks. The results of Probabilistic Risk Analysis are expressed in terms of probability distributions and ranges for project cost or project duration.

Project Delivery Decision Report: This is an archival report that communicates and justifies an individual project delivery decision to interested stakeholders.

Project Delivery Method: The project delivery method (or project delivery system) is the process by which a construction project is comprehensively designed and constructed for an owner. It refers to all the contractual relations, roles, and responsibilities of the entities involved in a project.

Project Delivery Selection System: This is the decision support system developed in this guidebook consisting of three tiers (analytical, weighted-matrix and risk-based) to help transit agencies select the most suitable delivery method for their projects.

Project Goals: Project goals are statements of technical or performance objectives that communicate the importance of project issues such as time, cost, quality, maintainability, and sustainability.

Project Lifecycle: Project lifecycle is the duration of a project, starting at project germination and including project conceptual, preliminary, and detailed design as well as the procurement and construction phases. It ends by the end of project operation and maintenance phase.

Project Stakeholder: Any individual or entity that has an interest in a project that may be directly involved in the project (e.g., the designer or contractor) or be affected by the project completion (e.g., communities or business owners adjacent to transit corridor) is a *project stakeholder.*

Qualitative Risk Approach: In this guidebook, a qualitative risk analysis approach is an approach where major project risks are identified and allocated to the parties best able to bear them. Risk identification and a risk-allocation matrix are the outcomes of this approach.

Quantitative Risk Approach: A risk analysis approach in which the project risks are quantified in terms of ranges and probability of occurrence is called quantitative risk approach. This approach usually applies various probabilistic models to arrive at a probability distribution for the parameter under study (e.g., project cost).

Risk-allocation Matrix: It is a tool used by risk analysts to assign major project risks to various entities based on the contractual mechanisms that determine project risk distribution.

Risk Allocation: Assigning a risk to a party in a design or construction contract.

Risk Factors: Risk factors are events that may have an adverse impact on project cost and schedule. Examples of risk factors may be the risk involved in utility relocation, latent underground conditions, inflation, etc.

Risk Management: All of the steps associated with managing risks, including risk identification, risk assessment, risk allocation and mitigation, risk monitoring and control.

Weighted Decision Matrix: This is a decision process that organizes Decision Factors in the rows of a matrix, and project delivery methods in the columns to structure a project delivery method decision. The Decision Factors are weighted by their importance to the project goals and scored by their alignment with each project delivery method. The weighted decision factors are summed up for each project delivery method for making the final decision.

APPENDICES C THROUGH H

Appendices C through H of this guidebook are available on the TRB website at http://trb.org/news/blurb_detail.asp?id=10054. Titles of Appendices C through H are the following:

Appendix C: Forms for Project Description and Goals
Appendix D: Forms for the Analytical Delivery Decision Approach (Tier 1)
Appendix E: Forms for the Weighted-Matrix Delivery Decision Approach (Tier 2)
Appendix F: Procedures for Determining the Weights of Selection Factors in the Weighted-Matrix Delivery Decision Approach (Tier 2)
Appendix G: Form for the Optimal Risk-Based Approach (Tier 3)
Appendix H: Application of the Tier 1 and Tier 2 Approaches to a Hypothetical Project

Abbreviations and acronyms used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation