NCHRP SYNTHESIS 402

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Construction Manager-at-Risk Project Delivery for Highway Programs

A Synthesis of Highway Practice

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP SYNTHESIS 402

Construction Manager-at-Risk Project Delivery for Highway Programs

A Synthesis of Highway Practice

CONSULTANTS

DOUGLAS D. GRANSBERG
University of Oklahoma
and
JENNIFER S. SHANE
Iowa State University

SUBJECT AREAS
Planning and Administration, and Materials and Construction

Research Sponsored by the American Association of State Highway and Transportation Officials
in Cooperation with the Federal Highway Administration

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.
2010
www.TRB.org

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Academies was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to the National Research Council is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the National Research Council and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the National Research Council and the Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

NCHRP SYNTHESIS 402

Project 20-5 (Topic 40-02)
ISSN 0547-5570
ISBN 978-0-309-14301-1
Library of Congress Control No. 2009938319

NOTICE

The project that is the subject of this report was a part of the National Cooperative Highway 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 program concerned is of national importance and appropriate with respect to both the purposes and resources of the National Research Council.

The members of the technical committee 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 committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the American Association of State Highway and Transportation Officials, or the Federal Highway Administration, U.S. Department of Transportation.

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

Published reports of the

NATIONAL COOPERATIVE HIGHWAY 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

FOREWORD

Highway administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to highway administrators and engineers. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire highway community, the American Association of State Highway and Transportation Officials—through the mechanism of the National Cooperative Highway Research Program—authorized the Transportation Research Board to undertake a continuing study. This study, NCHRP Project 20-5, "Synthesis of Information Related to Highway Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an NCHRP report series, *Synthesis of Highway Practice*.

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

By Gail Staba
Senior Program Officer
Transportation Research Board

Construction Manager-at-Risk (CMR) project delivery (also called Construction Manager/General Contractor or CM/GC) is an integrated team approach to the planning, design, and construction of a highway project, to control schedule and budget, and to ensure quality for the project owner. The team consists of the owner; the designer, who might be an in-house engineer; and the at-risk construction manager. The aim of this project delivery method is to engage at-risk construction expertise early in the design process to enhance constructability, manage risk, and facilitate concurrent execution of design and construction without the owner relinquishing control over the details of design as it would in a design-build project.

CMR project delivery has long been used in the building industry, but the use of CMR for federal-aid transportation projects requires SEP-14 approval. As a result, its use is relatively new in highway projects. A number of state and local transportation agencies have undertaken or experimented with CMR project delivery on road, bridge, and other projects.

The objective of this synthesis is to identify and synthesize current methods in which state departments of transportation (DOTs) and other public engineering agencies are applying CMR project delivery to their construction projects. The intended audience is transportation agencies that wish to explore CMR or alternative contracting methods.

The synthesis identifies three different models for CMR project delivery in use and effective practices and lessons learned that have been gleaned from the experiences of seven highway case studies (Alaska, Florida, Michigan, Oregon, and Utah DOTs, plus Pinal County and the city of Glendale, both in Arizona) and case studies from the airport, rail transit, and building industries; the Memphis Airport in Tennessee; the Utah Transit Agency; and Texas Tech University. Survey responses were received from 47 state DOTs regarding CMR experience. A formal content analysis of CMR solicitation documents from 25 transportation projects and 29 non-transportation projects from 17 states was also conducted. Finally, structured interviews were conducted with both agency and contractor personnel from the case study projects.

Douglas D. Gransberg, University of Oklahoma, and Jennifer S. Shane, Iowa State University, collected and synthesized the information and wrote the report. The members of the topic panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

CONSTRUCTION MANAGER-AT-RISK PROJECT DELIVERY FOR HIGHWAY PROGRAMS

SUMMARY

Construction Manager-at-Risk (CMR) project delivery (also called Construction Manager/General Contractor or CM/GC) is an integrated team approach to the planning, design, and construction of a highway project, to control schedule and budget, and to ensure quality for the project owner. The team consists of the owner; the designer, who might be an in-house engineer, and the at-risk construction manager. A CMR contract has two parts: (1) pre-construction services and (2) construction. The CMR and the designer commit to a high degree of collaboration. This is especially vital when the agency is using CMR to implement new construction technologies. Additionally, the CMR furnishes a means to negotiate the allocation of risk between the owner and the contractor through its pricing mechanism. A guaranteed maximum price (GMP) is established at a point where the design is sufficiently advanced and the contractor can furnish a price with a minimal contingency for possible increases in scope. The aim of this project delivery method is to engage at-risk construction expertise early in the design process to enhance constructability, manage risk, and facilitate concurrent execution of design and construction without the owner giving up control over the details of design as it would in a design-build project.

CMR project delivery has long been used in the building industry to deliver projects that require early contractor involvement to optimize cost, schedule, and quality. It is particularly well-suited for projects that have a revenue stream that starts when construction is complete, as exists in the retail building and health care sectors. Additionally, the education sector uses CMR to facilitate the expansion of school buildings in a manner that minimizes disruption to the students. Its major advantage is reported to be the ability to select both the designer and the contractor on a basis of qualifications and preserve competitive bidding at the trade subcontractor level. Another is the sense of design ownership that is developed by the constructor when it is allowed to make substantive input to the final design. Finally, the review shows that CMR is selected for building projects in which the owner wants to ensure a high level of sustainable design and construction.

The use of CMR for federal aid transportation projects requires Special Experimental Projects Number 14 approval. As a result, its use is relatively new in highway projects. A number of state and local transportation agencies have undertaken or experimented with CMR project delivery on road, bridge, and other projects. These include the Alaska, Arizona, Florida, Oregon, and Utah Departments of Transportation (DOTs). Utah is the most experienced having completed 13 CMR projects, with another 16 in progress. Florida also has multiple CMR project experience, but tends to reserve this project delivery method for projects that have a strong vertical construction component. Additionally, Maricopa, Pima, Pinal and other Arizona counties, as well as the Arizona cities of Flagstaff, Glendale, Phoenix, and Tempe have implemented CMR project delivery on major transportation projects. Phoenix has completed more than 200 CMR projects in both the transportation and building sectors. The Michigan and Rhode Island DOTs have overseen CMR projects for local airport and seaport authorities.

The objective of this synthesis is to identify and synthesize current methods in which state DOTs and other public engineering agencies are applying CMR project delivery to their

construction projects. The synthesis identifies three different models for CMR project delivery in use and effective practices and lessons learned that have been gleaned from the experiences of seven highway case studies (Alaska, Florida, Michigan, Oregon, and Utah DOTs, plus Pinal County and the city of Glendale, both in Arizona) and case studies from the airport, rail transit, and building industries; Memphis Airport in Tennessee; Utah Transit Agency; and Texas Tech University. The synthesis received survey responses from 47 state DOTs regarding CMR experience. It also conducted a formal content analysis of CMR solicitation documents from 25 transportation projects and 29 non-transportation projects from 17 states. Finally, structured interviews were conducted with both agency and contractor personnel from the case study projects.

The synthesis also addresses project characteristics and requirements that make a project a good candidate for CMR project delivery. The details of the selection process and preconstruction services are covered. Procurement policies and procedures found in the study including those used in the quality assurance process are also discussed. Finally, various options for establishing a GMP, a feature unique to CMR, are covered in detail.

The synthesis conclusions covered the gamut of CMR project delivery issues from making the project delivery method decision to its impact on final project quality. The detailed conclusions along with a list of effective practices and lessons learned are contained in chapter nine. The major conclusions are summarized as follows:

1. CMR project delivery's major benefit to the agency is derived from contractor input to the preconstruction design process. The cost of preconstruction is a reasonable investment that accrues tangible returns. The average fee for preconstruction services on highway projects was found to be 0.80% of estimated construction costs.
2. It is reported that modifications in agency's standard design contract are to specifically require the designer to coordinate its efforts with the CMR to accrue the benefits possible in preconstruction.
3. Allowing contractor input to design in CMR project delivery appears to have no impact on design quality. If the design and preconstruction services contracts are properly coordinated it may improve it by adding a layer of design quality control.
4. CMR services furnished during the preconstruction phase reduce design costs by diminishing the amount of design detail that is required and by focusing the early design effort on constructable solutions. In other words, the CMR can tell the designer when it has sufficient design detail to properly construct a given feature of work. The Utah DOT has experienced a 40% savings on its design contracts, whereas the U.S. Army Corps of Engineers reported a savings of 2% of on its design costs for medical facilities. Achieving these savings requires a high level of collaboration and strong spirit of partnering.
5. Selecting the CMR at a point in time where it can influence fundamental design decisions before they are made not only saves design costs but also maximizes the opportunity for the CMR to add value to the project. This can be before the selection of the designer. If an agency wants to evaluate cost and fees as part of the selection process, the CMR selection point is best if sufficient design has been completed to permit reasonable numbers to be generated for the scope of preconstruction services and/or the magnitude of quantities of work to be priced in the proposal.
6. Protests of CMR selection decisions are rare. Three protests were identified in the review and all were unsuccessful.
7. The use of progressive rather than lump sum GMPs appears to add value to the CMR project by reducing the total amount of contingency carried in the GMP and by allowing an orderly method to price early work packages and/or construction phases. It also provides a series of points where the agency can negotiate the allocation of cost and schedule risks with the CMR.

8. Allowing the CMR to procure early work packages (typically materials to be installed by subcontractors) is reported to mitigate cost risk by locking in the cost of the materials and services associated with those packages.
9. Limiting the CMR's ability to self-perform and constraining its freedom to prequalify and select its subcontractors does not ensure "competitive pricing" and actually diminishes the CMR's ability to use its professional contacts during preconstruction. Eight of ten case study projects allowed the CMR to self-perform and select subcontractors without constraint.
10. The qualifications of the CMR's personnel and its past project experience are the aspects that have the greatest perceived impact on project quality.
11. Incorporating a shared savings clause does not appear to create a significant incentive to the CMR and may actually add a layer of administration/accounting whose cost is not recovered by its actual benefit. Savings associated with actual costs being less than the GMP were less than 1% in the projects reviewed with shared savings clauses.
12. CMR project delivery is a less radical shift in procurement culture than design-build because the owner retains control of the design by holding the design contract. The case studies reported that design consultants prefer this arrangement because they receive the benefits of early contractor involvement without the pressure to design to the proposed design-build lump sum bid price. This project delivery method may furnish an attractive option to agencies that do not want to use design-build.

CHAPTER ONE

INTRODUCTION

BACKGROUND

The Construction Manager-at-Risk (CMR) (also termed Construction Manager/General Contractor or CM/GC in several states' enabling legislation) project delivery method is an integrated team approach to the planning, design, and construction of a project; to control schedule and budget; and to ensure quality for the project owner. The team consists of the owner; the designer, who could be an in-house engineer; and the at-risk construction manager. A CMR contract includes preconstruction and construction services. The CMR is usually selected early in the design process and collaborates with the owner and designer during all phases of the project, including but not limited to planning, design, third-party coordination, constructability reviews, cost engineering reviews, value engineering, material selection, and contract package development. The CMR and the designer commit to a high degree of collaboration. This is especially vital when the agency is using CMR to implement new construction technologies. A guaranteed maximum price (GMP) is established when the design of a specific feature of work is nearly complete (progressive GMP) or when the entire design is at a point where the CMR can reduce the magnitude of necessary contingencies. The CMR warrants to the owner that the project will be built at a price not to exceed the GMP. The CMR thus assumes the risk of meeting the GMP. After design is complete, the CMR acts as the general contractor during the project construction phase. Strang (2002) describes the relationship change like this: "The construction manager is an agent of the Owner in managing the design process, but takes the role of a vendor when a total cost guarantee is given."

A number of state and local transportation agencies have undertaken or experimented with CMR project delivery, including the Alaska, Arizona, Florida, Oregon, and Utah departments of transportation (DOTs). Additionally, Maricopa, Pima, Pinal, and other Arizona counties as well as the Arizona cities of Flagstaff, Glendale, Phoenix, and Tempe have implemented CMR project delivery on major transportation projects. The Michigan and Rhode Island DOTs have overseen CMR projects for local airport and seaport authorities. The California DOT is looking at CMR as a potential project delivery method and has completed a study of the method (Trauner Consulting Services 2007). CMR is widely used in the airport, transit, and water/wastewater industries, as well as in the building construction industry where it first evolved. Several transit megaprojects in Utah and Oregon have been successfully delivered using CMR (Touran et al. 2009b). Large and small airport projects in Colorado, Florida, Georgia, Massachusetts, Ohio, Tennessee, and Texas have also been delivered using CMR (Touran et al. 2009a).

In a 2008 presentation to the Western Association of State Highway and Transportation Officials by Jane Lee of the Oregon DOT (ODOT), she expresses the essential motivation for this synthesis by listing Oregon's six reasons for using CMR project delivery:

1. Collaboration and cost control;
2. Concurrent execution of design and construction;
3. Well-suited for complex projects, tight time frames;
4. Owner, A/E [architect/engineer], CM/GC [CMR] have mutual project goals;
5. Risk management: Team identifies—Owner controls; and
6. Collaborative process minimizes risk of construction and design disputes (Lee 2008).

Lee uses the words "collaboration" and "control" twice in her description. The Utah DOT (UDOT) confirms Lee's focus on collaboration and control and adds "to introduce innovation and new technologies" as another reason for using CMR (Alder 2007). Previous research has found that owners in the transit and airport sectors choose CMR project delivery for the same three reasons (Touran et al. 2009a,b). The aspect of owner "control" usually extends to the three salient aspects of project delivery: control over the details of design (i.e., quality), cost control, and schedule control (Scott et al. 2006). One early study of alternative project delivery methods found that owners' main goals for using design-build (DB) project delivery were compressing the schedule and controlling cost (Songer and Molenaar 1996). However, another study found that DOTs were often reluctant to use DB project delivery because they lost control over the details of design (Scott et al. 2006). Taking the essentials from these four studies and combining them with Lee's reasons for using CMR project delivery leads to the inference that CMR may furnish a project delivery method that satisfies owners' need for control over cost and schedule without losing control over the design. Additionally, the collaborative nature of CMR may provide added value through the fundamental structure of the contractual relationships. One report stated that this value is usually in the form of risk reduction to the owner:

> The collaborative approach of CM/GC also reduces risks to the owner. The CM/GC firm becomes an ally of the owner through independent evaluation of project costs, schedule, and overall

> construction performance, including similar evaluation of changes. Additionally, the structure of the CM/GC process offers a system of checks and balances to assure that owner's decisions and the decisions of the A/E are prudent (Gambatese et al. 2002).

Introducing new technologies is a means to leverage the collaborative atmosphere by bringing the owner, designer, and builder together to create the means and methods necessary to implement something new in the given market. It also allows the agency to ensure that the designer and builder are qualified and perhaps experienced with the new technology by selecting both on a basis of qualifications. Finally, the GMP process furnishes an opportunity for the agency to negotiate the allocation of specific risks before the contractor is required to commit to a price. Thus, this project delivery method becomes an option for those DOTs that may be reluctant or not legislatively authorized to implement DB (Strang 2002). This aspect is succinctly summarized by the following quotation from the transit sector:

> CM at-risk (or CM/GC) is assessed as more desirable than design-build on an urban light rail project because the engineer [designer] and construction contractor are carried under separate contracts. One can think of it as the engineer acting as the design agent for the owner and the CM at-risk as the owner's construction agent, which means *the owner still has a great deal of bargaining power when problems are encountered because it has not given away complete control, basically because the owner still controls the engineering* (Venturato and Schroeder 2007; italics added).

The previous discussion demonstrates the need for this synthesis and the potential benefits of CMR project delivery to public transportation agencies. Hence, the report will explore these and other aspects of this project delivery method.

SYNTHESIS OBJECTIVE

This synthesis was conceived from the need to review the nation's experience in CMR project delivery in transportation. Therefore, the objective of this synthesis is to capture the various ways in which state DOTs and other public engineering agencies are applying CMR project delivery to their highway construction projects. The synthesis will identify different approaches, models, and effective practices recognizing the differences in each of the different case study delivery methods. The synthesis will also address how the agencies in the study evaluate project characteristics and requirements to make the decision to use CMR project delivery.

PROJECT DELIVERY METHODS

For the past two decades, public owners have been demanding that the design and construction industries enhance quality, decrease cost, and compress the delivery period for public projects. As a result, both the owners and the industry have experimented with various forms of project delivery methods. As alternative project delivery methods have proliferated, the industry has coined various names for variations on the basic themes, some of which have been codified in enabling legislation. For example, CMR is also called CM/GC and GC/CM in various states' codes. The Veterans Administration calls it "construction manager as constructor (CMc)" to differentiate it from "construction manager as agent (CMa)," also called Agency CM, which is actually a management method not a project delivery method (Bearup et al. 2007). This terminology confusion makes understanding the definitions for alternative project delivery methods a substantial challenge in choosing the method most appropriate to the owner's needs and desires, especially if an agency is new to alternative project delivery. To address the issue of varying terms of art, this synthesis uses the same set of standard project delivery definitions used in other TRB reports (Scott et al. 2006; Touran et al. 2009). These definitions will be used to communicate the technical contractual aspects of the commonly used project delivery methods. The report will not change the specific term applied to CMR in quotations cited to preserve the integrity of the information.

Project delivery method is a term used to refer to all the contractual relations, roles, and responsibilities of the entities involved in a project. The Texas DOT (TxDOT) defines project delivery methods as follows:

> A project delivery method equates to a procurement approach and defines the relationships, roles, and responsibilities of project team members and sequences of activities required to complete a project. A contracting approach is a specific procedure used under the large umbrella of a procurement method to provide techniques for bidding, managing, and specifying a project (Walewski et al. 2001).

The Associated General Contractors of America (AGC) defines the 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" (*Project Delivery Systems for Construction* 2004). The different methods are distinguished by the way the contracts between the owner, the designer, and the builder are formed and the technical relationships that evolve between each party inside those contracts.

The Construction Industry Institute (CII) posits that there are really only three fundamental project delivery methods: Design-Bid-Build (DBB), DB, and CMR ("Owner's Tool for Project Delivery . . ." 2003). Although there are a multitude of names for project delivery methods throughout the industry, CII has simplified the categorization process by focusing specifically on the contracts. Therefore, this report will focus its information in those three categories. The AGC also distinguishes between the *delivery method* and the *management method.* The management method "is the mechanics by which construction is administered and supervised" (*Project Delivery Systems for Construction* 2004). This function is either retained by the owner agency or is outsourced. An example of out-sourcing the management process is to hire an Agency CM. Theoretically any management method may be used with any delivery method. As an example, the owner may hire an Agency CM to manage a DBB, DB, or even a CMR project on its behalf. This is a common practice in the transit sector (*Construction Project Management Handbook* 2006; Touran et al. 2009a).

The standardized definitions and a brief explanation with a graphic displaying the contractual relationships are included here to assist the reader in putting the contents of this report into proper context. Note that the lines of communication shown in the figures represent the ability to exchange information through the use of formal and informal requests for information between various entities in the project. The lines of contractual coordination designate contract requirements to exchange information and other services during design and construction.

Design-Bid-Build

DBB is the traditional project delivery method in which an owner either completes the design using its own design professionals or retains a designer to furnish complete design services. It then advertises and awards a separate construction contract based on the completed construction documents. In either case, the owner is responsible for the details of design and warrants the quality of the construction documents to the construction contractor.

Figure 1 shows that the owner is squarely situated between the designer and the builder in the project delivery process. In DBB, the owner "owns" the details of design during construction and as a result is financially liable for the cost of any errors or omissions encountered in construction, called the "Spearin Doctrine" (Mitchell 1999). Public DBB projects are generally awarded on a low-bid basis. There is no contractual incentive for the builder to minimize the cost growth in this delivery system. Indeed, there can be an opposite effect. A builder who has submitted a low bid may need to look to post-award changes as a means to make a profit on the project after bidding the lowest possible margin to win the project (Scott et al. 2006).

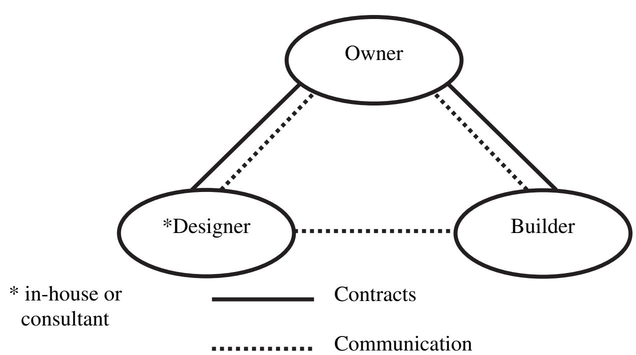

FIGURE 1 Design-bid-build (adapted from *Handbook on Project Delivery* 1996).

DBB projects can also be awarded on a negotiated basis and a best-value basis. In both cases, the probability that the project will be awarded to a builder who has submitted a mistakenly low bid is reduced (Scott et al. 2006). Additionally, the motivation of the builder in both cases is to complete the project in a manner that will get it invited back to do the next negotiated contract or that will reflect well in the next best-value selection. Regardless of the award method, DBB is distinguished by little builder input to the design. Thus, the owner relies on the designer alone for constructability review, if there is any, and trusts the designer to ensure that the design does not exceed the budget.

Construction Manager-at-Risk

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 provide input during project design. The owner will either complete the design with its own design personnel or outsource the design work to a consultant. The UDOT does it both ways depending on project requirements. It reported that the major issue with using in-house designers is ensuring that they can commit to a design schedule in the same way as consultants.

The original idea of CMR is to furnish professional management of all phases of a project's life to an owner whose organization may not have those capabilities internally (Strang 2002). CMR project delivery involves two contracts. The first is for preconstruction services during design and the second is for the construction itself. Typically, CMR contracts contain a provision in which the CMR stipulates a GMP above which the owner is not liable for payment if the project's scope does not change after the GMP is established. Often these contracts include incentive clauses in which the CMR and owner can share any cost savings realized below the GMP. Some states, such as 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. CMR contracts can contain provisions for the CMR to handle some aspects of design. For example, a CMR stormwater improvement project in Florida required the CMR to hire licensed design professionals and conduct a formal technical peer review of the design consultant's construction documents (Kwak and Bushey 2000). However, most commonly, the owner retains the traditional responsibility by keeping a separate design contract and furnishing the CMR with a full set of plans and specifications upon which all construction subcontracts are based, as seen in Figure 2. According to AGC (*Project Delivery Systems for Construction* 2004) the defining characteristics of the CMR are the following:

- The designer and the CMR hold separate contracts with the owner (as opposed to DB), and
- The CMR is chosen based on criteria other than just the lowest construction cost (as opposed to DBB).

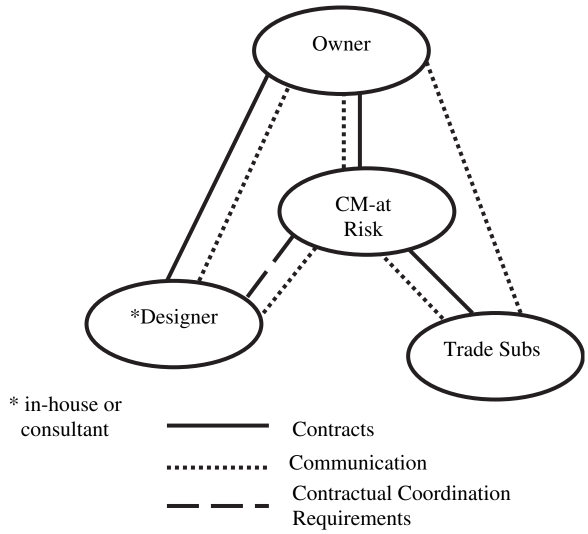

FIGURE 2 Construction manager-at-risk (adapted from *Handbook on Project Delivery* 1996).

Enhanced constructability, real-time construction pricing capability, and speed of implementation are the major reasons why an owner would select the CMR method. Additionally, transportation agencies use it to implement new and innovative technologies and to create an environment of rich collaboration in which to deliver complex projects. Unlike DBB, CMR brings the builder into the design process at a stage where definitive input can have a positive impact on the project. In CMR, the construction manager essentially becomes the general contractor at the time the GMP is established. In some markets, the term Construction Manager/General Contractor (CM/GC) is used to distinguish a contract where the contractor self-performs some portion of the work from the CMR where the prime contract holder subcontracts all the construction work (*Project Delivery Systems for Construction* 2004). However, as both variations would conform to the contractual relationships shown in Figure 2, this report will use these terms interchangeably. The CMR can and is expected to provide realistic project cost estimates early in the project life cycle. It is anticipated that after an adequate amount of design is complete to sufficiently define the project's scope of work, the owner will enter into a contract with the CMR for providing construction services. Many states reserve the right to go out for bid if they think that the CMR's price is not competitive (Minchin et al. 2007).

There are two types of CM arrangements, namely Agency CM and CM-at-risk. This synthesis focuses strictly on CM-at-risk. In Agency CM, the CM is not contractually responsible for the project costs or schedule. Its role is purely consultative and not to be confused with the CMR who ultimately delivers the project within contractually set time and cost limits. Thus, Agency CM is not a project delivery method but rather a project management method (Bearup et al. 2007).

Design-Build

DB 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. The method typically uses request for qualifications (RFQ)/request for proposals (RFP) procedures rather than the DBB invitation for bids procedures. There are a number of variations on the DB process, but all involve three major components. The owner develops an RFQ/RFP that describes essential project requirements in performance terms. Next, proposals are evaluated, and finally, with evaluation complete, the owner engages in some process that leads to contract award for both design and construction services. The DB entity is liable for all design and construction costs and normally provides a firm, fixed price in its proposal (Graham 1997; Ibbs et al. 2003; El Wardani et al. 2006).

Figure 3 clearly shows that from the owner's standpoint the project's chain of responsibility is considerably simplified. As in CMR, the builder has early constructability input to the design process. As the owner no longer owns the details of

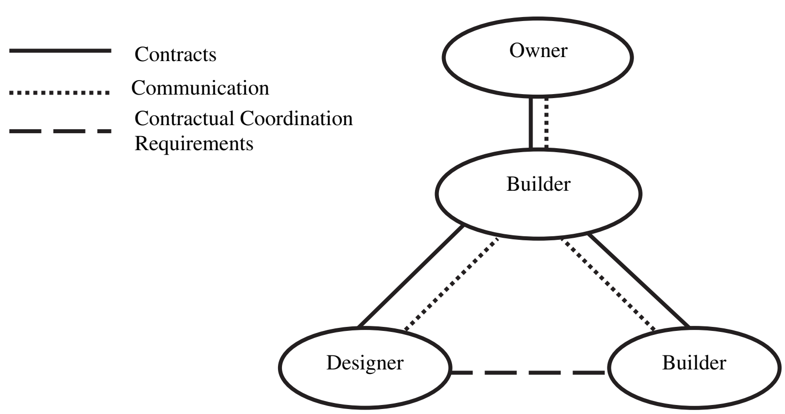

FIGURE 3 Design-build (adapted from *Handbook on Project Delivery* 1996).

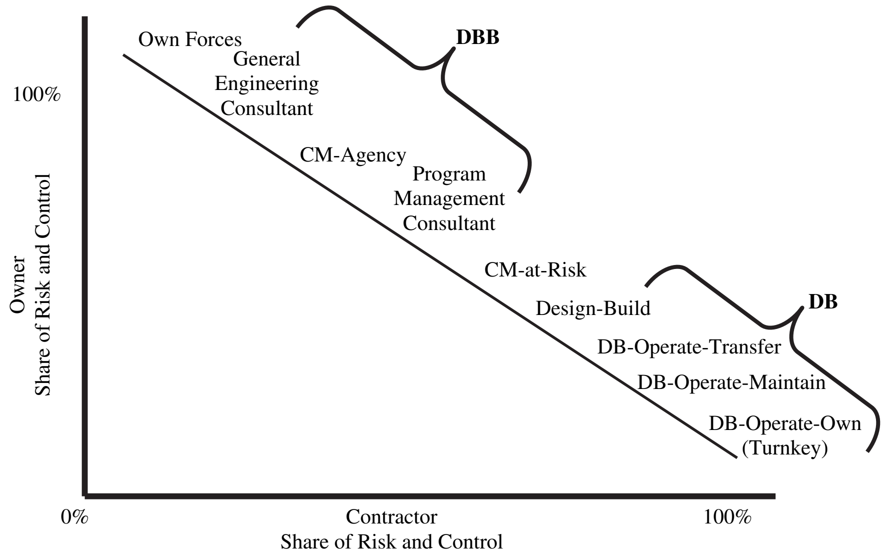

FIGURE 4 Project delivery methods ranked by risk/control shares (adapted from *Construction Project Management Handbook* 2006).

design, its relationship with the design-builder is based on a strong degree of mutual professional trust. The design-builder literally controls this project delivery process. As a result, DB is the delivery method that has the greatest ability to compress the project delivery period and as a result is often used for "fast-track" projects (Alder 2007).

Figure 4 is adapted from a FTA manual (*Construction Project Management Handbook* 2006) and summarizes the difference between variations on the three project delivery methods in terms of distribution of risk and control between the owner and its contractors. It places CMR on the risk/control scale between the versions of DBB and variations of DB project delivery.

The figure tracks with the Oregon and Utah DOTs reasons for using CMR cited by Lee (2008) and Alder (2007) as it shows CMR furnishing more owner control than DB, yet allowing an equitable sharing of the project risk with the contractor. Therefore, it confirms the inference that CMR may be used on projects where the owner desires a high degree of collaboration but wants to maintain control over the design and other salient aspects of the project.

KEY DEFINITIONS

As can be seen in the previous section, a precise definition of the common terms associated with CMR project delivery is essential to the ability to understand its advantages and disadvantages and put it in context with other project delivery methods in use by a public transportation agency. A glossary of all cogent terms is furnished at the end of this report. However, to facilitate reading and understanding the synthesis key terms are defined here:

- CMR contract: 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 provide input during project design. It may consist of two separate contracts: preconstruction services and construction. It is also called Construction Manager/General Contractor (CM/GC), General Contractor/Construction Manager (GC/CM), and Construction Manager as Constructor (CMc). This synthesis takes the approach that no matter what the specific term appears to imply, all of these designations are the same project delivery method because they involve separate design and construction contracts held by the owner and they involve the constructor in the design process through preconstruction services.
- Letter of Interest (LOI): Solicitation documents that merely ask contractors to indicate their desire to compete for a CMR without requiring them to submit a list of specific qualifications. Typically, these are used to negotiate a CMR contract with a GC based on the owner's past experience with the respondents.
- Requests for Qualifications (RFQ): Solicitation documents requiring contractors to submit specific information on the qualifications, which may include but are not limited to the qualifications of key personnel, past experience on related projects, quality management and other plans, the details of their preconstruction services package, and other evaluation factors. RFQs do not require submission of cost or pricing information.
- Requests for Proposals (RFP): Solicitation documents requiring contractors to submit specific information, which may include but are not limited to the qualifications of their key personnel, past experience on related projects, quality management and other plans, the details of

their preconstruction services package, proposed schedule and cost or pricing information, as well as any other evaluation factors.

- Preconstruction Services: The activities conducted by the CMR during the design phase. These include but are not limited to:
  - Cost estimates at predetermined stages of design development;
  - Preparing the schedule for the design phase, as well as a preliminary schedule for the construction phase;
  - Performing value engineering analysis;
  - Performing a constructability review;
  - Developing the construction logistics plan;
  - Preparation of [trade subcontractor] bid packages, bid evaluation, and, if required, preparation of recommendations to the owner for the award of trade contracts;
  - Market surveys of construction materials and equipment that have relatively long delivery requirements;
  - Early purchase of . . . long-lead items (Martinez et al. 2007); and
  - Other services required in the contract.
- Preconstruction Cost Model: A breakdown of the project's scope of work in dollar terms. In CMR project delivery, the contractor's first preconstruction task is typically the development of this tool in collaboration with the designer. Its purpose is to "validate the owner's budget" (Ladino et al. 2008) and to be able to price various alternatives during design in a manner that directly reflects how and when they will be built (Van Winkle 2007). Additionally, the model evolves as the design progresses and is used to support required cost estimates ("Contract for Construction Manager at Risk Design Phase Services" 2007).
- Guaranteed Maximum Price (GMP): A sum of money that represents the cost of work, overhead, CMR's fees (profit), and a contingency in a CMR project (Kwak and Bushey 2000).
- Progressive GMP: An alternate way to establish a GMP by breaking the project down into phases or work packages and asking the CMR to generate individual GMPs for each phase or package. The final GMP becomes the sum of the individual GMPs plus any remaining project-level contingencies.
- Contingency: The amount budgeted to covers costs that may result from incomplete design, unforeseen and unpredictable conditions, or uncertainties within the defined project scope. The amount of the contingency will depend on the status of design, procurement, and construction; and the complexity and uncertainties of the component parts of the project (*Cost Estimating Guide* 1997).

STUDY INSTRUMENTS

To accomplish the objective for this synthesis, varying sources of information were consulted and synthesized. Information was collected using the following seven study instruments:

1. Review of the current literature;
2. Surveys using a web-based questionnaire to state highway agencies and other transportation agencies to identify those with CMR experience;
3. Structured interviews with DOTs and other public transportation agencies with CMR experience;
4. Content analysis of RFQ/RFPs for CMR transportation projects;
5. Case studies of DOTs and other public transportation agencies that have implemented CMR;
6. Case studies from the transit, airport, and building sectors; and
7. Structured interviews with members of the construction industry.

The next chapter will detail how these instruments will be applied to achieve the synthesis's objective.

CHAPTER TWO

LITERATURE, METHODOLOGY, AND CASE STUDIES

INTRODUCTION

This synthesis involves the investigation of the use of CMR by DOTs. This is accomplished through a review of literature to understand what CMR is and followed by a study methodology that includes several different information collection approaches including CMR project case studies.

LITERATURE SUMMARY

The literature on CMR generally falls into one of two major categories. The first group encompasses journal papers and documents that report on a comparative analysis of two or more project delivery methods. The second category comprises information on the mechanics of implementing CMR as well as lessons learned from completed CMR projects. The first category is valuable in that it helps define the salient differences between CMR and other project delivery methods at the operational level.

Comparative Analysis of Project Delivery Method Performance

The most often cited example from the first category is the paper by Konchar and Sanvido (1998) that compared different project delivery methods (i.e., DB, DBB, and CMR) in 351 building projects with a standard set of performance criteria. The criteria were both objective and measurable. One of the results of the comparison is: "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 construction management at risk and 12.6% less than design/bid/build projects on average in terms of cost growth" (Konchar and Sanvido 1998). The authors have divided the projects into six different groups (e.g., as light industrial, complex office, and heavy industrial) to get a more robust result about the trends in each group. The paper's main conclusion is that CMR and DB projects tended to perform better in most measured criteria than traditional DBB projects. Additionally, a recent NCHRP study of best value contracting (Scott et al. 2006) furnished direct comparison of transportation project performance between delivery methods. Although that study did not include CMR projects, it did include DBB projects awarded on a best value basis where the contractors' qualifications and past performance were factored into the selection process. This parallels the CMR delivery method. The study found that DB projects had 4.7% less cost growth and 9.3% less time growth. Best value projects had 2.0% less cost growth and 18.5% less time growth. One study in this category was specifically directed at owner perceptions of the various delivery methods (Doren et al. 2005). This was a joint effort between FMI Consulting and the Construction Management Association of America (CMAA). This study had a plethora of interesting findings that will be reported as appropriate throughout the synthesis. The one most directly related to the performance of CMR project delivery versus other delivery methods is summed up as follows:

> . . . when we asked which method was used most frequently, which is design-bid-build at 66% of all responses followed by CM-at-risk at only 19%. However, *when asked which method delivers the best value, both CM-at-risk (35%) and design-build (29%) rated higher than design-bid-build (23%)* (Doren et al. 2005; italics added).

Thus, although DBB was used three times as often as CMR, CMR was perceived as the project delivery method that furnished the most value to the owner. The study went on to discuss project delivery methods in the public sector.

> Changing the delivery methods used, in the case of these [public] organizations, will often require changing laws and politics, but that is happening, too, because *the public is best served when it gets the best value for its tax dollars. . . . CM-at-risk will likely become the more dominant delivery method* for this group (Doren et al. 2005; italics added).

An article in the CMAA's *CM eJournal* summarizes the issues discussed previously:

> The great advantage to CM-at-Risk for most public Owners is that their governing bodies accept it . . . Most Owners see having a GMP as equivalent to having a Stipulated Sum Cost, and on that basis are willing to enter the experiment . . . The choice then for most public Owners is between CM-at-Risk and the traditional [DBB] system. If they do not want to use the traditional method because of past poor results, and are not bold enough to try Design-Build, they are encouraged in this direction (Strang 2002).

Construction Manager-at-Risk Implementation Experience

The literature on implementing CMR contracting is reasonably rich and contains the lessons learned by public agencies in all transportation sectors. Rather than attempt to exhaustively relate all the successes and failures, the report will concentrate on those factors of CMR that were cited repetitively by a diverse group of authors and agencies. The ones that were found to be most important to understanding the aspects that impact successful CMR project delivery will be discussed in detail. Tables 1 and 2 summarize the advantages and disadvantages found in the literature. If two or more authors specifically cited a specific factor as an advantage, it was recorded in Table 1. Then the disadvantages cited by the authors shown in Table 2 were tabulated to show their complete experience regardless of how many times an item was cited.

The first thing that one can see in the tables is that the information is very current. Ten of the 15 citations were published between 2005 and 2009. This provides confirmation of the applicability of these experiences to transportation agencies that may be contemplating the use of CMR and are looking for information that will assist them in matching the project delivery method with their project requirements. The next general observation is that the authors appear to have more positive than negative information about CMR. Four of the 15 papers did not list any disadvantages, and there were 17 advantages cited that were offset by 13 disadvantages. Additionally, there are 4 advantages that were cited by at least 10 of the papers (two-thirds of the population), whereas all but one disadvantage was cited by one-third or less of the sample. This appears to infer that the experience with CMR project delivery has generally been positive. It also provides confirmation to the results of the comparison of CMR with other delivery methods discussed in the previous section.

From Table 1, the top five advantages based on frequency of citation in the literature are:

1. The ability of the constructor to make substantive/beneficial input to the design.
2. The enhanced ability to accelerate the project's delivery schedule.
3. Enhanced cost certainty at an earlier point in design than DBB.
4. The ability to bid early work packages as a means to mitigate the risk of construction price volatility and accelerate the schedule.
5. Owner control over the details of the design.

Table 2 shows that the four most frequently cited disadvantages are:

1. Reconciling the conflict between the primary motivations of the CMR and the designer (i.e., cost control versus conservative design to reduce design liability).

TABLE 1
CMR ADVANTAGES SUMMARY

Advantages (ref. no.)	Times Cited of 15 Citations	Alder 2007 (1)	Anderson & Damnjanovic 2008 (2)	Armstrong & Wallace 2001 (3)	Gambatese et al. 2002 (4)	Koppinen & Lahdenperä 2004 (5)	Kwak & Bushey 2000 (6)	Ladino et al. 2008 (7)	Lee 2008 (8)	Mahdi & Al-reshaid 2005 (9)	Martinez et al. 2007 (10)	Rojas & Kell 2008 (11)	Scott 2007 (12)	Strang 2002 (13)	Thomsen 2006 (14)	Uhlik & Eller 2005 (15)
CMR design input	12	X	X		X	X	X	X	X	X	X	X	X			X
Ability to fast-track	10	X	X		X	X	X	X		X		X	X			X
Early knowledge of costs	10				X		X	X	X	X	X	X		X	X	X
Ability to bid early work packages	10	X		X	X	X	X		X	X	X	X				X
Owner control of design	8	X		X	X				X	X				X	X	X
GMP creates cost control incentive	6	X			X						X	X	X			X
Reduces design costs	5	X	X	X											X	X
Select GC on qualifications	4				X		X					X	X			
Open books contingency accounting	4			X	X			X	X							
Focus on quality and value	4			X	X			X								X
Flexibility during design/construction	4				X	X	X									X
Spirit of trust	4			X	X							X	X			
Competitive bidding possible	4	X									X			X		X
CMR is owners advocate during design	3				X					X				X		
Third-party coordination facilitated	3	X									X	X				
Less radical change from DBB than DB	2									X				X		
Risk transfer	2			X									X			

GC = general contractor.

TABLE 2
CMR DISADVANTAGES SUMMARY

Disadvantages*	Times Cited of 15 Citations	Alder 2007	Anderson & Damnjanovic 2008	Doren et al. 2005	Gambatese et al. 2002	Ladino et al. 2008	Mahdi & Alreshaid 2005	Martinez et al. 2007	Scott 2007	Storm 2007	Strang 2002	Uhlik & Eller 2005
CMR and designer have different agendas	7				X	X	X	X		X	X	X
Still have two contracts to manage	5			X	X	X	X		X			
Actual cost not known until GMP is set	5	X			X		X	X	X			
Training required for agency personnel	4		X		X	X				X		
Picks CMR early in process	3	X					X		X			
Requires different procurement culture	3				X	X				X		
Designer not obligated to use CMR input	2					X	X					
CMR can unintentionally assume design liability via review comments	2							X			X	
Contingencies difficult to allocate	2								X		X	
Lack of clear leadership during design	2			X	X							
CMR underestimates cost of preconstruction services	1			X								
Reduced competition among subs	1										X	
CMR doesn't control the design schedule	1	X										

*Armstrong and Wallace (2001), Koppinen and Lahdenperä (2004), Kwak and Bushey (2000), Rojas and Kell (2008), and Thomsen (2006) did not cite specific disadvantages.

2. That the owner must still administer/coordinate both a design and a construction contract.
3. The final actual cost is not known until the GMP is established.
4. Agency personnel are trained to properly implement CMR project delivery.

Project Delivery Concepts

Figure 5 is taken from a textbook on alternative project delivery and graphically illustrates the "three legs of a fair and stable contract" (Gransberg et al. 2006). The five primary advantages cover the three legs of the project delivery process: cost, schedule, and quality. On the other hand, the previously mentioned four disadvantages are basically linked to the contract administration process associated with implementing CMR. This is an interesting dichotomy that will be explored in detail in the following sections.

Looking at the three major project delivery methods allows the comparison of how each of the three legs is fixed in each method to create a fair and stable contract. In DBB, the quality and schedule legs are fixed by the contract completion date and the construction documents on which the contractors bid. Therefore, cost is the variable leg with the bids showing how much it will cost to deliver the specified quality within the specified time. In DB, the schedule remains fixed by contract and the cost leg is fixed by the design-builder's lump sum proposal. Therefore, quality is the variable leg in the stool and as a result the owner no longer controls the details of design. In CMR, the contractor is brought to the project during design and helps optimize all three legs of the stool before they are fixed. Thus, CMR holds potential for developing the high degree of collaboration necessary to maximize quality within the project's time and cost constraints without the interference of the contracts.

Quality Aspects of Implementing CMR

Two of the major cited advantages deal with quality: constructor design input and owner design control. Through the preconstruction services contract with the CMR, the

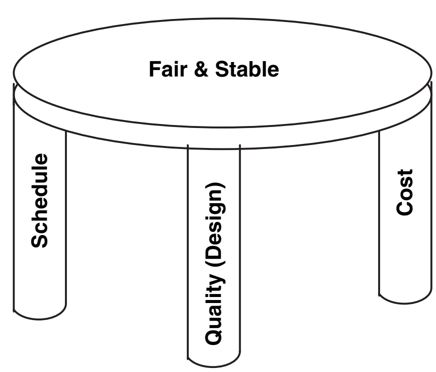

FIGURE 5 Project delivery concept (Gransberg et al. 2006).

constructor is formally included in the design process: "Contractor experience and expertise can aid the design team in preparing more cost-effective traffic control plans, construction staging plans, and perhaps more realistic construction schedules" (Anderson and Damnjanovic 2008). Chapter five of this report will discuss preconstruction services in detail. Two of the services performed by the CMR during the design phase are constructability reviews and design validation. Constructability is defined by the Construction Industry Institute as "the integration of construction knowledge and experience in planning, design, procurement, and construction phases of projects consistent with the overall project objectives" ("Project Delivery Systems . . ." 1997). One of the papers cited in Tables 1 and 2 provides useful advice for appropriately timing reviews:

> Constructability is achieved through the effective and timely integration of construction input into planning and design as well as field operations. For maximum effect, it should be initiated early in the design process and performed at predefined points during the design process in accordance with a well thought-out plan (Martinez et al. 2007).

This quote argues for selecting the CMR early in the design process to gain the "maximum effect" or benefit from the constructors' knowledge and experience before design effort is wasted developing potential alternatives that need to be changed as a result of the budget and constructability reviews. Another paper that reports on a successful CMR stormwater drainage project in Florida confirms this assertion and goes on to describe the benefits:

> The ability of the CM to input constructability reviews, construction phasing, material availability, and cost estimating throughout the design process reduces the probable occurrences of change orders, project construction delays, and increased project costs due to contractor identification of these elements in the design phase instead of the construction phase (Kwak and Bushey 2000).

The above discussion leads to the idea that the constructability process adds value to the project by enhancing the quality of the design and driving it to produce a buildable project (Jeargas and Van der Put 2001; Dunston et al. 2002). An NCHRP study (Russell et al. 2002) found that one of the major research issues in the transportation sector was implementing a constructability review program in the planning and design phases that focuses specifically on "deficiencies in quality and clarity of construction plans." It went on to recommend research on how to leverage constructability reviews as a means to increase the speed of construction. "The constructability review process, therefore, is recommended as an *indispensable means toward achieving quality* in the delivery of transportation projects" (Dunston et al. 2002; italics added).

Design validation is *not* a technical peer review of the design by the constructor. One author stated: "[t]he construction manager is not the licensed architect or engineer for the project and should avoid comments in the constructability reports that would more properly be included in a peer review by design professionals" (Martinez et al. 2007). That paper goes on to recommend that design validation reviews by the CMR be limited to ". . . industry standards, previous construction experience with similar designs, and previous experience related to re-work or warranty issues." Thus, design validation becomes the process of reviewing the design products to confirm that they can indeed be built as depicted and that they conform to available means, methods, and materials. A complex tunnel project in Portland, Oregon, was delivered by CMR and the owner reported measurable benefits as a result of the "contractor's early involvement with design review, value engineering, and risk analysis prior to design completion . . . which contributed to significant cost and schedule savings" (Gribbon et al. 2003). The benefits of design validation reviews are confirmed by another paper that reported that CMR project delivery "provides for flexibility in the implementation of design changes late in the design process without impacting construction schedules and final delivery dates" (Kwak and Bushey 2000). The bottom line is that "[q]uality [construction] documents facilitate quality construction and good relations with the construction industry, and projects delivered cost-effectively without extended duration greatly enhance public image for the STA [state transportation agency]" (Dunston et al. 2002).

To accrue these potential advantages, the owner can develop a process that manages the greatest disadvantage reported in the literature. This is the reconciling of the differing agendas of the CMR and the designer during design. By contract, the CMR is cost-focused during the design phase because the primary reason for an owner to select CMR project delivery is to have access to real-time cost estimating capability that exists only in the construction industry (Martinez et al. 2007). Thus, the owner's primary charge to the CMR is to ensure that the project does not exceed the budget. On the other hand, the owner charges the designer with ensuring that the project design details conform to all applicable codes, laws, and regulations while at the same time furnishing the desired technical capabilities and capacities. If the project does not meet these requirements, then the designer is liable to correct the problem. Additionally, the designer's liability for a structural failure in the project tends to last longer than the builder's. As a result of this issue, designers tend to be conservative in their designs, which can cause the construction cost to push against budget limits. Doren et al. (2005) provides a list of quality imperatives to be satisfied to reconcile the competing agendas:

- Need to pay more attention to controlling scope;
- A/Es [designers] need to be more conscious of the cost to build their designs;
- More coordination/collaboration among team members;
- There needs to be a thorough review of the technical design details;
- Need to bring contractors, subcontractors, and suppliers on board in the design phase; and
- Need quality reviews from CMs (Doren et al. 2005).

To accomplish this task it is necessary that both the CMR preconstruction services contract and the engineering design contract have language that makes "coordination/collaboration among team members" an explicit contractual requirement. The Memphis Shelby County International Airport solved the problem of conflicting agendas by adding a clause in their design contract that puts 10% of the design fee at risk for the quality of the construction documents (measured by the number of design changes made during construction owing to errors and omissions). It stated that this effectively changed the engineers' attitude from seeing the CMR constructability and design validation reviews as unwanted criticism to seeing the reviews as a valuable component of the design quality management program (Touran et al. 2009a). This also underscores the need to modify the design contract to facilitate the preconstruction services provided by the CMR.

Although chapter seven will discuss the quality management process in detail, it can be seen from this discussion that CMR provides a mechanism to enhance the quality of the design that necessarily translates into better construction quality owing to increased constructability (Dunston et al. 2002). This is confirmed by four of the papers cited in Table 1 that reported that CMR created a "focus on quality and value" rather than minimizing cost. This is nicely expressed by Dunston et al. when they state: "[t]he message is conveyed that the standard for top performance is measured by quality in terms of biddability, buildability, and maintainability in the project rather than by merely meeting a predetermined schedule" (Dunston et al. 2002). And this leads to the discussion of schedule issues in CMR project delivery.

Schedule Aspects of Implementing CMR

The second major advantage of CMR project delivery was cited by 10 of the authors reviewed for this report and it deals with the enhanced ability to accelerate the schedule. As with DB, CMR projects do not have to wait for the design to be complete. A careful reading of the literature shows the "construction process" defined to include the procurement activities that a contractor undertakes once it has a signed contract to arrange for materials and subcontractors (Alder 2007; Gambatese et al. 2002). The primary benefit comes from the ability to arrange the work in bid packages that correlate directly with design packages. This permits the CMR to bid out those packages as soon as each package's design is ready. This also allows the construction to begin before the entire design is finished without burdening the budget with unnecessary contingencies for possible design scope creep. These budget benefits will be discussed in the next section. To effectively accelerate the delivery period, the owner forms both the design and the construction contracts with this goal in mind. It cannot assume that the two can run independently and achieve this mutual goal.

"The construction manager should review the overall project schedule and conduct coordination meetings with the design professionals to make sure the design activities are in compliance with and integrated into the construction schedule" (Martinez et al. 2007). This issue speaks to the second most often cited disadvantage, which is the owner's need to properly coordinate and administer two contracts as opposed to the single contract in a DB project. It also advocates contractually assigning both design and construction scheduling responsibilities to the CMR. Doing so would ameliorate the cited disadvantage of "lack of clear leadership during design" by requiring the engineer to coordinate its efforts through the CMR for the best interests of the overall project's schedule. If the design contract does not have this type of language, the owner regresses to dealing with the major disadvantage of refereeing the different agendas of the designer and the builder.

Managing schedule risk is always significant in transportation projects and especially so when the project will disrupt the traveling public for significant periods of time. Transportation agencies are always looking for ways to reduce design and construction schedules (Ford et al. 2004). One way to manage this risk is to begin design and construction activities as soon as they can technically be started and to maximize the number of parallel activities that occur in the schedule (Touran 2006). As the CMR ultimately is at risk for delivering the completed project on time, it makes sense to involve it in the risk analysis. Touran puts it this way ". . . the CM is the entity who should be performing the risk analysis. The owner can benefit from an experienced construction manager that is present in the project since the beginning and understands the implications of various decisions regarding scope, budget, and schedule . . ." Thus, it appears to be important that the CMR's preconstruction services contract be specific about its roles and responsibilities for scheduling during design. Kuhn puts it this way:

> Preconstruction phase schedule management is one of the key roles of the [CMR's] preconstruction manager. Creating a realistic and detailed schedule for all design, approval, estimating, and purchasing activities to ensure that construction activities begin on schedule is the primary objective of the preconstruction schedule. The preconstruction schedule reflects what is expected of the design team, CM, and owner so that packaging and scoping of the work can be accomplished through documents that address required information at each stage of the design process. For this reason, it is critical that the preconstruction manager be involved in the project as early as possible to coordinate deliverables and expectations with the design team (Kuhn 2007).

UDOT's CMR implementation experience confirms that the schedule advantages found in the literature can be realized in the field. This agency cites a number of reasons why they believe that CMR project delivery allowed them to accelerate project schedules but warns that this advantage does not come to the owner risk free:

> The CMGC [CMR] process has *reduced the schedule for most projects.* Part of the reason for this is the *time saved in the design effort.* The contractor's participation helps to *identify solutions quickly and speeds up the design process.* Their participation also *reduces the detail that must be communicated to the contactor*

> *in drawings and specifications.* CMGC in general allows a project to begin at risk. One project began before the railroad right of way issues were cleared . . . By careful construction planning the railroad work was saved for last and right of way issues were cleared in time to complete the project on schedule. Choosing a contractor in the design process also *helps to clear utility issues.* Utility companies move more quickly to plan and execute solutions when they know the contractor they will be working with. *Phasing helps to reduce schedule time.* Long lead items were purchased during design that would be used later in construction. *This is not without some risk* (Alder 2007; italics added).

The old cliché that time equals money operates in this project delivery method. The risk of not finishing on time almost always results in additional hard costs to the agency and increased user costs to the traveling public. "While schedule risk assessment can be performed without regards to cost in most cases, calculation of cost risks has to be tied to schedule" (Touran 2006). This leads to the subject of the next section.

Cost Aspects of Implementing CMR

Two of the top five CMR advantages were directly related to cost. First, the owner is able to achieve cost certainty earlier in CMR than DBB because the constructor is furnishing estimates during design, as well as a GMP before 100% design completion. Additionally, the owner can choose to use a progressive GMP where the CMR commits to incremental bid package GMPs as design packages are complete and finalizes the project GMP when the majority of the work has been bid out to trade subcontractors and material suppliers. This reduces the risk to the constructor and the amount of contingency that the CMR maintains against the cost risks of material price escalation, subcontractor availability, and scope creep during design. The second advantage deals with the role of the GMP as an incentive to control costs. That the CMR is allowed to provide design input and then prepares progress estimates based on that input creates "buy-in" to the final design by the CMR. "If the CM At-Risk has been on board all along, [it] will find asking for changes because of ambiguities in the plans as difficult as ever" (Strang 2002).

These benefits are offset in the literature by the requirement to select the CMR early in the project development process and then wait until the design progresses to the point where a GMP can be established without excessive contingencies before the actual total cost is known to the owner. Although this is earlier than in DBB, a lump sum DB project fixes the design and construction costs at award. One of the other cited disadvantages is that the designer is not obligated to incorporate the CMR's design recommendations into the final design.

SYNTHESIS METHODOLOGY

The methodology was designed to analyze the output from multiple study instruments to identify intersections between the literature, information found in the case studies, points derived from the structured interviews of agencies, a survey of state DOTs, and the content analysis of CMR solicitation documents. Finally, structured interviews with contractors who have completed the case study CMR projects were conducted to validate the conclusions. The conclusions reported in the final chapter are the result of triangulation between three or more of those sources. Effective practices and lessons learned discussed at the end of each chapter are drawn from the intersection of the literature and one of the other study instruments. Thus, the rationale for developing conclusions and effective practices is to be able to map them back to two or three sources that all agree and further validate them by indicated construction industry confirmation.

Information for synthesis development was collected using the following study instruments:

1. Review of the current literature;
2. Surveys using a web-based questionnaire to state highway agencies and other transportation agencies to identify those with CMR experience;
3. Structured interviews with DOTs and other public transportation agencies with CMR experience;
4. Content analysis of RFQs/RFPs for CMR transportation projects;
5. Case studies of DOTs and other public transportation agencies that have implemented CMR;
6. Case studies from the transit, airport, and building sectors; and
7. Structured interviews with members of the construction industry.

Literature Review

All relevant literature was reviewed. Special attention was paid to national and international experience as it may apply to state-level projects. The literature review was used to prepare the survey of state DOTs to ascertain which agencies have actual CMR experience. Additionally, the literature was used as a basis to prepare the case study structured interview questionnaires. The industry structured interview questionnaire was also prepared based on information found in the literature review. Finally, the review also looked for parallel case studies from the architectural sector to permit a comparison of vertical building projects with horizontal transportation projects. These were used to compare the information gained from DOTs that reserve CMR for the delivery of projects with a strong vertical component such as multi-modal centers, airport terminals, and rest areas (i.e., Alaska and Florida).

National Survey

A short survey was uploaded to a commercial Internet survey site (see Appendix A for details). The consultants then e-mailed the state construction and design engineers for each DOT and requested that they visit the link on the survey and complete the survey. The purpose was to identify those state DOTs with CMR experience. Figure 6 shows the response rate and the results in a graphic manner.

One can see in Figure 6 that five states have some experience with CMR project delivery. The Rhode Island DOT is overseeing a CMR project for the Rhode Island Airport Corporation under the auspices of Special Experimental Projects Number 14 (SEP-14). The Michigan DOT (MDOT) is also overseeing a CMR project to construct a passenger ship terminal for Detroit Wayne County Port Authority. Neither of these DOTs has attempted to procure a typical highway project using the method. The survey response from Rhode Island indicated that the DOT did not have CMR contracting authority, and this is interpreted to mean that it can only use the method via the SEP-14 authorization. Michigan is different in that it does have the ability use the method, but the structured interview with the MDOT project manager indicated that the agency had not yet found a traditional highway project where CMR project delivery made sense.

Of the states shown in black in Figure 6, Arizona, Florida, and Utah have the most experience. The Florida DOT (FDOT) has largely used the method to procure transportation projects with a strong component of vertical/building construction, including a $1.3 billion multi-modal center in Miami. The Arizona experience is largely at the county and municipal level, where the local agencies in and around the Phoenix metroplex have a robust and long-standing CMR project delivery program. Arizona DOT has awarded two CMR projects that are underway at the time of this writing. UDOT has the nation's greatest experience in using CMR (termed CMGC in the literature from Utah) project delivery for typical road and bridge projects. UDOT has a memorandum of understanding with FHWA for 24 CMR projects authorized for federal funding with additional CMR projects planned to be funded solely by the state. Of that group, 13 are completed and another 16 are underway. Given this breadth and depth of experience with projects that are of prime interest to this synthesis, the Utah input from the various study instruments is given the most weight in the analysis. A member, UDOT, expressed the opinion stated here. However, UDOT has not adopted this as its policy and continues to select project delivery methods on a project-by-project basis.

> *Use CMGC* [CMR] *as the primary delivery method* unless schedule is the principle driver. When a shortened delivery schedule is the primary motivation design build should be used. If the [CMGC] contractor cannot deliver the project for a fair price then the fall back position is [Design] Bid Build. I make this recommendation because *we should always want the contractor's input to reduce risk, cost, and construction time* (Alder 2007; italics added).

The remaining two states, Alaska and Oregon, have limited experience. The Alaska DOT experience is much like FDOT's in that it has completed two airport terminal expansion projects and both had a large proportion of vertical construction. The interview with the project manager in Alaska indicated that the agency is looking to expand the use of CMR to road and

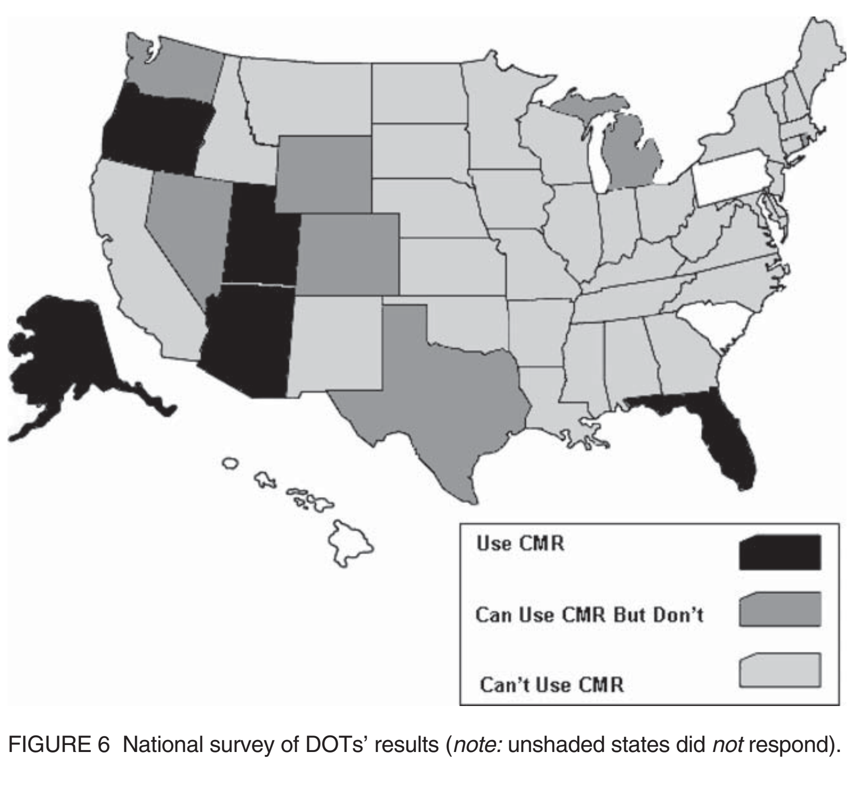

FIGURE 6 National survey of DOTs' results (*note:* unshaded states did *not* respond).

bridge projects, but will first deal with policy and procurement culture issues. ODOT is using CMR to deliver a major interstate bridge project with thorny environmental issues, and plans to continue its use of the method based on the positive experience with the first project.

Of the states that have authority but have not tried CMR, Nevada and Washington State, are actively pursuing the necessary tasks to implement it on a pilot basis. As with Michigan, Washington has not yet found a project that it believed would make a decent pilot project. Nevada received its authority in 2008 and has just embarked on the development of its program policy and procedures. Colorado and Wyoming both answered the survey by indicating that they had not yet had a project where CMR project delivery made sense. Texas stated that it did not believe that CMR project delivery was appropriate for horizontal projects.

Structured Interviews

The primary input to the case studies was gathered through structured interviews with the agencies that had implemented CMR project delivery. The structured interview outlines were developed on lines similar to the method prescribed by the U.S. Government Accounting Office ("Using Structured Interviewing Techniques" 1991). The agency method states that structured interviews can be used where "information must be obtained from program participants or members of a comparison group . . . or when essentially the same information must be obtained from numerous people for a multiple case-study evaluation" ("Using Structured Interviewing Techniques" 1991). Both of these conditions apply to this synthesis; therefore, the tool is appropriate for the study.

Agency Interviews

The structured interviews of the agencies with CMR experience were centered on a single case study project. However, the interview was broadened to include a more general set of policy, procedure, and effective practices for those agencies that had completed several CMR projects. A total of 10 agencies were interviewed either face-to-face or telephonically, depending on their availability. The total value of the case study CMR projects associated with these agencies is $2.3 billion. Table 3 shows the salient details on each agency interviewed. This list constitutes most of the DOTs with some sort of CMR experience. It also includes two non-state transportation agencies with significant CMR experience. The list also covers a wide range of project sizes, from a low of $10 mil-

TABLE 3
AGENCY STRUCTURED INTERVIEWS

Agency	CMR Experience (no. projects)	Case Study Project	Location	Size ($)	Primary Type
Alaska DOT&PF	2	Fairbanks Intl. Airport Expansion	Fairbanks, AK	$99.0 million	Building
Florida DOT	9	Miami Intermodal Center	Miami, FL	$1.3 billion	Building, Rail, Road, Bridge
City of Glendale	18	Glendale Pedestrian Improvements	Glendale, AZ	$16.2 million	Road, Utilities
Michigan DOT	1*	Passenger Ship Terminal	Port of Detroit, MI	$10.0 million	Building, Marine, Utilities
Oregon DOT	1	I-5 Willamette River Bridge	Eugene, OR	$150.0 million	Road, Bridge
Pinal County Public Works	5	Ironwood–Gantzel Road (U.S. 60) Improvements	Florence, AZ	$63.7 million	Road, Bridge
Utah DOT	13	I-80 State St. to 1300 East. Reconstruction	Salt Lake City, UT	$130.0 million	Road, Bridge
Non-Highway Case Study Agencies					
Memphis Airport Authority	25	Whole Base Relocation	Memphis, TN	$245.0 million	Runway, Building
Utah Transit Authority	4	Weber County Commuter Rail	Salt Lake City, UT	$241.0 million	Rail, Road, Bridge, Building
Texas Tech University	40+	Lanier Law School Center	Lubbock, TX	$13.7 million	Building

*Oversight on behalf of another agency responsibility only.

lion to a high of $1.3 billion. It also covers nearly all modes of transportation.

Contractor Interviews

It is extremely important for this study to gauge the perception of the construction industry on this particular topic. These stakeholders are directly affected by any change to the requirements for bidding on public works contracts. The contractors who won the CMR contracts on the case study projects were interviewed (see Table 4 for details). They represented both large and small companies as well as local, regional, and national areas of operation. Three of the contractors had CMR experience with more than one highway agency. All the contractors interviewed expressed a strong positive perception regarding their experience with CMR. This included one national contractor that had won the first two CMR projects that were advertised by a given DOT.

Solicitation Document Content Analysis

The content analyses of public transportation solicitation documents was conducted to create a basis for identifying CMR effective practices and to quantify the state of the practice regarding the procurement phase of CMR projects. The content analysis consisted of gathering and reviewing solicitation documents and searching for the requirements for qualifications that were outlined in the documents. The formal content analysis furnishes quantitative measurements of current DOT requirements for CMR selection factors. They are found by counting the number of times that specific terms of interest are required to be submitted by contractors to be considered for the project. This type of analysis can be used to develop "valid inferences from a message, written or visual, using a set of procedures" (Neuendorf 2002).

The primary approach is to develop a set of standard categories into which words that appear in the text of a written document, in this case the structured interview questionnaire, can be placed and then the method uses the frequency of their appearance as a means to infer the content of the document (Weber 1985). This allowed an inference to be made regarding the given owner's approach to CMR selection. When the results are accumulated for the entire population, trends can be identified and reported.

The output from the content analysis can then be compared within the population to determine how CMR selection policy is being implemented in project-specific solicitation documents. The output can also be compared with the responses from the survey and structured interviews to map respondents' output against their respective agency policy and solicitation documents.

There are three types of solicitation documents: Requests for LOI, RFQ, and RFP. LOIs are defined as documents that merely ask contractors to respond indicating their desire to compete for a CMR without requiring them to submit a list of specific qualifications or cost information. RFQs require contractors to submit their qualifications, past experience, and other evaluation factors, but do not require any cost or pricing information. RFPs require submission of cost or pricing information in addition to other evaluation factors such as qualifications, past project experience, and schedule. Figure 7 shows the geographic distribution of the content analysis. Table 5 is a summary of the content analysis population. A total of 25 documents related to a transportation

TABLE 4
CONTRACTOR STRUCTURED INTERVIEW DETAILS

Case Study Project	Location	Type	Annual Volume	CMR Experience with More than One Agency
Fairbanks Intl. Airport Expansion	Fairbanks, AK	Regional General Contractor	<$250 million	No
Glendale Pedestrian Improvements	Glendale, AZ	National General Contractor	>$500 million	Yes
I-5 Willamette River Bridge	Eugene, OR	Regional General Contractor	<$250 million	Yes
Ironwood–Gantzel Road (U.S. 60) Improvements	Florence, AZ	National General Contractor	>$500 million	Yes
I-80 State St to 1300 East. Reconstruction	Salt Lake City, UT	Local Bridge Contractor	<$250 million	No
Non-Highway Case Study Contractors				
Whole Base Relocation	Memphis, TN	Regional General Contractor	>$500 million	Yes
Weber County Commuter Rail	Salt Lake City, UT	National General Contractor	>$500 million	Yes
Lanier Law School Center	Lubbock, TX	Local Building Contractor	<$250 million	Yes

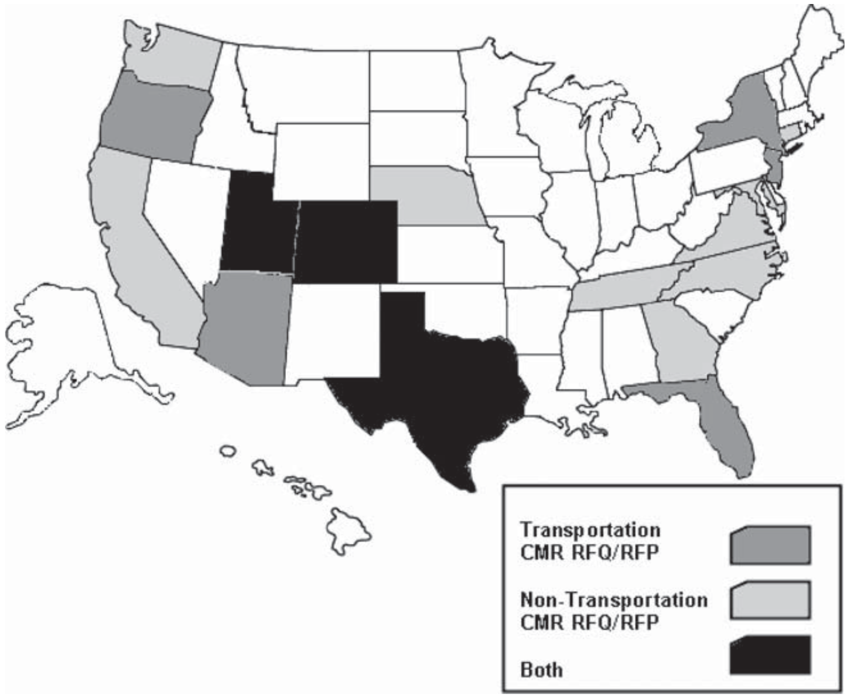

FIGURE 7 Locations of solicitation documents used in the content analysis.

project from 8 different states were analyzed. Additionally, 29 documents from 12 states related to non-transportation projects were analyzed. The content analysis includes documents from a wide range of monetary value, $2.25 million to $2.16 billion for transportation projects and $1.2 million to $114 million for non-transportation projects.

Case Studies

The primary source of information in this synthesis is the analysis of case studies. The analysis occurred on the following three levels:

1. Analysis of CMR highway road and bridge projects.
2. Analysis of corresponding public transportation agencies with CMR experience.
3. Analysis of case study projects from the airport, transit, and building sectors.

The case studies were collected using Yin's methodology for case study research data collection (Yin 1994). Therefore, the information gleaned from the case studies is coupled with information collected in the survey and the literature review to validate any conclusions drawn from the case studies. Note the case study information was gathered by both face-to-face and telephone interviews.

CASE STUDY SUMMARY

Case study data were collected based on the results of the literature review. The team proposed to identify and analyze at least four projects from across the spectrum of highway

TABLE 5
SOLICITATION DOCUMENT CONTENT ANALYSIS SUMMARY

Project Type	Transportation	Non-transportation
	Type of Organization	
State DOT	15	N/A
Other Public	10	29
	Monetary Range	
Low	$2.25 million	$1.2 million
High	$2.16 billion	$114 million
	Type of Procurement	
LOI	0	0
RFQ	10	9
RFP	15	12
RFQ + RFP	0	8

N/A = not available.

projects that had been delivered using the CMR project delivery method. The team was able to identify and gain access to information on ten projects worth more than $2.5 billion from nine agencies that represent the cross section of variations on CMR delivery. It is important to note that, to the best of our knowledge and confirmed by the survey, every state DOT with some form of CMR experience was contacted. The projects ranged from a low of $10.0 million to a high of $1.35 billion. The project types spanned the upgrade of pedestrian/bicycle access on an urban thoroughfare to a greenfield freeway to a billion dollar multi-modal terminal facility. Two different sets of contract responsibility were also found. The first is classic CMR delivery where the DOT holds both the design and the CMR contracts, and the second set involved the DOT in an oversight relationship on behalf of another agency that furnished the funds. Additionally, another enhancement to the original study plan was realized when the team was able to identify CMR projects where a state DOT actually delivered multi-modal facilities that interfaced with airports and seaports, as well as rail and light rail. Finally, case studies from the airport, rail transit, and building sectors are presented to allow the reader to compare and contrast the variations on CMR across these industry sectors with the cases from the highway sector.

The depth and validity of each agency interview was enhanced, where possible, by an interview with the contractor that held the CMR contract. This allowed the collection of information that compared and contrasted the owner's perceived benefits and constraints with a parallel set of benefits and constraints perceived by the contractor on the same project. Table 6 is a summary of the case study projects that were sampled for this report. One can see that the projects span from coast to coast but tend to be concentrated in the southwestern United States.

Details of each case study project are contained in Appendix C. The following sections will summarize those details and compare the various projects in the major categories of information that was collected.

TABLE 6
SYNTHESIS CASE STUDY PROJECT SUMMARY

Agency (case no.)	No. CMR Projects (abbr.)	Case Study Project (value/duration)	Construction Type (location)	Solicitation Type	Contract Type	Precon. Fee (% GMP)
Full CMR Experience						
Alaska DOT & PF (1)	1–5 (ADOT)	Fairbanks Airport Expansion ($99 million/24 mos.)	Terminal, apron, parking, road (Fairbanks, AK)	RFQ	Lump sum GMP	0.25%
City of Glendale, Arizona (2)	>10 (CGA)	Downtown Pedestrian Improvements ($16.2 million/10 mos.)	Lighting, landscaping, sidewalk, curb/etc. (Glendale, AZ)	RFQ	Lump sum GMP	1.10%
Florida DOT (3)	>10 (FDOT)	Miami Intermodal Center ($1.7 billion/60 mos.)	Road, bridge, rail, vertical, etc. (Miami, FL)	LOI	Unit price/ progressive GMP	0.02%
Oregon DOT (4)	1–5 (ODOT)	Willamette River Bridge ($150 million/48 mos.)	Bridge (Eugene, OR)	RFP	Lump sum GMP	0.15%
Pinal County, Arizona (5)	1–5 (PCA)	Ironwood ($63.7 million/36 mos.)	Road and bridge (Florence, AZ)	RFQ	Progressive GMP	0.60%
Utah DOT (6)	>10 (UDOT)	I-80/State St. to 13th ($130 million/18 mos.)	Road and bridge (Salt Lake City, UT)	RFQ + RFP	Unit price GMP	0.10%
CMR Oversight Experience for Another Agency						
Michigan DOT (7)	1–5 (MDOT)	Passenger Ship Terminal ($10 million/12 mos.)	Marine, pier, road (Detroit, MI)	RFQ	Lump sum GMP	0.50%
Non-Highway Sector Case Study Projects						
Utah Transit Authority (8)	1–5 (UTA)	Weber County Commuter Rail ($241 million/72 mos.)	Rail, bridge, road (Salt Lake City, UT)	RFQ	Lump sum GMP	0.21%
Memphis Shelby County Airport (9)	6–10 (MEM)	Whole Base Relocation ($245 million/36 mos.)	Vertical, apron, taxiways, utilities (Memphis, TN)	RFQ + RFP	Lump sum GMP	0.35%
Texas Tech University (10)	>10 (TTU)	Lanier Law School Center ($13.7 million/18 mos.)	Vertical, auditorium, offices (Lubbock, TX)	RFQ	Lump sum GMP	0.33%

RATIONALE FOR CHOOSING CONSTRUCTION MANAGER-AT-RISK PROJECT DELIVERY

The structured interviews asked each agency to explain their rationale for selecting CMR project delivery. First they were asked to identify the factors that they consider in making the project delivery selection decision and next they were asked to identify the reasons they selected CMR for the case study project. Tables 7 and 8 show the output from those questions. An analysis of Table 7 shows that the six major factors that are considered by at least eight agencies in their project delivery method decision are:

1. Monetary size
2. Budget control issues
3. Schedule issues
4. Technical complexity
5. Project type (typical agency project or nontypical agency project)
6. Project type (bridge/structure or road).

This shows that the agencies are considering alternative project delivery methods as a means to better grapple with the requirements of budget and schedule, as well as use project type and complexity as decision criteria when making the project delivery method decision. The table also shows that the main factors (at least five cites) that tend to drive that decision toward CMR are:

1. Schedule issues
2. Technical complexity
3. Third-party interface issues.

The driving factors are interesting in that they indicate that agencies are looking for constructor assistance in meeting aggressive schedules for complex projects where third-party stakeholders such as utilities, railroads, and permitting agencies could have an impact on the project's success. The reason why CMR was selected for each case study project shown in Table 8 confirm this observation.

TABLE 7
PROJECT FACTORS CONSIDERED IN PROJECT DELIVERY METHOD SELECTION DECISION

	Highway Projects							Non-Highway		
Project Factor	ADOT	CGA	FDOT	ODOT	PCA	UDOT	MDOT	UTA	MEM	TTU
Monetary size		X	X	X	X	X		X	X	X
Budget control issues	X	**X**	X	**X**	X	**X**		X	X	
Schedule issues		**X**	X	**X**	**X**	**X**		X	**X**	X
Technical complexity		**X**	X		X	**X**	**X**	**X**	X	**X**
Type (typical vs. non-typical)	**X**	**X**	**X**	X	X	X	**X**		X	
Type (bridge vs. road)			X			X			**X**	
Technical content	X		X			X	**X**	X	X	X
Location (urban vs. rural)			X	X	X	X		X		X
Environmental issues					X	X				
Third-party interface issues		**X**			**X**	**X**		**X**		**X**
Traffic control issues					X	X				
Quality assurance requirements						X			X	X
Life-cycle issues						X		X		X
Sustainability issues					X	X				X
Incentives for funding						X			X	
Generates revenues						X		X		
Staff review/ inspection reqts.		**X**		X	X	X				
Experience with delivery method				X	X	X		X		X
Staff availability				X	X	**X**	X	X		**X**
Include specific innovation			X		X	**X**				
Public interface				**X**	**X**			X	**X**	X

Note: Bold indicates a factor that drives the decision toward CMR.

TABLE 8
REASONS FOR SELECTING CMR ON CASE STUDY PROJECT

	Highway Projects							Non-Highway		
CMR Reasons	ADOT	CGA	FDOT	ODOT	PCA	UDOT	MDOT	UTA	MEM	TTU
Accelerate delivery period	X	X	X	X	X	X	X	X	X	X
Establish budget early	X	X		X		X	X	X	X	X
Constrained budget	X	X	X	X		X	X		X	X
Early contractor involvement	X	X	X	X	X	X	X	X	X	X
Encourage innovation		X	X			X	X	X		
Facilitate value engineering		X	X	X	X	X		X	X	X
Encourage constructability	X	X	X	X	X	X	X	X	X	X
Encourage price competition		X				X			X	
Compete different design solutions						X				
Redistribute risk	X	X	X	X		X			X	X
Complex project requirements	X	X	X		X	X	X		X	X
Flexibility during construction	X	X	X		X	X	X	X		X
Third-party issues	X	X		X	X	X	X	X	X	X
Reduce life-cycle costs		X				X				
Provide follow-on O&M		X				X				
Innovative financing		X			X	X				
Encourage sustainability										X
Reduced staffing						X		X		
Reduced review/inspect.										X
Legal requirements									X	

O&M = operations and maintenance.

CONSTRUCTION MANAGER-AT-RISK PROCUREMENT PROCEDURES

The study found that three different models are in use for procuring CMR projects. These will be discussed in detail in chapter four. Table 9 illustrates the content of each case study project's solicitation documents. The striking thing is the simplicity of most of the solicitations. This shows the major difference between CMR and the other project delivery methods. Because the total construction cost is not part of the selection process, this permits the content of the solicitation documents to be relatively straightforward. Four of the projects included preliminary plans and specifications. Three of the projects made do with only a narrative

TABLE 9
CASE STUDY SOLICITATION DOCUMENT CONTENT

RFQ/RFP	RFQ					RFP			RFQ/RFP	
content	ADOT	CGA	FDOT	MDOT	PCA	ODOT	TTU	UTA	MEM	UDOT
Description of scope of work	X	X	X	X	X	X	X	X	X	
Preliminary plans/specs.			X		X				X	X
Quality mngt. roles and responsibilities					X	X	X	X		X
Design criteria						X				

description of the project. Half the projects listed the roles and responsibilities of the CMR and the owner with regard to quality.

To respond to the solicitation, each competing CMR prepares a submittal that incorporates all the information that the agency wishes to evaluate. As one moves from left to right in Table 10, the size of the proposal gets larger. The primary difference between the RFQ model and the other two models is the lack of cost information. Thus, in the RFQ model, the agency is selecting its CMR solely on a basis of qualifications and past performance. This is the way design professionals are typically selected.

It is noted that there are no obvious differences between the highway and non-highway agency case study requirements in the previous four tables. Therefore, it appears that highway agencies can use examples from other transportation and building sectors in their states. Specifically, comparing UDOT and Utah Transit Agency (UTA) shows that whereas there are differences in the content of their solicitation documents and proposal submittal requirements, those differences are not skewed to or away from any single category.

Once the submittals are received, the CMR selection process begins. In all cases, it was composed of an evaluation of the written statement of qualifications (SOQ)/proposal and an interview/presentation made by the competing CMRs. Table 11 shows the difference between each case study agency's selection process. It shows that most keep the presentation focused on the CMR's qualifications and experience. There is also strong preference to direct point scoring and weighted categories to determine the winner. Price was also used as a selection factor by four of the five RFP agencies.

CONSTRUCTION MANAGER-AT-RISK PROJECT ADMINISTRATION

The major element of CMR project administration is the decision to establish the GMP. This aspect will be discussed in detail in chapter six. Table 12 shows how each case study project compares with regard to the type of contract used, the timing of the GMP, and the way contingencies were handled. The progressive GMP system allows the CMR to price work and bid out work packages as soon as they are complete. This allows construction to begin before design is complete without forcing the CMR to include a large contingency for the undersigned features of work. The table shows that all cases

TABLE 10
CASE STUDY SUBMITTAL CONTENT

RFQ/RFP requirements	RFQ					RFP			RFQ/RFP	
	ADOT	CGA	FDOT	MDOT	PCA	ODOT	TTU	UTA	MEM	UDOT
Organizational structure/chart	X	X		X			X		X	X
Past CMR experience		X	X	X	X	X	X	X	X	X
Past related experience	X	X	X		X	X			X	X
References		X		X	X	X	X	X	X	X
Qualifications										
Project Manager	X	X		X	X	X	X	X	X	X
Precon. Manager		X			X				X	
General Superintendent					X				X	X
Quality Manager	X							X	X	
PR person					X	X	X			X
Quality plan		X		X		X	X		X	
MOT plan							X		X	X
PR plan					X	X	X			
Preliminary schedule				X	X	X	X		X	X
Self-performed work				X	X		X		X	
Sub plan				X			X		X	X
DBE plan				X			X			
Precon. fee						X	X	X	X	X
Construction fee						X	X		X	
General conditions						X	X	X	X	
Rates for self-performed work									X	X
Budget analysis					X		X	X	X	X

Precon. = preconstruction; DBE = Disadvantaged Business Enterprise.

TABLE 11
CASE STUDY SELECTION PROCESS CONTENT

	RFQ					RFP			RFQ/RFP	
	ADOT	CGA	FDOT	MDOT	PCA	ODOT	TTU	UTA	MEM	UDOT
Presentation										
Corporate qualifications/ past projects	X	X		X	X	X	X	X	X	X
Qualifications/ key personnel	X									X
Project-specific issues					X		X	X	X	X
Precon. services components			X							
Public info. plan					X					
Method to Identify the Winner										
Direct point scoring in *unweighted*			X							
Direct point scoring in *weighted*	X	X		X	X	X		X	X	X
Adjectival rating in *unweighted*							X			
Price as criterion						X	X		X	X
Price Factor Weight										
0%–25%						X	X			
26%–50%									X	

TABLE 12
CASE STUDY GMP ASSEMBLY AND TIMING

	Highway Projects							Non-Highway		
Contract Type	ADOT	CGA	FDOT	ODOT	PCA	UDOT	MDOT	UTA	MEM	TTU
Lump sum GMP	X	X		X	X		X	X	X	X
Unit Price GMP			X			X				
Unit Price no GMP						X				
Preconstruction only hard bid						X				
Point where GMP negotiated										
Before 100% design	X	X	X	X	X		X	X	X	X
After 100% design						X				
Early as possible agency call	X		X	X						X
Early as possible CMR call						X			X	
After sub bids		X			X		X	X		
Progressive GMP		X			X	X				
Transparent contingencies	X	X	X	X	X	X	X	X	X	X
Single				X		X			X	
Owner and CMR		X			X		X	X		X
Management reserve + contingency	X		X							

TABLE 13
CASE STUDY PRECONSTRUCTION SERVICES

Preconstruction Services Included	Highway Projects							Non-Highway		
	ADOT	CGA	FDOT	ODOT	PCA	UDOT	MDOT	UTA	MEM	TTU
Validate agency estimates	X	X				X	X			
Validate agency schedules	X	X				X				
Validate agency/consultant design	X	X			X	X	X	X		
Prepare project estimates	X	X	X	X	X	X		X	X	X
Prepare project schedules	X	X	X	X	X	X	X	X	X	X
Input to agency/consultant design	X	X	X	X	X			X	X	X
Constructability review	X	X	X	X	X	X	X	X	X	X
Cost engineering reviews		X	X	X	X	X		X	X	X
Value analysis	X	X	X	X	X		X	X	X	X
Market surveys					X			X		X
Coordinate with third party stakeholders	X	X		X	X	X	X	X	X	X
Assist in right-of-way acquisition					X			X		
Assist in permitting actions					X			X		X
Public information					X	X				X

had transparent contingencies and all but one set the GMP before 100% design.

PRECONSTRUCTION SERVICES

The ability to involve the contractor in the design phase occurs through the preconstruction services contract. This will be discussed in detail in chapter five. Table 13 shows how each case study agency configured the services it wanted from the CMR. The table shows that scheduling, estimating, and constructability reviews are the most prevalent preconstruction services. Additionally, value analysis and coordination with third-party stakeholders are also very common to these contracts.

SUMMARY

The salient aspects of each case study will be compared and contracted in the remaining chapters of this report. The information gleaned form the case study projects forms the foundation upon which the conclusions, effective practices, and lessons learned are based.

CHAPTER THREE

PROCEDURES

INTRODUCTION

SEP-14 was launched to allow the FHWA the ability to implement, on an experimental basis, various contracting practices suggested by DOTs (*Transportation Research Circular 386* 1991). Under SEP-14 and later laws allowing the use of alternative practices agencies requests approval for use of the alternatives. It has been stated that,

> Quasi-public and government organizations predominately use the design-bid-build method, but clearly, many have tried other methods and most would consider either CM-at-risk or design-build to be the best-value alternatives. Changing the delivery methods used, in the case of these organizations, will often require changing laws and politics, but that is happening, too, because the public is best served when it gets the best value for its tax dollars. . . . CM-at-risk will likely become the more dominant delivery method for this group as long as the experience is positive (Doren 2005).

In addition to the federal laws, it is important that the DOTs consider state and local laws pertaining to project delivery and contracting. To implement alternative project delivery methods DOTs have established methods of selecting projects that are appropriate for alternatives, such as CMR, and procedures for execution.

STATE LAWS

State laws can be more restrictive than federal laws pertaining to the use of alternative project delivery methods such as CMR. In the survey, conducted as part of the report, respondents were asked about the laws in their states pertaining to CMR (see Table 14). All 47 states that responded to the survey are allowed to use DBB within the DOT. Only 26% of the respondents are allowed to use CMR, whereas 62% are allowed to use DB for DOT projects. When asked about other agencies within the state using CMR, 36% of the respondents indicated that other public agencies in their state have the authority to use CMR. Seventy-nine percent of the respondents did not know of other transportation-related agencies in their region that use CMR.

A survey conducted by the AGC and the National Association of State Facilities Administrators explored the legal status of CMR in five areas in all 50 states and Washington, D.C. The five areas of interest were state building construction, schools for kindergarten through twelfth grade, higher education, local government, and horizontal non-building DOT projects. The survey found that 38 states allow CMR in at least one of these areas. Seven states do not allow CMR in any of the areas investigated and three states were across the board inconclusive. For DOT projects 12 states plus Washington, D.C. allow CMR, 24 states do not, and 14 states were inclusive (see Table 15) ("Nationwide CM at-Risk Survey Results" 2009). Note that these figures are somewhat at odds with those shown in Figure 6, which are the output of the survey. This is probably because of the difference in timing of the literature sources and the survey respondents' knowledge. It is also likely that some of the survey respondents did not know and reported that they could not use CMR because they have never used it. Therefore, they are reported as inconclusive and the reader take care to not draw conclusions about the status of CMR in those states.

Use of Construction Manager-at-Risk

When considering use of alternative delivery methods one needs to consider owner attributes as well as project attributes. The literature, case studies, and content analysis of solicitation documents of this project find similarities in the characteristics described. The literature and case studies provide most of the information, as the content analysis of solicitation documents remains fairly silent on the decision of project delivery methods (see Table 16).

Appropriate Owner Characteristics

When considering the use of an alternative project delivery method an owner first considers if the authority exists to use the method. If the authority exists then the owner needs to determine if it is compatible with the chosen system. Factors to consider include:

- Construction sophistication,
- Current capabilities,
- Risk aversion,
- Restrictions on methods, and
- Other external factors (Gordon 1994).

The *Oregon Public Contracting Coalition Guide to CM/GC Contracting* (Gambatese et al. 2002) echoes these ideas and states "that a significant amount of owner participation is

TABLE 14
AUTHORITY TO USE PROJECT DELIVERY METHODS BY STATES

	No. of responses	Percentage of responses
Delivery method allowed by DOT		
DBB	47	100
CMR	12	26
DB	29	62
CMR use allowed by other public agencies in state		
Yes	17	36
No	27	57
Dont know	3	6
CMR use by other transportation-related public agencies in region		
Yes	10	21
Not that I know of	37	79

required compared with other contracting methods. The owner participates and collaborates to a great extent with the other project team members to administer and coordinate the CM/GC process, identify and develop the project scope, manage the project budget, and evaluate and negotiate changes. The public agency maintains sufficient resources available to undertake these duties." Further, "the mindset which the owner brings to the project is of importance as well. It is critical to the success of the project that the owner view CM/GC as a collaborative, coordinated process as opposed to separate and confrontational." The "owner must be able to make timely decisions," and "owner personnel assigned to the project should have the authority to make the needed decisions . . . [and] stay abreast of what is happening on the project" (Gambatese et al. 2002).

Appropriate CMR Projects

The selection of a project delivery method for a particular project is dependent on a number of factors. These project factors may include:

- Time constraints,
- Flexibility needs,
- Preconstruction services needs,
- Design process interaction, and
- Financial constraints (Gordon 1994).

More specifically, the *Oregon Public Contracting Coalition Guide to CM/GC Contracting* (Gambatese et al. 2002) notes that "the benefits resulting from the use of CM/GC can be greatest for projects that":

- Are high risk,
- Possess a high level of technical complexity,
- Are governed by significant schedule constraints,
- Require complex phasing,
- Contain budget limitations requiring a construction cost guarantee during design, or
- On which value engineering will result in substantial cost savings.

An evaluation of projects completed by UDOT found that "CMGC requires additional preparation and effort in the Concept Development stage . . . however, contractor involvement in design reduced errors and improves constructability. . . In general, DB will support large projects with little right of way or utility risk while CMGC is more useful

TABLE 15
AGC AND NASFA SURVEY OF LEGISLATION FOR DOT PROJECTS

Allow DOT CMR	Do not allow DOT CMR		Inconclusive
Alaska	Alabama	Minnesota	Hawaii
Arizona	Arkansas	Mississippi	Idaho
Colorado	California	Missouri	Kentucky
Florida	Connecticut	Nebraska	Maine
Michigan	Delaware	New Hampshire	Maryland
Nevada	Georgia	New Mexico	Montana
Oregon	Illinois	North Carolina	New Jersey
Rhode Island	Indiana	Ohio	New York
Texas	Iowa	South Carolina	North Dakota
Utah	Kansas	South Dakota	Oklahoma
Washington	Louisiana	Vermont	Pennsylvania
Washington, D.C.	Massachusetts	West Virginia	Tennessee
Wyoming			Virginia
			Wisconsin

Source: "Nationwide CM at-Risk Survey Results" (2009).

TABLE 16
OWNER AND PROJECT CHARACTERISTICS THAT LEND THEMSELVES TO CMR PROJECT DELIVERY

Characteristics	Gordon (1994)	Gam-batese et al. (2002)	Alder (2007)	Trauner (2007)	Anderson & Damn-janovic (2008)	Case Studies (Table 1 case no.)	Content Analysis
Owner Characteristic							
Sophisticated construction experience	X	X	X			All	
Sufficient resources	X	X				2,3,4,5,6, 8,10	
No opposition or restrictions to CMR	X		X	X		All	
Project Characteristic							
Benefit from integrated design	X		X	X		All	2
Benefit from augmented resources				X	X	5,8,9	
Constructability essential for project success			X	X		All	1
Volatile material costs				X	X	1,2,6,7,8, 9,10	1
Financial constraints	X	X	X	X		1,2,3,4,6, 7,9,10	2
Needs flexibility during construction	X					1,2,3,5,6, 7,8,10	
Technically complex		X				1,2,3,5,6, 7,9,10	2
Need to manage possible public controversy				X	X	4,5,8,9,10	
Phased construction		X	X	X	X	2,3,5,6,8,9	1
Flexible risk distribution						1,2,3,4,6, 9,10	1
Explore innovation and technology				X	X	2,3,6,7,8	1
Benefit from preconstruction services needs	X					All	
Specialized resources needed					X	1,3,6,7,8,9	
Time constraints	X	X		X	X	All	3
Opportunities for value engineering		X	X			2,3,4,5,6, 8,9,10	1
Third party concerns (utility, railroad, etc.)			X	X		1,2,4,5,6, 7,8,9,10	1

for projects with right of way and utility concerns and where UDOT wants to control design and select innovative solutions that a contractor is not experienced with" (Alder 2007). One benefit of CMR is that the contractor is selected before completion of the design so that the design can be tailored to the contractors experience, methods, and techniques.

In 2007, Trauner Consulting Services (2007) submitted a report to the California DOT (Caltrans) regarding innovative procurement practices in which it evaluates selected strategies. This evaluation includes a set of project selection criteria.

- Large projects with multiple phases and contracts;
- Fast-tracking—Staged construction;
- Time-sensitive construction;
- Limited internal agency management resources and expertise;
- Requirement for specialized resources or expertise;
- Limited time or funding constraints;
- Minimal public controversy;
- Complete or obtainable environmental documents and permits for the entire project;
- Established project footprint;
- Well-defined project conditions, with minimal third-party conflicts/uncertainties; and
- Acquired right-of-way (Trauner Consulting Services 2007; Anderson and Damnjanovic 2008).

Before making the decision regarding project delivery methods DOTs need "to create a project selection tool." This "would involve developing a process to align project goals and objectives with the alternative delivery, procurement, and contracting methods that would most likely achieve these objectives (Trauner 2007)." Project objectives that align with CMR include:

- Accelerate delivery,
- Promote innovation,

- Enhance quality/performance,
- Early cost certainty, and
- Staffing considerations (Anderson and Damnjanovic 2008).

UDOT has a process that involves project screening for the use of CMR, which includes "justification, geographic location, and project type. Project justification will include a comparison of using Design/Build vs. Design/Bid/Build vs. CMGC. The comparison of the three contracting methods may include an evaluation of risk, schedule, design, environmental, material availability, and innovation" (Alder 2007). This comparison also involves design and constructability, costs, project types, and impacts on the public (Alder 2007).

PROJECT DELIVERY PROCEDURES

CMR is well-accepted in Utah and, as a result, UDOT has developed a formal procedure for its use. This includes a concept development, design, and construction phase (see Figure 8). The concept development phase includes three sub-processes, the design phase two sub-processes, and the construction phase one sub-process (Alder 2007).

The focus of the concept phase includes the identification of risks and analyzes them within the scope of the possible project delivery methods. If the analysis points to CMR as the appropriate delivery method, then the process moves into the design phase and selects a consultant to begin the design and the CMR. Early work packages are also procured during this phase by the CMR. Once a GMP has been established, the project moves to completing the construction. The overall process described for UDOT is similar to every other project delivery system in that it starts with a concept, design follows, and finally, construction. The difference is who is involved and how they are involved in the various phases.

Within the UDOT concept development phase, the project delivery methods are evaluated (see Figure 9). As previously discussed, this involves a comparison of project delivery methods on a number of different levels including risk, location, and other factors. The outcome of this process is the determination of the project delivery system (Alder 2007).

This process starts with a risk analysis for the project. An evaluation team is then assembled to explore the use of the different delivery methods. This involves a consideration of project characteristics and how these characteristics align with the strengths and weaknesses of the delivery methods. When considering CMR the process also involved consideration of the funding source. If federal funds are included than the FHWA approves the use of CMR. If the FHWA does not approve the project for CMR, the evaluation team reevaluates the project characteristics and delivery methods. The point here is that UDOT looks at CMR if the comparison between DB and DBB does not indicate DB. Thus, it uses CMR as a means to capture the integration benefits found in DB without the loss of design control.

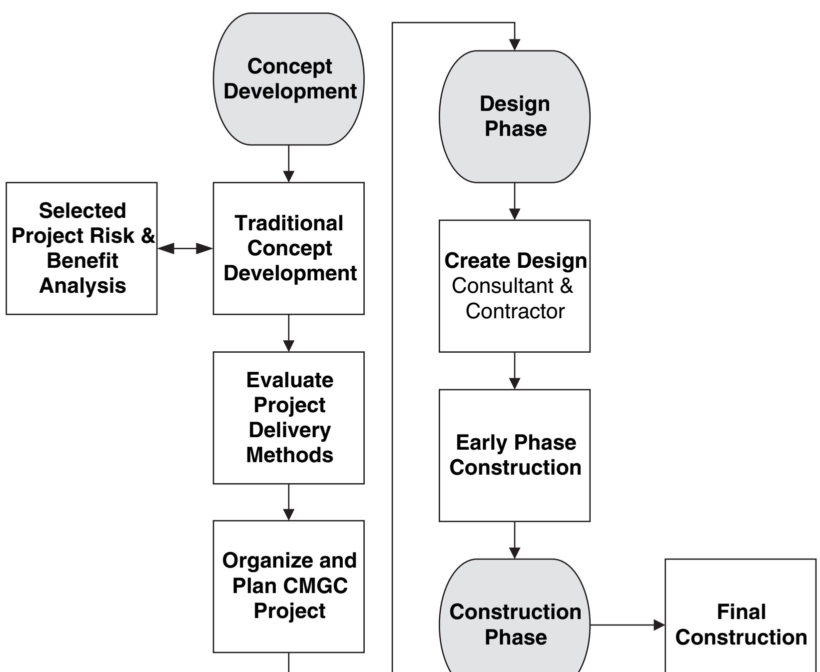

FIGURE 8 UDOT CMR process (adapted from Alder 2007).

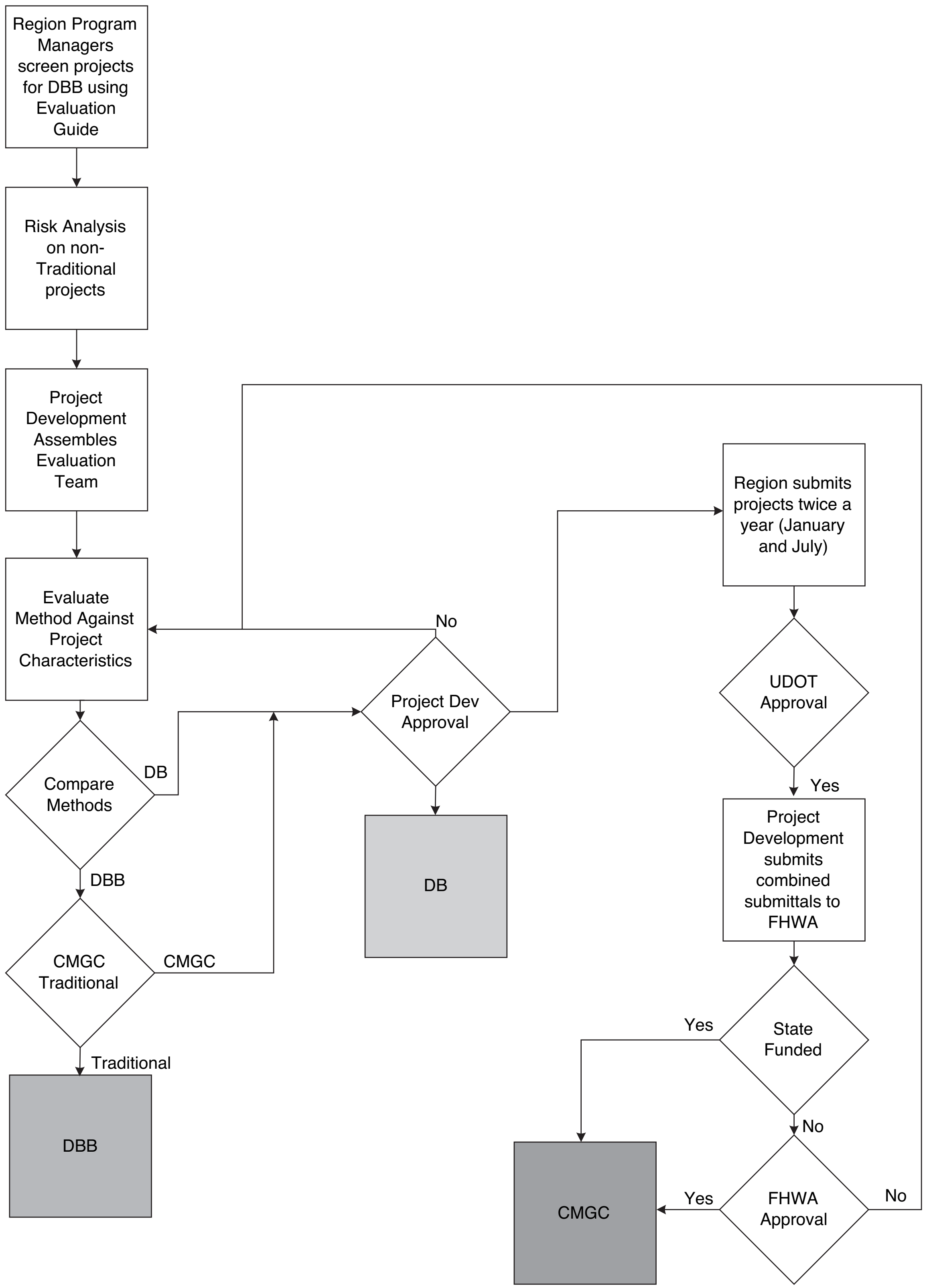

FIGURE 9 UDOT evaluates contract delivery methods process (adapted from Alder 2007).

The final sub-process in the Concept Development Phase is to Organize and Plan CMR Project (see Figure 10). This sub-process includes determining who at UDOT is going to be on the project team. Once the team is selected, the project tasks are identified and assigned. UDOT then begins to develop the scope in greater detail and select a contract method for the project. An independent cost estimate (ICE) is also developed by a consultant. The RFQ is then developed or a contractor is chosen from a pool. Once the consultant is selected a contract is negotiated. Finally, UDOT and the other parties develop a staffing plan, financial plan, the project schedule, and the cost of the project.

Once the UDOT team is selected, the process then moves to the Design Phase (see Figure 11). The Design Phase includes selection of the designer and selection of the contractor. Estimates are produced and the CMR is either awarded the project or not. If not, and there is a decision not to continue to work with the CMR, the project is advertised and awarded to a low bid contractor. If UDOT decides to continue to work with the CMR the design is refined. Once the contract for construction is awarded construction can commence.

Within the Design Phase there is a contractor selection sub-process (see Figure 12). This sub-process involves the

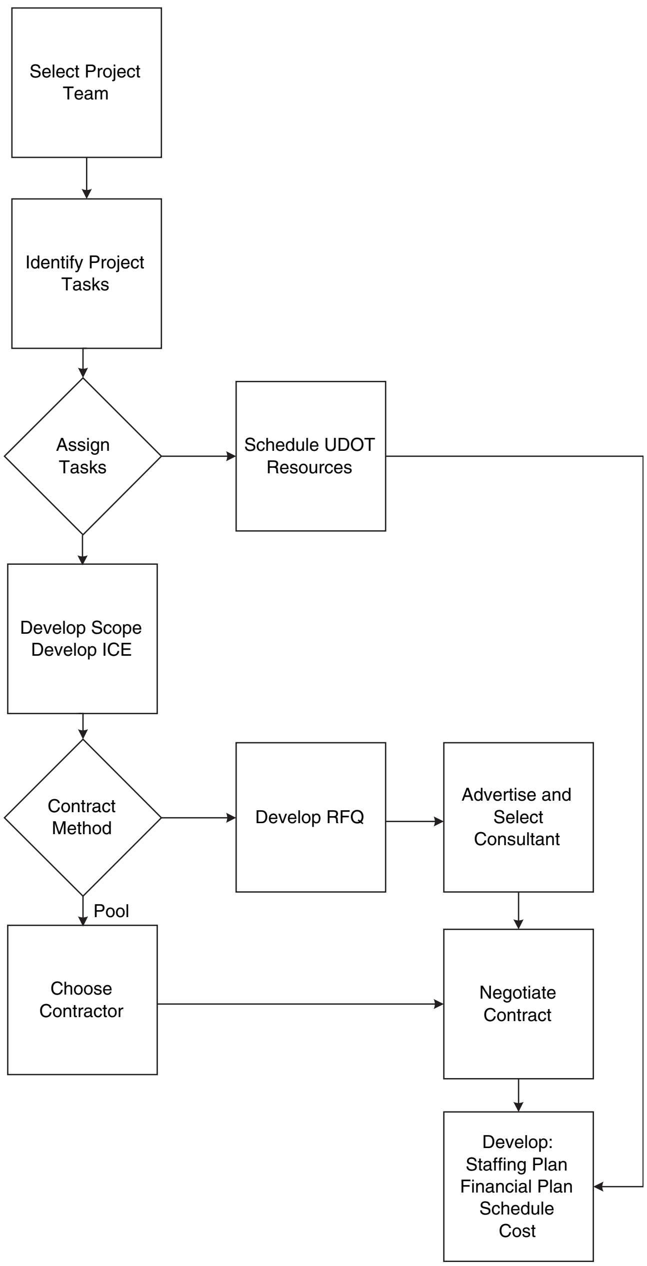

FIGURE 10 UDOT organizes and plans CM/GC project sub-process (adapted from Alder 2007).

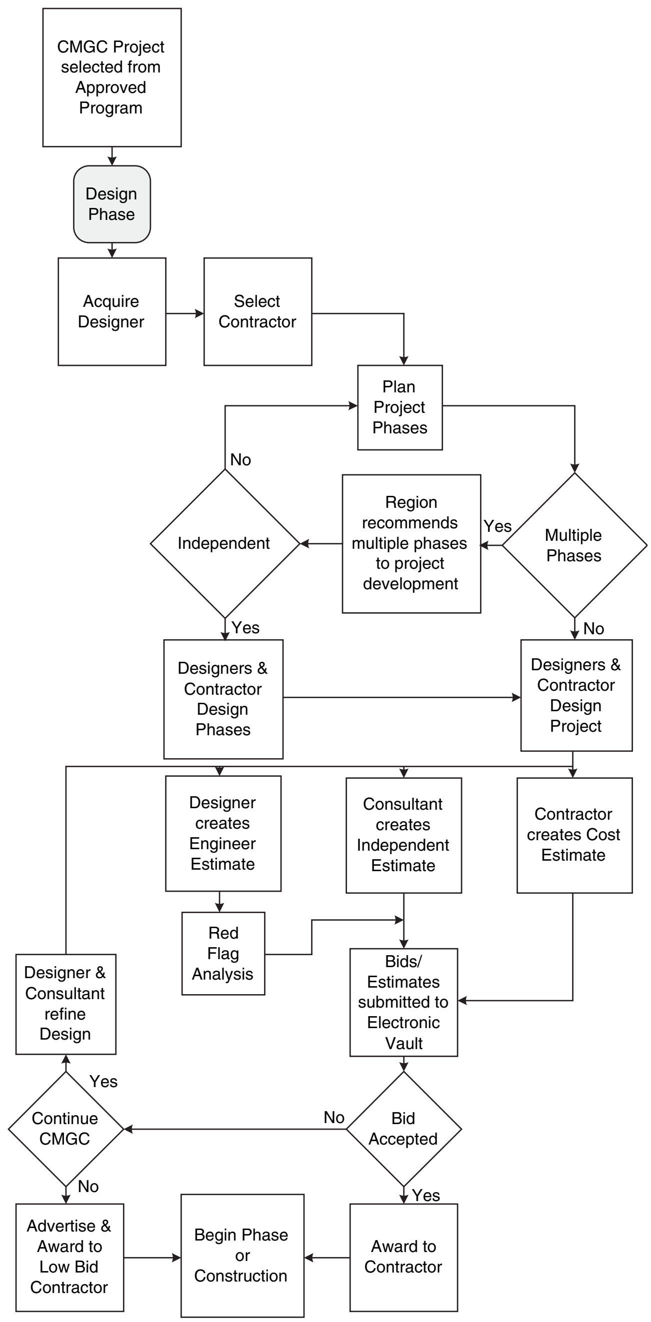

FIGURE 11 UDOT design phase (adapted from Alder 2007).

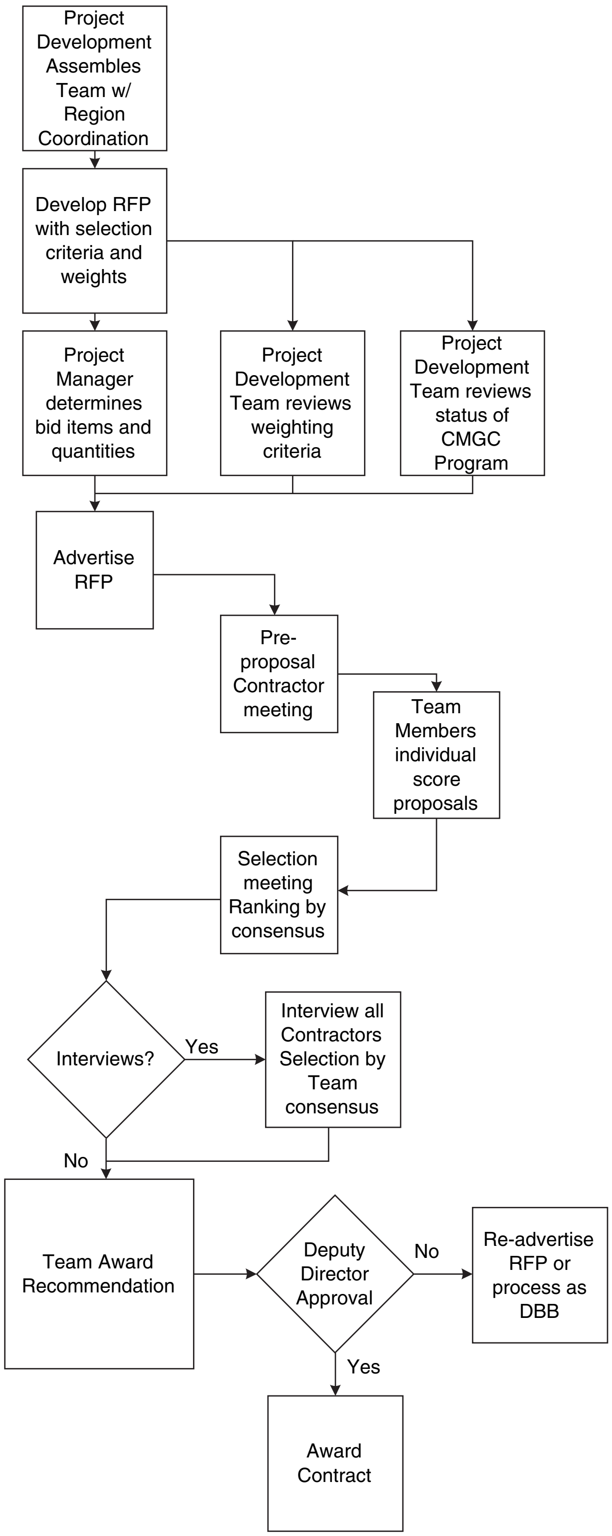

FIGURE 12 UDOT contractor selection sub-process (adapted from Alder 2007).

selection of a team that evaluates the proposals, possibly interviewing the proposers, and making a recommendation about contractor selection. The final outcome of this sub-process is either the award of the CMR contract, re-advertisement of the RFP, or deciding to continue with the project through DBB.

SUMMARY

Assuming that the laws are in place to allow for the use of CMR, owners using CMR typically consider their own characteristics as well as those of the project before deciding to use CMR project delivery. A documented procedure for project delivery selection may also prove helpful.

Conclusions

It is concluded from the literature, case studies, and content analysis that important characteristics for agencies that want to use CMR are as follows:

- Sophisticated construction experience;
- Adequate level of resources for current projects; and
- Minimal policy, statutory, and political constraints on implementing CMR project delivery method.

Additionally from the same analysis, the characteristics of a project that is a good candidate for CMR project delivery as found in the three study instruments are:

- Requires integration of the design process with construction expertise,
- Requires constructability,
- Early cost certainty,
- Control costs owing to financial constraints,
- Meet schedule challenges,
- Large project size,
- Multiple construction phases,
- Opportunity to promote innovation,
- Ability to implement value engineering, and
- Need/ability to manage third-party issues (utilities, railroads, business impact, public relations, etc.).

Effective Practices

One effective practice was identified. Owners develop a documented procedure for selecting CMR as the project delivery method based on project characteristics.

CHAPTER FOUR

CONSTRUCTION MANAGER-AT-RISK SELECTION METHODS

INTRODUCTION

One of the advantages of CMR as cited in Table 1 was the ability to select the contractor on the basis of its qualifications, past performance, and record of success. *NCHRP Synthesis 390* concluded that "the 'soft' factors related to managerial competence and past performance are more important to the prequalification process than the 'hard' aspects related to bonding and financial status" (Gransberg and Riemer 2009). Hence the procurement method used for CMR project delivery follows a "best-value" process. The following is its definition from *NCHRP Report 561:*

> Best-Value—a procurement process where price and other key factors are considered in the evaluation and selection process to enhance the long-term performance and value of construction (Scott et al. 2006).

NCHRP Report 561 goes on to describe the fundamental theory of best-value procurement. That description is worth repeating in this synthesis because it essentially forms a foundation around which CMR selection methods can be designed and evaluated.

> Best-value procurement methods allow various elements to be considered in selecting a contractor on the basis of performance. Objective elements include contractor experience with similar projects, completion within schedule, compliance with material and workmanship requirements, timeliness and accuracy of submittals, and record of safety. Subjective elements include effective management of subcontractors, proactive measures to mitigate impacts to adjacent properties and businesses, training and employee development programs, corporate commitment to achieving customer satisfaction, and client relations. These elements not only affect the ultimate performance and overall cost of the completed facility, but also contribute to the efficient execution of the work. Efficiency is very important to contracting authorities that are interested in a high level of public acceptance. It is also recognized that, because of constrained staffing and budgets, it is not possible for state agencies to "inspect" quality into the work. Therefore, a procurement process is needed that *considers value-related elements in awarding contracts* (Scott et al. 2006; italics added).

The layman's definition of best-value selection systems is simply selecting a contractor on a basis of something other than price alone. The selection methods found in the case study of CMR projects ranged from pure qualifications-based selection (QBS) to combining qualifications, proposed schedule, proposed fees, and unit prices for selected critical pay items. None awarded to the lowest bidder. The design industry is represented by the American Council of Consulting Engineers (ACEC), which is the primary advocate of QBS for awarding design contracts.

CONSTRUCTION MANAGER-AT-RISK SELECTION MODELS

CMR selection processes and procedures were found in four study instruments. The combination of the case studies, the content analysis, the contractor interviews and the literature review found that there are three standard models for selecting a CMR. Table 17 shows the frequency of each of the four possible options found in the study. They are differentiated by whether or not the competitors are asked to include proposed fees and other costs and whether the selection decision is made in one step or two steps.

The LOI and the RFQ only solicitations are essentially the same process. The difference is only in the level of detail requested in the submittal. Therefore, these two can be combined and that leaves three models from which an agency can pick to develop its CMR selection process. The three models are:

1. One-step QBS selection—One-step response to an RFQ only.
2. One-step Best-value selection—One-step response to an RFP only.
3. Two-step Best-value selection—Two-step response to RFQ and RFP.

As a result of this synthesis, three figures were derived from the analysis, one to represent each of these selection models. Each includes information regarding the actions for the CMR or its staff and actions by the agency. Also contained in each figure is an example of the information that is included in the response to solicitation documents.

One-Step Qualifications-Based Selection Construction Manager-at-Risk Selection Model

The first selection method is the QBS One-step model. This model is the simplest and probably the fastest CMR selection method. Four of the ten case study projects have used this method: the Alaska Department of Transportation and Public Facilities (DOT&PF), MDOT, city of Glendale, and Pinal County. It used an even simpler form. FDOT issues a request

TABLE 17
PROCUREMENT TYPE FINDINGS

Research Instrument	Procurement Type			
	LOI	RFQ Only	RFP Only	RFQ/RFP
Content Analysis: Transportation	0	10	15	0
Content Analysis: Non-Transportation	0	9	12	8
Highway Agency Case Study	1	4	1	1
Non-Highway Agency Case Study	0	0	2	1
Contractor Interviews	1	4	1	1
Literature Review	0	2	5	4

for a LOI along with a preliminary set of plans and specifications that only seek a limited amount of qualifications and past performance data. The competitors that are found to be minimally qualified are then interviewed from a pre-published set of questions. The selection decision is then made based on the results of interviews. To keep the numbers straight, FDOT is included in the QBS One-step group for analysis. Additionally, 18% of the transportation solicitation documents reviewed in the content analysis used one-step QBS and 17% of the non-transportation documents fell into this category.

The RFQ contained a description of the scope of work in all five cases. In two cases preliminary plans and specifications are also provided (FDOT and Pinal). Finally, Pinal County also included a description of the agency's quality management roles and responsibilities and expects the competitors to organize to satisfy those requirements. The SOQ submittal requirements for the competing CMRs are shown in Table 18 for those items found in at least two cases. The top three are the qualifications of the project manager, the company's prior experience executing CMR projects, and the company's experience on other projects of a similar type. Figure 13 shows how the various components in this model relate to one another.

Figure 13 illustrates the flow of documents and decisions through this model. Once a CMR is selected, the remainder of the contract is formed through negotiation. Nothing from the SOQ is carried forward to the GMP. Two of the agencies (Pinal County and MDOT) asked the CMR to declare the work packages that it intended to self-perform. Both allow the CMR to prequalify and select its subcontractors without constraint. MDOT limits the CMR to self-performing 35% of the contract and Pinal County's limit is 45%. Of the five, Pinal County asks for the most information in the SOQ. One interesting requirement is a critical analysis of the project's published budget. They also ask for a preliminary schedule and a public relations plan with the qualifications of the public information manager. Hence, this agency has some quantitative information that it can refer to in the GMP negotiations. Asking for the budget analysis also allows the CMR to express its budget concerns, if any, before award. So if the CMR's final GMP is higher than the county hoped, it is not a surprise. The preliminary schedule serves much the same purpose to justify time growth.

Figure 13 shows that the agency can ask for anything that it believes will assist it on selecting the best-qualified CMR. However, when approaching QBS, the agency restricts itself to items that assist it in discriminating between highly qualified competitors rather than accumulating submittals that essentially say the same thing. Therefore, if the CMR's safety plan is cogent to the selection process, the agency has justification to ask for those parts of the overall plan that will help it identify the best plan. Every contractor will require its personnel to obey Occupational Safety and Health Administration constraints. Therefore, having the entire safety plan before award has limited utility. However, asking each competitor to detail its plan for protecting the public during construction in an area with a large volume of pedestrian traffic (city of Glendale case study) will draw different approaches from different contractors. This then allows the agency to effectively rate both the CMR's understanding of the hazards and the realism of its proposed solution.

In Figure 13, once a CMR is selected the process proceeds to the provision of preconstruction services and a negotiation of the GMP as the design is developed. The important point

TABLE 18
ONE-STEP QBS STATEMENT OF QUALIFICATIONS (SOQ) SUBMITTAL CONTENTS

SOQ Requirement	No. Agencies Requiring
Qualifications of the CMRs project mana ger	5
Past CMR project experience	4
Past related project experience (non-CMR)	4
References from past projects	3
Organizational structure/chart	3
Qualifications of the CMR's preconstruction services manager	2
Construction quality management plan	2
Declaration of self-performed work	2
Preliminary project schedule	2

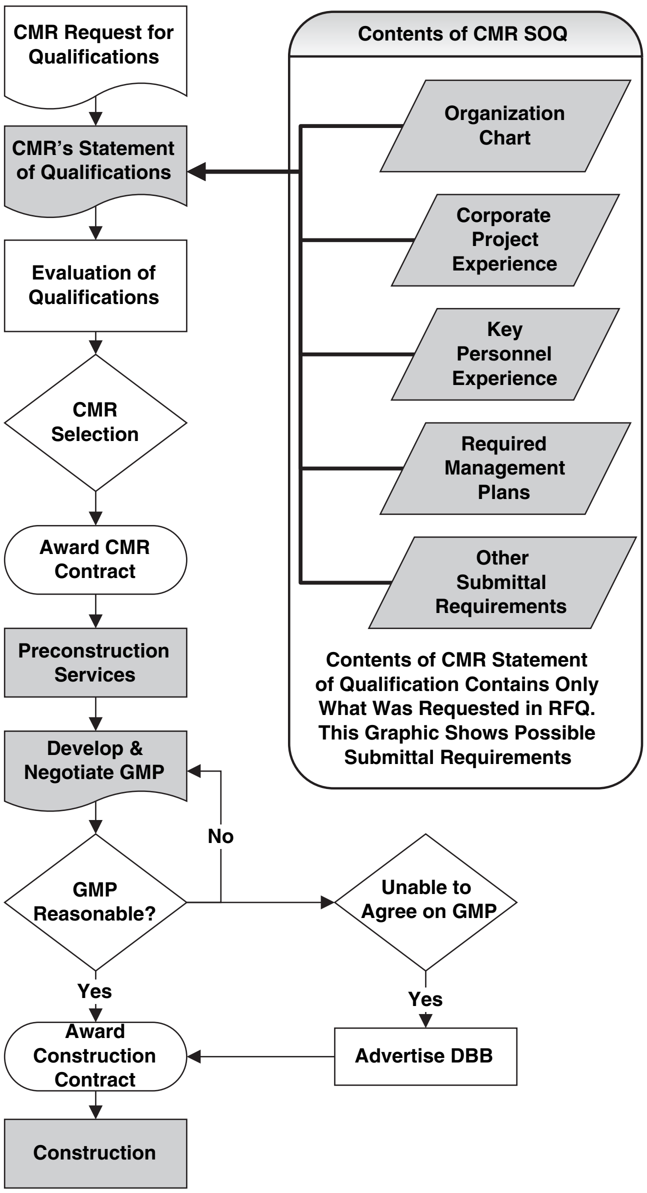

FIGURE 13 QBS one-step CMR selection model. (Shaded areas are actions by the CMR or its staff; unshaded areas are agency actions.)

in this model is the need for agency documentation of the discussions held during the interviews. There is also a need to ensure that the SOQ commitments for specific individuals has been achieved; these could potentially influence the GMP itself. For instance, if a given subcontractor named in the SOQ later becomes unavailable to work on the project, the GMP line for that trade may change. A similar issue arises in the quality assurance (QA) program. The cost of the QA/QC (quality control) tasks that were assigned to the CMR will be reflected in the GMP and the agency can evaluate the thoroughness of the program by looking at how much money has been assigned to cover its costs. To summarize, the one-step QBS CMR selection model is the simplest procedure of the three. Therefore, it can be fast and uncomplicated. The trade-off is the lack of quantitative cost information that can be carried forward to GMP negotiations.

One-Step Best-Value Construction Manager-at-Risk Selection Model

The one-step best-value model looks similar to a one-step DB procurement used by the federal government before 1996 (Gransberg et al. 2006). The major difference is that the proposed costs are not a lump sum price for the project. In this model, the competing CMR firms are asked to furnish their qualifications, proposed fees, and other technical information such as a conceptual schedule or manufactures' catalog cuts for specific alternative technical concepts. The selection panel then evaluates the proposal and selects the winner using a best-value award algorithm that was published in the RFP. The mechanics of this model are shown in Figure 14.

This model was used by the ODOT, the UTA, and Texas Tech University case study projects. The content analysis found that 28% of transportation projects and 22% of non-transportation projects used this model for CMR selection. Table 19 lists the submittal requirements for items that were required by two or more agencies. The majority of these cases had roughly the same requirements for the qualifications portion as the QBS model. They appeared to request additional management plans. In the cost portion, all asked the competitors to propose their preconstruction services fee. ODOT and Texas Tech also asked for the construction fee and the contractor's general conditions.

The content analysis revealed that some RFPs also ask for certain construction costs that are cogent to the selection process. For example, in the Boston Logan International Airport CMR RFP, the CMR is asked to furnish the cost of preparing and submitting the application for Leadership in Energy and Environmental Design (LEED®) certification. Others ask for mobilization costs and unit prices for a limited number of pay items.

Figure 14 shows the major advantage of this model in that the selection process creates quantitative cost information that can be carried forward into the GMP negotiations. Several of the case study interviewees believed that it created some competitive pricing for those items. That notion was confirmed by the contractor interviews where concern about competitiveness drove the actual numbers that they had to provide in the proposal. The UTA case study project CMR stated that they cut their preconstruction services fee and made a conscious business decision to self-finance the preconstruction phase because they were ready to do this project and believed that they could recover the losses booked in preconstruction by influencing the final design in a manner that aligned with their strengths as well as their existing plant and equipment.

To summarize this model, its main feature is the combination of qualifications and price. The cost information

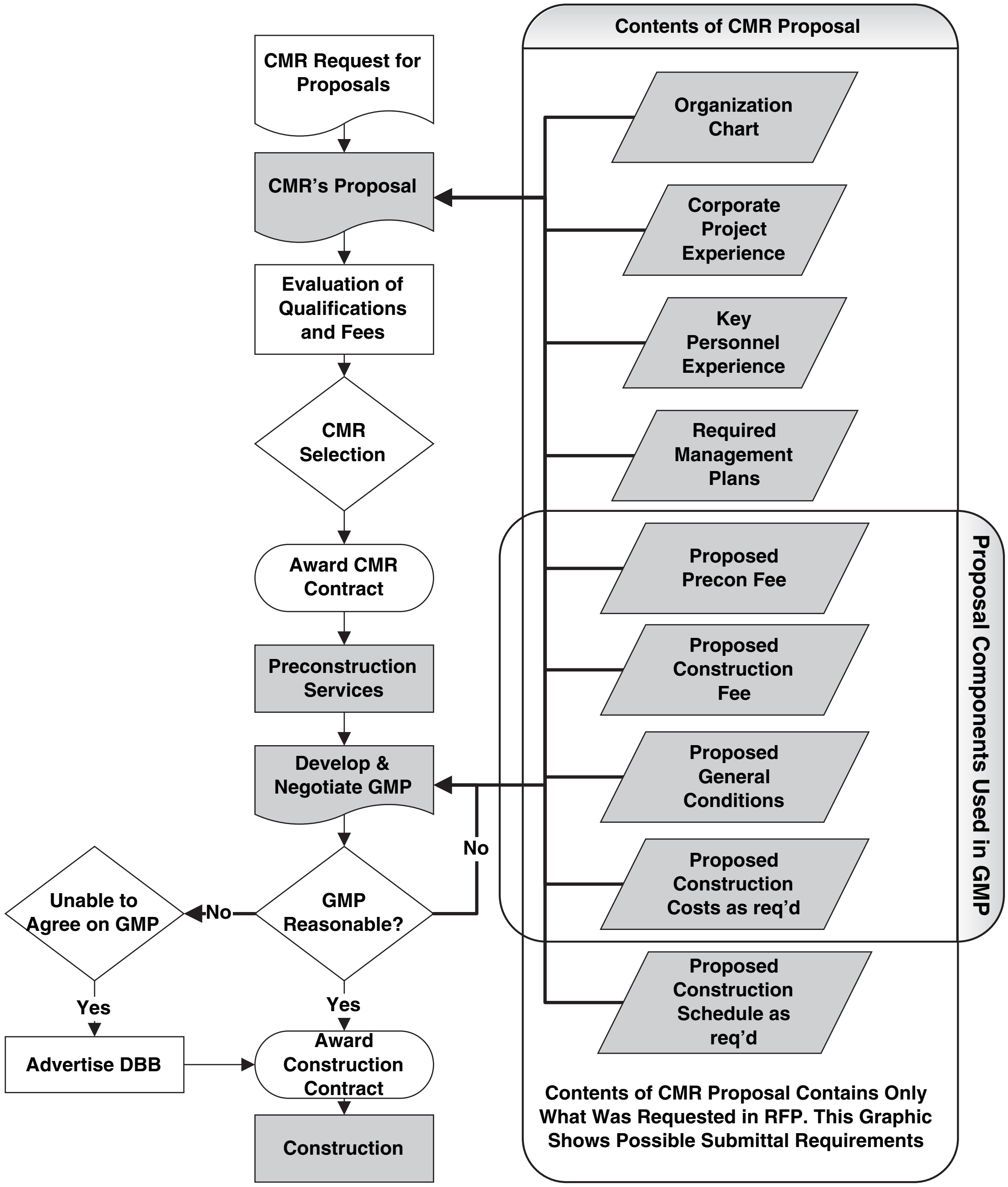

FIGURE 14 One-step best-value CMR selection model.

TABLE 19
ONE-STEP BEST-VALUE PROPOSAL SUBMITTAL CONTENTS

RFP Requirement	No. Agencies Requiring
Qualifications of the CMR's project manager	3
Past CMR project experience	3
References from past projects	3
Proposed preconstruction fee	3
Qualifications of key personnel	2
Construction quality management plan	2
Other key plans: Public relations	2
Preliminary project schedule	2
Proposed construction fee	2
Proposed general conditions	2

contained in the proposal act as an owner's risk mitigation tool to control total cost in GMP negotiations by locking down the indirect costs and fees. Some agencies also lock down a few items of direct construction cost if it appears appropriate for their project. There are two major disadvantages of this model. First, agencies need to keep in mind that best-value is not low bid. However, the temptation to allow an unexpectedly low proposed cost to override the remainder of the evaluated criteria will be strong. Second, furnishing proposed costs demands that the project be developed to the point where reasonable numbers can be generated. This pushes CMR selection to appoint after design has begun, and reduces the opportunity for the CMR to add value through its input.

Two-Step Best-Value Construction Manager-at-Risk Selection Model

This model is based on the dominant form of DB procurement in transportation ("Design-Build Effectiveness Study" 2006), whereby the agency issues an RFQ and evaluates the qualifications of the respondents. It then develops a short list of the most qualified firms and invites the short listed competitors to submit a proposal in response to an RFP. The proposal will include specified cost information as well as other items of interest to the agency's selection panel. The cost-related portion of the proposal generally asks for the CMR's proposed fees for preconstruction, construction, and sometimes its general conditions. This allows the owner to establish those costs on a competitively negotiated basis. It also allows those to carry forward to the GMP negotiations. The cost submittal may also contain elements of construction direct costs.

This model requires a significant amount of front-end effort by the agency to administer the selection process. As with the One-step model, the competing contractors will need design information to generate proposed costs. Additionally, this model allows the agency to ask for possible design alternates during the selection process and use that information to identify the best-value proposal. Figure 15 shows this model's sequence and flow of information.

Two case study projects used this model: UDOT and Memphis International Airport. The content analysis also found that 15% of the non-transportation documents were based on this model. Table 20 describes the contents of the solicitation documents that were common to both case studies, plus the cost-related items. Figure 15 illustrates the flow of this model.

The two cases in this category are an interesting and informative contrast in the way two agencies approach the cost features required in the selection process. Memphis asked for all the fees and general conditions of the CMR to be included in the proposal. Therefore, they locked these in and carried them forward into GMP negotiations. Memphis did not ask for any direct construction cost numbers at this point, but it required the CMR to advertise and accept low bids from its subcontractors. Thus, this agency fixed the indirect costs and trusted in the competitive bidding process to furnish direct costs and competitive pricing.

On the other hand, UDOT only asked for the preconstruction fee and required the competing contractors to furnish unit prices for several high-value pay items. It expected the contractors to include their construction general conditions and profit in the unit prices it would furnish in the GMP. The unit prices contained in the proposal were carried forward into the GMP. UDOT's rationale is as follows.

Price is important in the selection process because:

1. Price motivates the contractor to think about the task and focus on the detail of what has to be done. Until the contractor has put a price to the task it is only an intellectual exercise.
2. Price brings cost competition and the innovation to deliver an affordable project.
3. Price documents costs and approach to cost that we can use in negotiations.
4. Contractors who honor their cost proposals show accountability and we can use their commitment to a reasonable price in the selection for future projects.
5. Price demonstrates to the public our stewardship over public funds (Alder 2007).

Although UDOT has the most experience implementing CMR, it has still not finalized its selection process, as evidenced by the following from the same report:

> We need to develop the price component of the selection process to create a stronger link between the items asked for in the selection process and costs in the negotiation process. The price tool also needs to be developed in a way that allows us to select the contractor earlier in the process even as soon as the design consultant. This will enable contractor input at the beginning of the design process before too many design decisions are made (Alder 2007).

In summary, this model seeks to reduce the cost to industry of preparing a full proposal by splitting the procurement into its two steps. This method also furnishes competitive pricing of CMR fees and potentially major bid items. A word of caution is needed about this particular feature. UDOT very consciously keeps the pay items selected to a minimum and picks only those that it believes are potential budget busters. It would be easy and not perceptive to ask for more and more direct cost pricing and erase the benefit of not forcing the contractor to price undesigned features of work, the benefit of a dramatically reduced contingency from those measured in DB projects (Armstrong and Wallace 2001). The content analysis was nearly silent on this issue with only 6 transportation and 11 non-transportation documents requesting proposed indirect cost and fee information. None of the 54 documents reviewed asked for construction direct cost information.

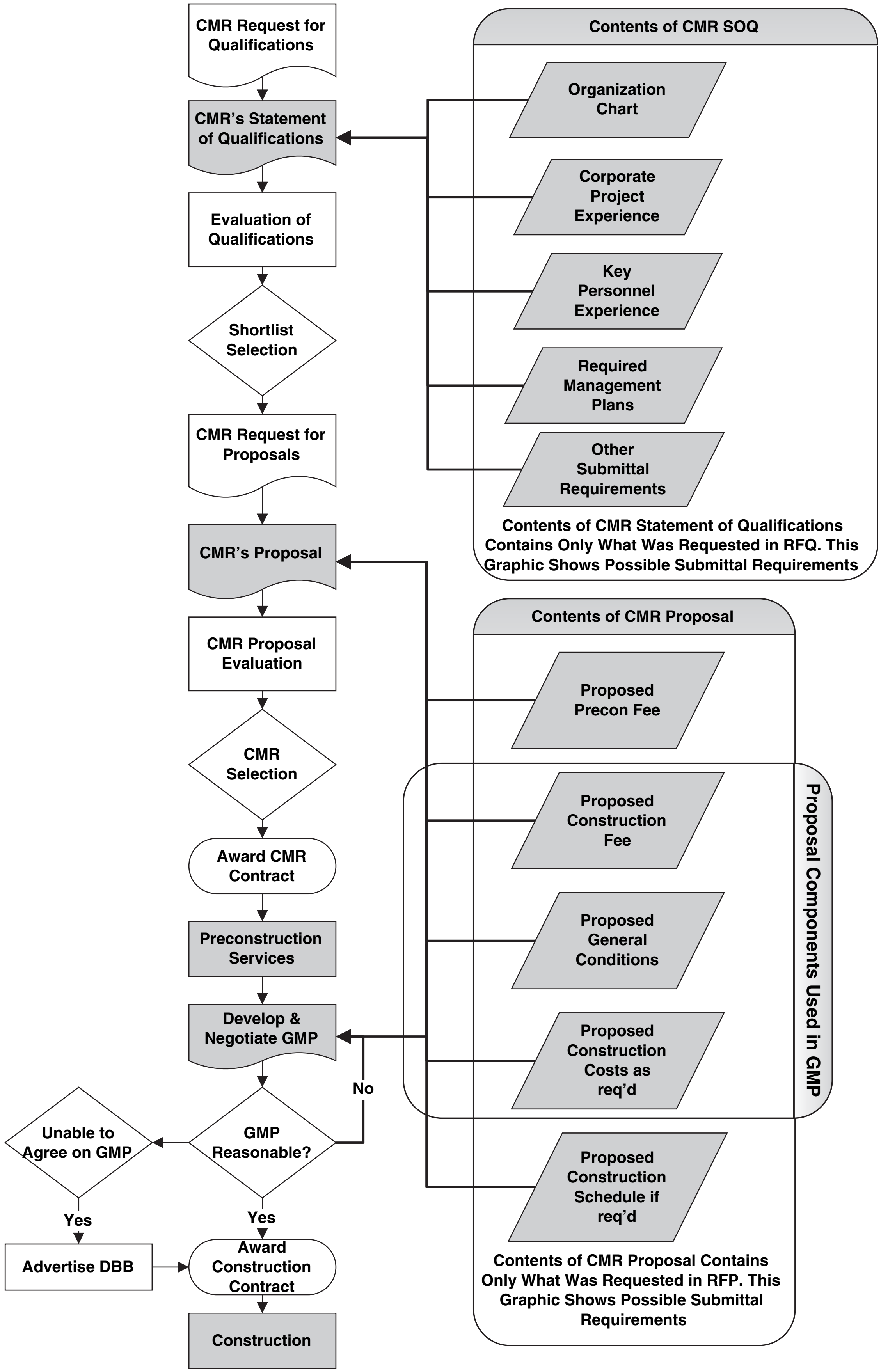

FIGURE 15 Two-step best-value CMR selection model.

TABLE 20
TWO-STEP BEST-VALUE PROPOSAL SUBMITTAL CONTENTS

RFP Requirement	No. Agencies Requiring
Organizational structure/chart	2
Qualifications of the CMR's project manager	2
Past CMR project experience	2
Past project experience (non-CMR)	2
References from past projects	2
Qualifications of CMR's general superintendent	2
Subcontracting plan	2
Construction traffic control plan	2
Preliminary project schedule	2
Proposed preconstruction fee	2
Proposed construction fee	1 (MEM)
Proposed general conditions	1 (MEM)
Rates for self-performed work	1 (UDOT)

MEM = Memphis International Airport; UDOT = Utah DOT.

CONTENT ANALYSIS REQUEST FOR QUALIFICATIONS/REQUEST FOR PROPOSAL SUBMITTAL REQUIREMENTS

The content analysis indicates that there are a number of requirements for the submittal of proposals (see Table 21). The most predominant requirements are similar between the transportation and non-transportation documents and include organizational charts, past experience, references, qualifications of key people, and project plans. Submittal requirements that appear more predominantly important in non-transportation projects than transportation projects include the proposed fees.

In addition to the qualifications of the project manager, preconstruction services manager, superintendent, estimator/scheduler, and quality manager, qualifications were also

TABLE 21
CONTENT ANALYSIS PROPOSAL SUBMISSIONS

Requirement	No. of Transportation Documents	No. of Non-transportation Documents
Organizational structure/chart	20	16
Past CMR project experience	23	23
Past related project experience (non-CMR)	18	22
References from past projects	18	23
Qualifications of the CMR project manager	10	10
Qualifications of the CMR's preconstruction services manager	1	4
Qualifications of the CMR's general superintendent	4	11
Qualifications of the CMR's estimator/scheduler	2	7
Qualifications of the construction quality manager	1	3
Qualifications of other key personnel	22	19
Construction quality management plan	5	10
Safety management plan	3	7
Schedule control plan	4	9
Sustainability certification plan	1	5
Construction traffic control plan	0	1
Other key project plans	14	17
Preliminary project schedule	4	5
Declaration of self-performed work	2	7
Subcontracting plan	9	8
DBE plan	4	9
Proposed preconstruction services fee	4	11
Proposed construction fee	4	11
Proposed post-construction fee (profit)	1	0
Proposed general conditions fee	2	6
List of proposed subcontractors	0	1
Claim reduction and claim resolution plan and dispute resolution	1	2
Claim history and litigation	7	12
Contract or subcontract default history	7	10
Current workload	7	10
Adequate bonding capacity	14	12

DBE = Disabled Business Enterprise.

requested for the security information manager, public involvement specialist, utility manager, traffic control manager, and safety manager. Often the RFQ was general and would simply ask for the qualifications of key personnel or the people who would be working on the project.

Key plans that are not individually listed in Table 21 include environmental management, cost control, project management, individual phases of the project, project staffing, request for information approach, value engineering, coordination of design solutions with architect and other consultants, communication, problem solving, design review, utility coordination, public involvement, phasing, maintenance of traffic (MOT), document control, dispute resolution, and apprenticeship/training program. These are sometimes asked for in a narrative form, such as, "Describe systems used for planning, scheduling, estimating, and managing pre-construction and construction phase services (AZ document)."

Other types of submittals contain a wide range of items, including:

- Professional and contractor licenses;
- Identification of challenges that might be faced on the project and how to address these challenges;
- Unique qualifications of the company to perform the work;
- "Approach to Price—Bidders will describe risk associated with each unit price. Bidders will provide reasons and justifications on what would cause prices to either increase or decrease. These reasons and justifications will be the basis for future price negotiations. Identify how raw material cost variations would affect your unit price; in your response consider addressing how the following will affect unit prices—schedule, maintenance of traffic, risk, innovation, substantial changes in quantities, etc." (UDOT).
- "In conjunction with your team's approach to the project, your team may have some innovative ideas that may or may not meet the technical information provided that could increase the likelihood for success with this project. The selection team will consider how well your innovative ideas help balance the goals of the project" (UDOT).
- "Share 2 significant lessons learned on innovative delivery projects and provide a narrative on how you would approach the issues differently, or apply the lessons learned in those experiences on this project" (ODOT).
- "Knowledge of market volatility as it relates to construction commodities and long range estimating skills" (Parker, Colorado).
- "Why is it in the City's best interest to select (the submitting firm) for the project" (Golden, Colorado)?
- "Awards: List awards, recognition received, or any other achievements that demonstrate your commitment to construction excellence. Any unsolicited letters of appreciation from owners, professional organizations, or regulatory agencies for any outstanding action performed by the contractor over and above the contract requirements may be submitted" (Denver, Colorado).

SELECTION PROCESS DETAILS

The selection process can be broken down for analysis into four stages. The first is the timing of the CMR selection with respect to the selection of the designer. Next is the composition and duties of the CMR selection panel. The third stage is the evaluation itself, including interviews if appropriate and the final stage deals with the algorithm used to select the winning contractor. Information for this section was drawn from all the study instruments.

Timing of Construction Manager-at-Risk Selection

The UTA's CMR policy states that: "*Prior to or concurrently with* selection of the final designer, the CM/GC is selected based upon criteria that allow the owner to evaluate past performance, quality, and price" ("CM/GC Peer Review Meeting" 2003). This represents one end of the selection timing and is one that was advocated by most of the interviewed contractors in this study. The rationale is this permits "the participation of the construction manager in design and phasing decisions so that "unbuildable" or costly design details or phasing plans may be avoided and design/drawing inconsistencies may be limited" (Rojas and Kell 2008). Early selection of the CMR also allows input "very early in the process when there is little information available but decisions must be made that affect the future of the project, what is the maximum increase in project cost that could be justified by the value added by faster project delivery" (Reinschmidt and Trejo 2006).

The United Kingdom Highways Agency uses a project delivery approach that is similar to but not the same as CMR. It is termed "early contractor involvement" (ECI) and it brings the constructor to the project during the planning and permitting process (*Early Contractor Involvement* . . . 2004). This system actually allows the constructor to assist the owner in the designer selection process. That is not unheard of in U.S. CMR projects. The content analysis found one non-transportation project where this was required. Many private commercial building owners advocate this type of process (Ketcham and Epps 2000). *NCHRP Synthesis 379* draws the distinction as follows: ". . . early contractor involvement may be most influenced by project complexity, whereas construction manager at risk is most influenced by project type" (Anderson and Damnjanovic 2008). The top four advantages cited in Table 1 all deal with getting the constructor involved at an early point in the project delivery process. Therefore, the wisdom that early selection provides viable benefits is supported by both the ECI model and the CMR process. UDOT's opinion is that the selection process can be configured in a "way that allows us to select the contractor earlier in the process even as soon as the design consultant . . . before too many design decisions are made" (Alder 2007).

Three Table 2 citations listed "picks CMR early in the design process" as a disadvantage. These encapsulate a second school of thought that holds that the constructor needs some design detail to work with to be able to develop a reasonable and realistic proposal. This is particularly cogent when the contractor is being asked to furnish direct cost pricing in addition to fees and general conditions. Studies in the building sector recommend that the CMR be selected at around 30% design (Carlisle 2006) to give the CMR enough information to be able to furnish realistic subcontracting plans, preliminary schedules, etc. However, building projects are often much more complex in terms of the number of subcontractors, number of systems to coordinate, and the level of architectural detail. Therefore, it makes sense to wait until preliminary designs are complete in that sector. The three Table 2 disadvantages cited all related to the accuracy with which the CMR can furnish cost information. One of those was the UDOT report (Alder 2007) and because UDOT asks for unit prices in the proposal, lack of design detail makes accuracy at that stage more difficult.

Therefore, by bringing all of that above information together, the conclusion on selection timing becomes one of determining how much cost information the agency wants to receive and what the demands for accuracy are at the time of selection. The overwhelming sense found by all study instruments is that the best practice is to select the CMR as soon as practical given the requirements of the project. This leads one to question the reason the agency needs cost information before selection is made. There are at least five possible reasons:

1. The agency's statutory constraints require pricing to be included in the selection decision.
2. The agency prefers to eliminate the reasonableness of construction fees and general conditions as a point negotiated in the GMP.
3. The agency believes that receiving direct construction cost data in the proposal allows it to shed risk for escalation and other potential reasons for cost growth.
4. The agency wants to have competition among the contractors for the cost of preconstruction services.
5. The agency is seeking to demonstrate price competition in the selection process.

To sum this up, the point at which the CMR is selected in the design development process does make a difference. Early selection gives the CMR the most time to have a beneficial impact on the final design (Carlisle 2006; Ladino et al. 2008). If cost and price factors are going to be included in the selection process, then selecting the CMR after enough design progress to furnish a good picture of the scope of work would be indicated. If direct construction cost information is required, then CMR selection can be timed to happen when the agency has sufficient design detail to permit reasonable numbers to be submitted that do not contain excessive contingencies.

Selection Panel Composition and Duties

Empanelling a selection committee is very straightforward; there are two primary decisions to be made. First, that the panel has the technical expertise and experience to make an informed decision. This usually requires assigning agency members from both design and construction to cover those areas. The second decision is whether or not to involve members from outside the agency. Typical external members are representatives from the local contractor's association whose charter is to ensure that no favoritism is allowed to influence the decision: Members from third-party stakeholders that have a vested interest in facilitating the process and will add value to the decision with their specialized expertise, members of the impacted community to give the public a voice at the table and, finally, the design consultant with whom the CMR collaborates.

Often the composition of the panel is defined by the agency's enabling legislation. For example, Arizona law requires the panel to have a minimum of three, but not more than seven members. They include a licensed contractor, an agency senior manager, and one licensed design professional (Ladino et al. 2008). The UTA Weber County project added a member of the railroad company with which they shared track and a representative from the state environmental agency. Including a specific external member such as the railroad in the UTA case study creates "buy-in" to the process that UTA was later able to trade on when it needed to negotiate a right-of-way swap to facilitate a value engineering change. To loosely paraphrase the interviewee, "the railroad was with us every step of the way and as a result understood the real value of the changes we asked for and why they were important. They gave nothing away, but were more amenable to discussing issues with the CMR than if they had not been included in the selection process."

If the designer is selected before the CMR, then an opportunity exists to include it on the selection panel. Eight of the case study projects opted for this method. The Florida and Oregon DOTs did not involve the designer. Florida's selection system is the most uncomplicated of the case study projects; FDOT merely asks the competing contractors to answer a set of pre-published questions at the in-person interview. So with those constraints, the designer would add no value to the process. Oregon uses an RFP process with a formal interview and stated that although it did not involve the designer in the case study project, it will in the future. The project was their first CMR contract and their procedures are still evolving based on their experience from the Willamette River Bridge project. Table 22 shows the tasks that were assigned to the designer and their frequency of occurrence by selection model when it was asked to assist the selection panel. Seven agencies assigned the designer to the panel and of those two (MDOT

TABLE 22
DESIGNER SELECTION PROCESS ASSISTANCE DUTIES

Designer Selection Panel Responsibility	1-Step QBS (out of 4)	1-Step BV (out of 2)	2-Step BV (out of 2)
Voting member of panel	2	0	0
Non-voting member of panel	1	2	2
Developing short list	1	0	0
Evaluation of CMR qualifications	4	0	1
Checking CMR references	2	0	1
Evaluation of CMR interviews/presentations	2	0	1
Evaluation of CMR fees	1	0	0

and Pinal County) gave the designer voting privileges. The remaining agency (Alaska) merely used the designer's services on behalf of the panel.

The content analysis only found one transportation project and one non-transportation project that specifically indicated that the designer would assist the owner in CMR selection and neither spelled out the nature of that assistance. The lack of information in the content analysis and Table 22 shows that the case study agencies do not ask much from their designer in the way of assistance during the selection process. Evaluating the CMRs' qualifications is the only task that was reported by more than two agencies.

Construction Manager-at-Risk Interview Process

One of the authors of this report had the privilege of being a member of the selection panel of the first CMR contract awarded in Oklahoma. The agency issued a letter to the four contractors on the short list to appear at its office for an interview. No specific details were included regarding the information that the agency wanted to evaluate in the interview. The agency head believed that the constructors "knew" what to do, the same as the design consultants. The contents of the four interviews ranged from an exceptionally long formal presentation of the contractor's qualifications including videotaped testimonials and animated fly-bys of past projects to one firm that walked in, took their places at the table, and asked what questions the panel needed answered. The lesson learned for subsequent selection panel experiences is that the agency may specify exactly what it wants the CMR to present and make that information available at the interview for further discussion. FDOT's list of published questions confirms the wisdom of that lesson. The problem with ambiguous requirements for interview content is that it makes it extremely difficult to compare apples to apples. In the example just given, the panel had to differentiate between a competitor that gave too much information and a competitor that offered nothing, not to mention the other two that fell somewhere in the middle. As a result, the panel finally decided to discount the interview ratings and select the CMR based on the written material in their SOQs.

The previous discussion leads to the idea that the agency determines exactly what it is that it wants to get from the interview. The CMR literature was silent in this regard. The most relevant writings were in the DB area, where the purpose of the interview is quite different. However, the structure of that mechanism can probably be replicated. A report on DB project delivery (Gransberg et al. 2006) recommends that the owner specify not only the agenda of the interview but also the people that the owner would like to have make the presentation. It also expands on the depth it would like to see in each agenda item, noting any specific information that is particularly important to the selection process. For example, three of the case study projects asked the contractors for a "critical analysis" of the project budget in their proposals. If there were questions or the need for more information in the submitted analysis, the agency could then indicate in the letter announcing the interview schedule that it expected the competitors to justify their budget analysis as part of the presentation and bring facts and figures that could be shown if necessary.

The content of the CMR interviews was not consistent among case study projects. On one end, Pinal County (One-step QBS model) required a very comprehensive presentation of the contents of the SOQ. The other end was FDOT with its list of questions and nothing else. ODOT focused its interview on presentation of project issues and the CMR's proposed preconstruction service package, relying on the written proposals for the remainder of the evaluation. Table 23 shows the case study results for interview content alongside the results of the content analysis. This juxtaposition is important because the solicitation documents are the first form of project communications between owner and contractor. The number of instances where the interview was mentioned in the solicitation documents was high (24 transportation, 25 non-transportation). That it was included this frequently in the RFQs and RFPs shows that it does have a place at that point in the process.

The formula for success in CMR project delivery is in developing a sense of trust through free-flowing, information-rich communications (Gambatese 2002; Doren et al. 2005; Storm 2007). Detailing the requirements for the interview in the initial solicitation document allows the competitors to not only prepare for it as early as possible but also to craft their written submission in a manner that compliments their oral presentation. Lastly, it creates a "no surprises" atmosphere at the outset of the process and reinforces an "open book" approach to the entire process, which "eliminates

TABLE 23
CONTENT OF THE SELECTION PROCESS INTERVIEWS

	Case Studies			Content Analysis	
Selection Process Topic	1-Step QBS (out of 5)	1-Step BV (out of 3)	2-Step BV (out of 2)	Transport Documents (out of 25)	Non-Transport Documents (out of 29)
Formal presentation of corporate qualifications/past projects	4	2	2	1	2
Formal presentation of qualifications/past project experience for key CMR personnel	3	2	2	1	3
Formal presentation of project-specific issues	1	3	2	13	1
Formal presentation of preconstruction services components	2	3	2	0	0
Other: Answer pre-published list of questions	1	0	0	0	0

hidden agendas. . . . and creates a 'win-win-win' environment" (Ladino et al. 2008). Of the 49 solicitation documents that indicated there would be an interview only 27 went on to detail the content of that interview.

An example taken from a CMR RFP for the Washington State Ferries' (WSF) multi-modal terminal project (a two-step best-value model) illustrates how the content of the interview can be included in the solicitation.

> Should your firm be invited to an interview, questions will be directed solely to the proposed key project staff. At a minimum, the corporate executive dedicated to the project, the project manager(s), the project superintendent(s), project estimator(s), and the key individuals responsible for pre-construction services shall be in attendance. In addition to presenting their qualifications and experience and the Project Team's approach to the project, the interviewees will be expected to respond to questions from the panel regarding the firm's proposal as well as additional questions that might be posed in correspondence to the "most qualified" Proposers invited to an interview ("Request for Proposals . . ." 2005).

The RFP for the UDOT case study project also indicated the content of the interview. This document was more concise than the WSF description. UDOT merely indicated that the formal presentation includes: "Understanding of the work, approach to the project, schedule control, [and] management of project." A UDOT RFP for another CMR project asked for a different content: "Constructability, MOT [maintenance of traffic], business impacts, utility relocations, [and] ROW [right-of-way]." The point to be taken is that UDOT tailors each interview to focus on the issues that are of most concern to selecting the best CMR for a given project.

Selection Process Decision Procedures

It is important that the process used to identify the winning CMR be transparent, logical, and defensible (Shane et al. 2006). Figure 16 provides a model illustrating the components of the selection system for QBS and best-value selection systems. It shows that the design of a means to identify and select a CMR using QBS or best-value begins with determining the parameters that will be evaluated to make the CMR selection decision. Once established, the parameters guide the development of the evaluation criteria against which each SOQ or proposal will be measured, the method used to actually rate a given criterion, and the algorithm used to determine the winning competitor to whom the CMR contract will be awarded.

Parameters are drawn from the benchmarks and constraints inherent in the given project and come from five general areas:

1. Cost parameters: includes any and all items that are expressed in financial terms, such as a preconstruction services fee.

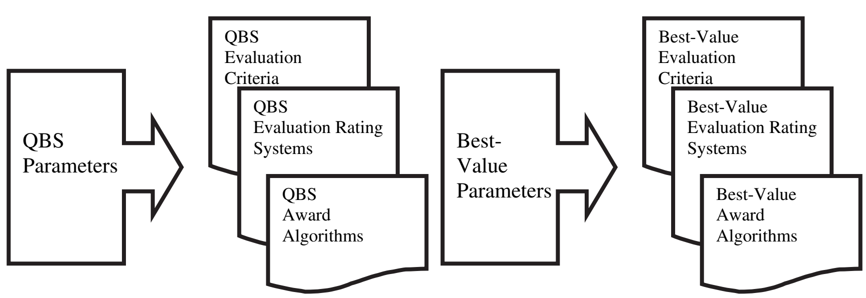

FIGURE 16 CMR selection framework (adapted from Scott et al. 2006).

2. Time parameters: covers all items that either define or affect the project's schedule. A preliminary schedule or a list of long-lead time items would fall here.
3. Qualifications/performance parameters: includes both the personal qualifications and experiences of key project personnel and the corporate experience of the entities that will complete the construction. The subcontracting plan is an example of this type of parameter.
4. Quality parameters: covers all aspects of the project's quality management system including mechanisms to ensure long-term quality such as warranties. Most are not biddable in that they cannot be converted to a dollar or time amount.
5. Design alternates parameters: covers any aspects of the project's preliminary design (if there is one) that the construction contractor is allowed to either propose different solutions or alter the existing solution. Proposed resizing of structural members to accommodate the limitations of the contractor's equipment fleet is an example.

Once the parameters are established, evaluation criteria can be developed to provide the agency with a logical and defensible means to differentiate between competing SOQs and proposals. These are connected with a system to assign a rating to each criterion to ensure a uniform evaluation of all competitors across the selection panel. There are four types of rating systems in use in the United States for this application (Scott et al. 2006).

- Satisficing (more commonly called "Go/No Go"): To use it, the evaluator establishes a minimum standard for each and every evaluation criterion against which the proposals can be measured.
- Modified Satisficing: recognizes that there may be degrees of responsiveness to any given criteria. As a result, the range of possible ratings is expanded to allow an evaluator to rate a given category of a proposal across a variety of degrees. Thus, a proposal that is nearly responsive can be rated accordingly and not dropped from the competition as a result of a minor deficiency. Additionally, a proposal that exceeds the published criteria can be rewarded by a score that indicates that it exceeded the standard.
- Adjectival Rating: These systems use a specific set of adjectives to describe the conformance of an evaluated area within a proposal to the project's requirements in that area.
- Direct Point Scoring: evaluation allows for more rating levels and thus may appear to give more precise distinctions of merit. However, it may lend an unjustified air of precision to evaluations. Evaluators assign points to evaluation criteria based on either some predetermined scale or the preference of the evaluator (Scott et al. 2006).

Using the previous WSF example, this CMR project's evaluation criteria and their direct point ratings that show each criterion's weight are as follows:

- Ability of professional personnel and qualifications of the firm (9 points).
- Past performance on GC/CM projects (5 points).
- Past performance of the firm in completing similar projects (6 points).
- Ability of the firm to meet time and budget requirements (5 points).
- Location (2 points).
- Recent, current, and projected workload, and capability of the firm including financial stability (5 points).
- Concept of the proposal (5 points).
- Accident prevention program (5 points).
- Preconstruction services (6 points).
- QC (2 points).
- Interview (35 points).
- Final proposals [proposed costs] (15 points as presented in Table 24) ("Request for Proposals . . ." 2005).

The final element is the award algorithm used to identify the winning candidate. These can range from algebraic formulae that combine direct points with weighted categories to the mere subjective evaluation of the ratings by the panel. For a detailed discussion on the rating, evaluation, and award process for alternative project delivery methods, the reader is referred to *NCHRP Report 561: Best-Value Procurement Methods for Highway Construction Projects* (Scott et al. 2006). Completing the WSF example, the best-value award algorithm is described in the RFP as shown in Table 24. This agency uses the "lowest conforming proposal" as the benchmark against which the others are measured. The lowest conforming proposal is the one that proposes the lowest combined cost of fees and general conditions and is rated as satisfactory in all the previous evaluation criteria. WSF uses direct point scoring, but it also includes a "fatal" deficiency for each evaluation criterion that ensures that the proposals are fully responsive.

All but one of the case study projects (Texas Tech) used direct point scoring similar to the WSF example, and of those, only FDOT did not adjust the point scores by measures of individual importance or weights. Florida merely added up the total score for each competitor. Using the weighted criterion award algorithm (Scott et al. 2006) requires that the agency rank each evaluation criterion in order of importance. This can be accomplished two ways. The first is as shown in the WSF example where each criterion is assigned a specific number of possible points. Thus, the criterion with the most assigned points is the most important factor in the evaluation. The second way is to assign a fixed number of rating points to each criterion and then differentiate between them by assigning a weight. These weights are often expressed as a percentage. Then a standard arithmetic weighted average is computed by multiplying the score in each criterion by its weight and adding the total sum. Regardless of which method is used, the agency furnishes the relative importance of each criterion to the competitors so that the contractors can craft their proposal in a manner that makes then highly responsive to the project's needs. The weighting scheme in the WSF

TABLE 24
WASHINGTON STATE FERRIES (2005) CMR AWARD ALGORITHM

Rating System for Final Proposals	The firms/teams that the Selection Committee believes to be most qualified based upon their evaluation of the submittals received in response to this Request for Proposals will be requested to submit Final Proposals for fee and specified general conditions that will be evaluated as follows.
Low Conforming Proposal	15 points
Proposals within 5% of Low Proposal*	12.5–14.5 points
Proposals within 10% of Low Proposal*	7.5–11.5 points
Proposals within 15% of Low Proposal*	0–6 points
Others	0 points
* Computed as follows: $\frac{\text{Proposal being evaluated – Low Conforming Proposal}}{\text{Low Conforming Proposal}} = \%$ For each percent that the proposed sum of fee and general conditions work is higher than the low conforming proposal deduct ½ point up to 5%, one point up to 10%, and 1.5 points up to 15%.	
Final Award Algorithm	The firm/team with the highest scoring proposal resulting from the Selection Committee's evaluation of the submittal, the interview, and the final proposal will be selected for MACC [GMP] Negotiations. (Total Possible: 100 points). In the event of a tie in total points, the firm/team with the lowest conforming final proposal will be selected.

example shows that the most important factor in the evaluation is the interview rating, followed by the proposed costs and the qualifications of the CMR team. Therefore, to be as competitive as possible, a contractor will need to ensure that the five specific individuals proposed to be assigned to this contract are present at the interview.

The WSF scheme also indicates that the proposed fees and other costs are more important than the qualifications of the team, leading to a potential trade-off between lower cost, less experienced individuals and/or perhaps an effort to minimize general conditions costs by keeping the project QC staff at a minimum to reduce the proposed fee. Therefore, it is extremely important that the agency make a deliberate effort to assign points and weights to each criterion in a manner that accurately reflects their contribution to project success.

The Memphis, Oregon, and Utah case study projects all used cost as a selection criterion. Memphis weights cost at approximately 25%. Oregon gave cost a weight of 15%, whereas Utah assigned a higher weight that ranges from 26% to 50%, but usually averages 30%. The content analysis found that 12 transportation and 12 non-transportation documents showed that cost was included in the selection decision. Only two disclosed the assigned weight of cost factors and they correspond to the weights found in the case study projects. This lack of transparency is disturbing and can lead to protests based on an agency not awarding to the proposal with the lowest costs (Parvin 2000).

SELECTION PROCESS PROTESTS

When a public agency attempts to implement a procurement method that does not depend on awarding to the lowest bid, it will open itself up to criticism unless staff carefully devises a system where it can prove, if necessary, that favoritism did not enter into the contractor selection decision. One author, a lawyer serving the construction contracting industry, discussed the legal view of the need for fair and open evaluation processes in the transportation industry. In it, he highlighted the following two points that are of interest in this synthesis:

1. Clearly state the *evaluation criteria and weight* given for each item and ensure that the evaluation team uses them.
2. Leave *no doubt about the honesty and integrity* of the public agency's evaluation team (Parvin 2000; italics added).

The commentary argued that without a transparent evaluation plan, the owner would find itself constantly defending award protests. A case study that involved a protest of a best-value selection system is presented next to provide context to the discussion of this critical issue.

Minnesota Department of Transportation Protest Case

The Minnesota DOT (MnDOT) successfully defended itself and its best-value selection process from a protest on its first project delivered using an award that was not based on low bid. The case presents a number of rules for an agency that wants to implement QBS or best-value selection of CMRs to abide by while developing the details of their proposed system. Although this case revolved around a DB project, its results are generally applicable to any type of nontraditional selection process that uses contractor qualifications in its evaluation plan. In this case, MnDOT chose to use a two-step best-value procurement to select a DB contractor for a $110 million project (Shane et al. 2006). The first step of this method is to evaluate the qualifications of interested contractors and develop a short list comprised of the best qualified group. The RFQ stated that "The selection team shall evaluate the DB qualifications of responding firms and shall compile a short list of no more than five most highly qualified firms in accordance with qualifications criteria described in the RFQs" (Shane et al. 2006). To accomplish this task, it established and pub-

TABLE 25
MNDOT DESIGN-BUILD PREQUALIFICATION EVALUATION CRITERIA

Prequalification Evaluation Criteria	Possible Points
Legal and Financial Qualifications	Pass/Fail
Organization and Experience	15
Key Personnel	30
Project Understanding	10
Project Approach	25
Project Management	20
Total	100

lished a set of evaluation criteria and a method for scoring each potential competitor as shown in Table 25.

Within the "Organization and Experience" category, the evaluation criteria were further defined to include:

- Effective project management authority and structure
- Design and construction management structure
- Effective utilization of personnel
- Owner/client references
- Experience on projects of similar scope and complexity
- Experience with timely completion of comparable projects
- Experience with on-budget completion of comparable projects
- Experience with integrating design and construction activities
- Experience of DB team members working together.

The RFQ asked the contractors to both describe their specific DB experience by listing at least one completed DB project and to list other projects "with scope comparable" to the project on which they were competing. It went on to state that DB experience would be considered but was not required.

Issues at Stake in the Protest

Five contractors responded to the RFQ, submitting their qualifications in accordance with the RFQ, and were evaluated as described in that same document. Scores ranged from 69.4 to 85.7, with three contractors being rated above 80. Those three were then announced as comprising the short list of "most highly qualified firms" and deemed to be qualified to continue in the competition. The fourth ranked firm with a score of 71.9 filed a protest citing the following reasons:

- MnDOT violated the state DB statute by requiring that the evaluation rely on and emphasize previous DB experience, which would restrict competition (as this was MnDOT's first DB project and therefore no local firms had DB experience);
- MnDOT engaged in unpublicized rule making; and
- That the judgment regarding who was short listed was arbitrary and capricious fact finding and the conclusions were not substantiated by the evidence (Shane et al. 2006).

The court overturned the protest and upheld the validity MnDOT's evaluation system for this specific project. First, it found that considering DB experience for MnDOT's first DB project was entirely reasonable and, as it was considered but not required, it did not restrict competition. Next, it found that as *MnDOT published the details of its qualification evaluation plan and as those rules applied only to a single project, the process did not constitute "unpublicized rule making" as alleged* and, finally, it found that *MnDOT had followed its procedures exactly as they were published and had a rational basis for justifying their short listing decision.* Therefore, the process was not "arbitrary and capricious."

Lessons Learned for Implementing CMR Selection Programs

This court test yielded some excellent information for agencies that plan to use CMR project delivery on a general scale. MnDOT won this case for three major reasons:

- The prequalification evaluation criteria were transparent to all offerors,
- The owner followed its prequalification plan as published, and
- The owner could defend its decision logically.

In this case, MnDOT clearly articulated the definition of contractor qualification. It helped its case by stating that it would narrow down the field to a short list of the "most highly qualified firms in accordance with qualifications criteria described in the request for qualifications." The requirements for prequalification were clear, and each potential competitor could compare itself with the competition and make an informed decision as to its ultimate competitiveness in the known field of players. This transparency serves to reduce the element of subjectivity that is inherent in best-value award evaluation systems by spelling it out rather than hiding it.

Second, as the requirements for prequalification were clear, it was easy for the courts to find that MnDOT had followed its own evaluation plan. This speaks to the first point in the earlier Parvin quote. Once an owner publishes its prequalification program, it loses all flexibility in applying it to the competitors that respond. If it wants to be able to defend against a protest, it exhibits that it follows its own rules. If it does, the second Parvin requirement regarding leaving no doubt about the honesty and integrity of the evaluation team is satisfied.

Finally, the use of the terms "most highly qualified" gave MnDOT great latitude about determining the final size of the short list. The resultant scores showed that three competitors fell within a range of three points of each other, whereas the plaintiff was 10 points below the third highest score. This created a solid argument that the three competitors on the short list were indeed the most highly qualified. MnDOT was unintentionally doing the plaintiff a favor by not being conservative in forming the short list with four firms. The cost of preparing a technical and price proposal for $110 million project would probably be in the range of $300,000 to $500,000 (Shane et al. 2006). If MnDOT had arbitrarily set a minimum point score to be considered "qualified" of 70 (i.e., minimally qualified), then three instead of two firms would have had to invest that significant amount of money in a losing effort. Thus, the logic of short listing only the "most highly qualified" instead of all the minimally qualified is compelling in an economic sense and in the long run is fairer to industry.

Thus, several lessons can be drawn from this case and applied to an agency's CMR program. First, the owner publishes transparent prequalification criteria along with its procedures for using the input from contractor's proposals in determining the outputs of the evaluations. This puts all the contractors on an even footing and makes the defense against a possible protest stronger. Second, once published, the owner follows its evaluation procedures to the letter, collecting documentation along the way to prove that the decisions made for the project flow directly from the published evaluation plan and its attendant criteria. Finally, the CMR selection program is logical and the decisions that flow out of it are based on defensible logic.

Avoiding Protests

"The ability to prequalify and select your construction manager on the basis of its reputation and record in controlling costs, meeting deadlines, and satisfying customers" (Rojas and Kell 2008) is a benefit of CMR project delivery touted in the literature (Kwak and Bushey 2000). Therefore, an agency would not want to invalidate its ability to accrue this benefit by promulgating a procurement system that is plagued by protests of award. Taking the lessons learned in the MnDOT case leads to possible practices that can be followed to make an agency's CMR selection system as immune to protest as possible. The first is the assurance of evaluation and award transparency. By publishing the details of its evaluation plan, the competing contractors have an opportunity to measure their competitive potential against that of the others in the race. It allows them to make business decisions on whom to propose for key positions and how, if successful, this project will be coordinated with the contractor's other work. Finally, it provides a time for questions about the system. This period serves to highlight to the agency those aspects that the construction community, through its questions, does not fully understand. If a major problem with interpretation arises, the agency can move to ameliorate the problem before it becomes a dispute. Once published, the agency can train its evaluation panel to ensure that the evaluation proceeds in accordance with its published plan. FDOT does just this. As previously mentioned, it restricts its interview process to the answering of a pre-published list of questions, scores the answers, and selects the CMR with the highest score. An interview with a contractor that does business with FDOT confirmed that there are no concerns about either selection equity or favoritism in the way they assess qualifications in their process (Gransberg and Riemer 2009).

The second practice is to seek means to add probity to the process and ensure the credibility of the selection panel's fairness and integrity. One method in use is to publish the names of the panel members in the selection documents. UDOT uses this technique and furnishes a list of all panel members and their affiliations. Knowing the personalities and professional qualifications of the panel members is valuable to the contracting community for two reasons. First, in many if not most highway projects, the agency's personnel are well known to the contractors that furnish it construction. Past experience with one of the panel members can directly influence the contractor's choice of key personnel for a given CMR job. If a specific panel member has had a past conflict with one of the contractor's superintendents, then a prudent business person would not assign that individual to this project. The same theory holds true for assigning the company's best superintendent if there are panel members who can attest to the person's competence and professionalism. Second, if the panel is staffed with members whose technical qualifications or construction experience is limited given the type of project under competition, then the proposers can take care to explain the technical/constructability aspects of their approach in a manner that can be understood by the evaluators. UDOT experienced this issue with their first CMR project that entailed accelerated bridge construction methods and was able to alert the competitors merely by naming the panel.

Another method to generate the appearance of fairness and to guard against favoritism is to empanel members of the construction and/or consulting engineering industries on the selection board. The Arizona DOT and UDOT require that all selection panels include a contractor and a design professional (Ladino et al. 2008). UDOT established an industry advisory board to assist it in implementing CMR in Utah. That board assisted UDOT in the development of its selection procedures and, as a result, a member of the AGC is on every selection board in addition to a local member of the ACEC. Each non-UDOT member is required to sign a statement promising not to reveal the contents of any of the competing proposals to ensure confidentiality of their contents. The minutes of the advisory board that had reviewed the performance of on-going CMR projects included this statement:

> The AGC representative should continue to participate in contractor selections. UDOT will develop a method to verify the confidentiality statement (Alder 2007).

Instances of CMR transportation project protests are isolated as a result of the delivery method's relatively recent appearance in the industry. The ODOT case study project had an unsuccessful protest lodged on the award of its first CMR project. The basis of the protest was that ODOT had failed to pursue clarifications to the scope of work that materially affected the scoring. Although the protest was denied, it did point ODOT to areas in its CMR selection procedures that could be improved to avoid an appearance of unfairness. The building sector has much greater CMR experience and hence a longer period in which to make selection system design errors that encourage protests. The content analysis found three transportation and one non-transportation project where the procedure for protest was contained in the RFQ/RFP. It also found two non-transportation projects that stated that protest of the selection was not permitted. "The decision of the selection committee will be final and *no appeal will be allowed or permitted*" (Parker, Colorado; italics added). The most comprehensive study on the subject was done for the Washington State Joint Legislature Audit and Review Committee (Septelka and Goldblatt 2005).

The Washington study found that in 82 CMR projects awarded over 14 years, 97% of the respondents had no protests; only two protests lodged, and they were 10 years apart. The first protest in 1993 was based on the state awarding the contract to a contractor that was not the low bidder when price was one of the selection criteria. The protest was unsuccessful. Ten years later a protest was filed on an award where the basis for cost evaluation was to award to the "median proposal price" rather than the lowest price. In this case, the plaintiff had forgotten to include the stipulated preconstruction services fee in its total and as a result was low owing to an "obvious mathematical error." This protest was also unsuccessful. The report concludes that "protests over the GC/CM selection process have been rare" (Septelka and Goldblatt 2005).

CONSTRUCTION MANAGER-AT-RISK SELECTION IMPACT ON COMPETITION

One of the criticisms that have been raised is the potential that alternative project delivery methods such as CMR will reduce competition and decrease the ability for small and/or new companies to be able to compete with the larger companies. The case study project contractors interviewed were asked to furnish their opinion on this question. Two-thirds indicated that the impact on the number of bidders was positive, and the other segment believed it would be worse. The two negative opinions were from contractors on a DOT's first CMR project; therefore, their responses may have been influenced by the feeling of uncertainty that some members of the industry experience when the status quo is changed. The positive opinions came from contractors who work for agencies that have experience with multiple CMR projects and hence may have worked the bugs out of their system to the point where the industry is no longer believed to be uncomfortable with the change from DBB.

The response from the national survey of 47 DOTs resulted in 8 DOTs that believed their local construction industry supported CMR and 8 that believed that there was no support for CMR. The majority, 31, had no opinion on that question. That group contained 15 respondents who indicated that they did not know what CMR project delivery was. Interestingly, none of the respondents indicated that industry opposition was the reason they did not use CMR in their state. Ignorance of the method and lack of enabling legislation were the two major reasons for non-use across the country.

The case study agencies were not asked to comment on CMR impact on competition; however, some information directly related to that aspect was collected, and it furnishes a means to speculate about CMR project delivery's impact on competition in the case study projects. Each agency was asked about its policy for establishing a short list. Eight of ten reported that they do short list and all indicated that their short lists are of three or more qualified contractors. Thus, they apparently are receiving at least three responsive proposals that would indicate that a reasonable level of competition is being achieved by those agencies. The two DOTs that did not short list on their projects were Alaska and Michigan. Alaska received only two proposals and evaluated both. The nature and size of the construction industry in Alaska may account for the low response rate. Michigan's policies prohibit short listing, and this case study project evaluated five proposals.

The Washington State study of CMR public building projects specifically sought to identify if the project delivery method had a discernable impact on competition. The study found that projects typically received an average of five proposals and the number of firms that had not previously competed for a CMR project declined over time. It found that smaller companies (annual revenue under $100 million) were less competitive, with 8% of the projects being awarded to small construction contractors (Septelka and Goldblatt 2005). This study also measured a metric they termed "competition intensity." It is defined as the ratio of the number of firms competing to the number of projects available. A number greater than one indicates more competition, and a number less than one indicates less competition. The study found that the mean competition intensity over 14 years was 2.59 and that it dropped below two in only three of those years. Therefore, the conclusion is that CMR project delivery did not negatively impact competition in that market (Septelka and Goldblatt 2005).

SUMMARY

The CMR selection process is an important component of a successful CMR project. It requires planning, forethought, and careful design to make it transparent, fair, and defensible.

Conclusions

The following conclusions were reached in this chapter:

- The CMR procurement process can be standardized by using one of the three models presented in this chapter.
- Making the CMR project delivery method selection decision as early as possible provides an opportunity to bring the contractor on board at a point where it has the maximum opportunity to add value to the project.

- Selecting the CMR as soon as practical maximizes its opportunity to add value to the project and to minimize wasted design effort.
- The probability of protest is low and the agency can bear this in mind as it creates its selection process.
- The impact on competition appears to be minimal and transient as the project delivery method matures in a given market.

Effective Practices

The following effective practices were reported in this chapter:

- The agency can select which of the three CMR selection models best fits its statutory constraints and the project's requirements and then design a procurement process that is both transparent in its detail and defensible in its logic.
- Publishing as much information as practical about the content of the selection process and how the competing contractors will be evaluated enhances the transparency of procurement and avoids the appearance of favoritism.
- Publishing the role of the designer in the selection process as well as the required content of the interview, if there is one, reduces the probability of protest.

Lessons Learned

The MnDOT protest defense provides the main lesson from this chapter.

CHAPTER FIVE

PRECONSTRUCTION SERVICES

INTRODUCTION

Table 1 shows the most often cited advantage of CMR project delivery to be "CMR design input." This directly links to the CMR's collaboration with the designer through its preconstruction services contract. Although design input is but one aspect of preconstruction services, it is the one that differentiates CMR project delivery from the traditional DBB. Contractor design input may be another phrase for the term constructability. A comprehensive study of applying constructability concepts specifically to highway projects was completed in 1997 and found that to be effective it had to be applied in the planning, design, and construction phases of a project (Anderson and Fisher 1997). The U.K. ECI method does just this (Anderson and Damnjanovic 2008). CMR project delivery gives an agency the opportunity to assign responsibility for the project's constructability to the constructor during the design and construction phases. It also creates an opportunity for additional services that will not only improve the project's construction but also facilitate the design process.

Preconstruction services can include almost anything the agency desires from its CMR. The range of possibilities runs the gamut from the typical estimating and scheduling assistance to the innovative, such as managing public relations, to the nearly unthinkable, such as preparing and submitting environmental permits, to the unheard of, for instance developing a plan to relocate vagrants from under a bridge. Table 26 is a listing of every preconstruction task that was found in the literature, solicitation document content analysis, and case studies. It is not meant to be all inclusive but rather to show how agencies have used this tool to facilitate the successful execution of their projects.

ODOT's approach to preconstruction services appears to be typical based on the literature review and the case study output. It works on the principle that the CMR will collaborate with the agency and the designer to achieve the owner-defined project goals. ODOT lists the major preconstruction services as follows:

- Cost estimates
- Schedule analysis
- Work sequence
- Risk identification/mitigation/pricing
- Constructability reviews
- Develop work packages for bid
- Develop a GMP that meets owner requirements and budget restraints (Lee 2008).

This list of services is not all inclusive but is representative of those generally found in typical CMR highway projects. However, each project has different goals as well as unique requirements. Therefore, most agencies modify the preconstruction services contract to fit the specific requirements of each project. Synthesizing the available information and data leads to the idea that preconstruction services can be grouped into the four categories shown in Table 26. An agency can build both its design and preconstruction services contracts around each requirement to ensure collaborative effort and the achievement of project goals.

DESIGN-RELATED PRECONSTRUCTION SERVICES

One issue found in this study regarding the implementation of CMR project delivery has nothing to do with the agency or the contractor; it is concerned with the willingness of the designer to actively and willingly participate in realizing the method's potential benefits for the owner. Perhaps the most significant lesson learned in this study is the agency's need to ensure that the designer has an opportunity to appropriately price its work by modifying the design contract to reflect the change in effort that CMR project delivery entails (Memphis case study). This is not to say that the study found that design costs increase with this form of project delivery method. Indeed, the finding is just the opposite (Utah case study; Uhlik and Eller 1999; Alder 2007). The difference is that the design process proceeds in a different manner than in a DBB contract (Kuhn 2007). One case study interviewee likened it to a tennis match where the designer and the builder take turns evaluating and improving the design. One content analysis document stated it like this: "the CMR will function as one of three key team members."

A second difference is the need to directly correlate the design packages with the subcontractor bid packages (Utah, Pinal County, and Oregon case studies), especially if the project will be fast-tracked or if early bid packages are desirable to mitigate escalation risk. Thus, the designer evaluates a sequence of work that is different from the one it normally follows. To bring a bridge design to a level where the CMR can order the structural steel as soon as possible may necessitate

TABLE 26
PRECONSTRUCTION SERVICES FOUND IN THE RESEARCH

Preconstruction Service	Case Study Number	Table 1 Reference Number or Literature Cited	No. in Content Analysis
Design-Related Preconstruction Services			
Validate agency/consultant design	1,2,5,6,7,8	(Carlisle 2006)	1
Assist/input to agency/consultant design	1,2,3,4,5,8,9,10	1,2,4,5,6,7,8,9,10,11,12,15 (CM/GC . . . " 2003); (*Operating Manual* . . . 2006)	15
Design reviews		10 (Shadan et al. 2006)	26
Design charrettes	4,6,9,10	11,14 (Carlisle 2006)	6
Constructability reviews	1,2,3,4,5,6,7,8,9,10	1,2,4,5,6,7,8,9,10,11,12,15	35
Operability reviews	2,4,5,6,8,10	(Carlisle 2006)	
Regulatory reviews	2,4,5,9,10	(Brinkman 2007); (Spata and Kutilek 2006)	
Market surveys for design decisions	5,8,10	(Brinkman 2007); (Uhlik and Eller 1999)	
Verify/take-off quantities	8	("CM/GC . . ." 2003); (Van Winkle 2007)	4
Assistance shaping scope of work	2,5	("CM/GC . . ." 2003); (Touran 2006)	10
Feasibility studies	6	(Carlisle 2006)	
Cost-Related Preconstruction Services			
Validate agency/consultant estimates	1,2,6,7	(Carlisle 2006); (Lee 2008)	6
Prepare project estimates	1,2,3,4,5,6,8,9,10	4,6,7,8,9,10,11,13,14,15	36
Cost engineering reviews	2,3,4,5,6,8,9,10	4,6,7,8,9,10,11,13,14,15	0
Early award of critical bid packages	2,4,5,6,8,9	1,3,4,5,6,8,9,10,11,15	11
Life-cycle cost analysis	2,6,10	(DeWitt et al. 2005); (Carlisle 2006)	2
Value analysis/engineering	1,2,3,4,5,7,8,9,10	3,4,7,15 (Kwak and Bushey 2000)	29
Material cost forecasting	5	(Brinkman 2007)	1
Cost risk analysis	4	(Carlisle 2006); (Lee 2008)	3
Cash flow projections/Cost control		(Carlisle 2006); (Trauner 2007)	3
Schedule-Related Preconstruction Services			
Validate agency/consultant schedules	1,2,6	(Carlisle 2006); (Brinkman 2007)	2
Prepare project schedules	1,2,3,4,5,6,7,8,9,10	1,2,4,5,6,7,9,11,12,15	34
Develop sequence of design work	4,5	1,5,6,7,9,15 (Brinkman 2007)	9
Construction phasing	1,2,3,4,5,6,7,8,9,10	1,4,11 (Van Winkle 2008)	10
Schedule risk analysis/control	2	(Carlisle 2006); (Lee 2008)	10
Administrative Preconstruction Services			
Coordinate contract documents	6	1	1
Coordinate with third-party stakeholders	1,2,4,5,6,7,8,9,10	1,10,11 (Migliaccio et al. 2008)	11
Public information/public relations	6,8,9	1 (Trauner 2007)	2
Attend public meetings	4,8	4,9,13 (Carlisle 2006)	2
Biddability reviews	2,3,4,5,6,8,9,10	14	
Subcontractor bid packaging	2,4,5,6,8,9,10	1,3,5,6,8,9,10,14 (Kwak and Bushey 2000); (Brinkman 2007); (Lee 2008)	9
Prequalifying subcontractors	1,2,4,5,6,7,8	11,14 (Septelka and Goldblatt 2005)	18
Assist in right-of-way acquisition	5,8	(Carlisle 2006); (Trauner 2007)	2
Assist in permitting actions	4,5,8,10	10 (Brinkman 2007); (Trauner 2007); (Van Winkle 2007)	14
Study labor availability/conditions		(Jergeas and Van der Put 2001)	1
Prepare sustainability certification application	10	(Carlisle 2006)	1

assigning the consultant's most senior structural engineers early in the design, which may create conflicts with other design projects the firm has underway that are following its standard work flow. It might also require the consultant to assign more engineers to the steel design to complete it as quickly as possible. Finally, early bid packages can often require engineering disciplines not directly involved with a specific package to accelerate their work in order to furnish supporting information.

Design Contract Modifications

The solution is to modify the design contract to facilitate CMR project delivery. Intuitively, this could force the agency to make a project delivery method decision before advertising the design contract to avoid having to modify it after the fact. The case study interviews revealed that two of five highway agencies and two of three non-highway agencies selected CMR project delivery before bringing a designer on board. Those that did not reported they made the decision before achieving 30% design completion. However, when asked if their DBB design contracts were changed to accommodate CMR project delivery, five of seven highway agencies and all the non-highway agencies answered affirmatively. The two agencies that used the same design contract in both DBB and CMR were the Utah and Michigan DOTs. During the interview, Utah stated that they inform the design consultant of the project delivery methods the department is considering for a given project and expect the consultant to account for the possibilities in their proposals. Given that UDOT has institutionalized CMR project delivery and routinely uses it on a variety of projects (Alder 2007), the consulting community has no doubt adjusted its proposal preparation process to account for the eventualities. Michigan is overseeing its first CMR project for another agency and has no programmatic requirement to address this issue in its design contracts.

Table 27 shows typical changes to design contracts found in the case study projects and their frequency of use by the eight agencies that reported them. By inspection, the top four modifications are all concerned with coordinating the efforts of the designer and the CMR during preconstruction. The coordination of the design and construction work packages introduces efficiency to the joint work effort and ensures that the bids received from subcontractors are as accurate as possible by largely reducing the scope risk for the subcontractor. A well-coordinated package will give the subcontractor all the technical information it needs to furnish a competitive price and eliminates the risk of having missed some scope that is displayed elsewhere in the construction documents as happens in DBB (Martinez et al. 2007). The Boston Harbor Project used 133 coordinated design and construction packages as detailed here:

> This breakdown [of work packages] was intended to maximize competition among local construction firms by orienting packages within the limits of the bonding capacity of local firms. . . . . The combination of effective packaging and timely bidding. . . . resulted in construction bids that were, on average, 10.4 percent below the engineers' estimates and yielded savings of $225 million (Armstrong and Wallace 2001).

The second contract modification, joint coordination with third parties, also addresses risk: the risk that the design will not accurately reflect the scope of work necessary to satisfy

TABLE 27
DESIGN CONTRACT MODIFICATIONS TO ACCOMMODATE CMR PROJECT DELIVERY

DBB Design Contract Modification	Number (out of 8)
Coordination of design packages with construction bid packages	6
Joint coordination with third parties during design	6
Facilitate CMR design reviews	5
Joint value engineering with CMR	5
Design milestones specified to match preconstruction services	4
Mandatory budget review points	3
Requirement to respond to CMR comments and incorporate as appropriate	2
Requirement to notify CMR of major design changes	2
Allow the CMR to assist in material selection decisions based on market surveys	2
Design in accordance with CMR designated means and methods	2
Pass design changes through CMR for cost/schedule impact validation	1
Over-the-shoulder review of construction submittals with trade subs	1
Expedited review of construction submittals at CMR's request	1
Design fee at risk for design quality	1
Collaborate with CMR on cost model development	1
Participate in joint scheduling conference	1
Collaborate with CMR to define required right-of-way	1
Provide CMR design products to facilitate CMR-obtained permitting	1
Furnish graphic design support to CMR public relations effort	1
Joint planning and participation in public outreach meetings	1

third parties such as utilities and permitting offices. By bringing the contractor in during design, the agency can assign the responsibility for quantifying the third-party impact to a project by locating and coordinating with the third parties and assisting the designer in furnishing solutions to meet their requirements. Third-party issues can be project stoppers and as a result are typically addressed as soon as they are identified. The UDOT case study interview indicated that permitting agencies are more willing to expedite their process if they are dealing with a contractor, because they believe the chance of significant design changes has passed when a contractor has been selected (Alder 2007). The ODOT interview confirmed this when they indicated that the CMR was able to obtain a permit in 3 months that historically took a consultant a year. One author believed that the construction manager was better suited than either the consultant or the owner to deal with permitting agencies, utilities, railroads, and other third parties simply because it is a daily part of their work, and they have organized themselves to efficiently satisfy these entities (Van Winkle 2007).

The next four items in Table 27 deal with activities undertaken to keep the project on budget throughout the design phase or to bring it back into budget if it strays. This requires a spirit of collaboration and partnering that can be enhanced through clear direction to the designer in its contract. The designer produces the design products necessary for the CMR to undertake the different types of reviews it is required to do in its preconstruction services contract and the design contract specifies the schedule on which these are to be completed. These range from purely design reviews to checking constructability or offering possible material substitutions based on a market survey to administrative reviews of biddability. This clause is typically linked with a compatible clause in the CMR's preconstruction services contract so that the contractual requirement to "work friendly" runs both directions. Often the budget review points are scheduled to fall at the same time as the design milestones. The purpose of both of these clauses is to impose a scheduling discipline on both the designer and the CMR. Often the CMR is assigned the responsibility to establish the preconstruction sequence of work for the team and identify opportunities to reduce risk by locking in material and subcontractor pricing through early work package awards (UDOT and Memphis case studies). Thus, the budget review points may be better set to fall after the pricing is fixed. This then allows the team to evaluate its impact on the project's contingency pool and invoke value engineering if necessary or release pricing contingency to the owner to enhance the project's design.

The remaining design contract modifications in Table 27 are essentially "work friendly" clauses that seek to codify the behavior of the design consultant in a manner that makes it a contributing rather than reluctant member of the CMR project delivery team. The ODOT interviewee stated "I want them [the engineer and the CMR] to be friends but not close friends. Creative tension between the two enhances the project's quality." The Memphis case study found that the consultant initially viewed the CMR reviews as unwelcome and unnecessary interference by an unqualified entity and as a result was less than cooperative in facilitating design and constructability reviews by the CMR. The agency modified the design contract for the next phase of the project to put 10% of the design fee at risk for the final quality of the construction documents (5% for design quality and 5% for construction issues resulting from design quality problems), as well as codified design milestones, budget review points, a requirement to coordinate the design work with the construction work packages, and mandated joint coordination with third parties. This created a different environment where the consultant saw the CMR reviews as another layer of design QC and the cooperation required to successfully complete the CMR project happened. A portion of the CMR design contract design quality clause follows:

> The "Milestone QA" services will be earned following each milestone submittal for the construction documents. The value of the "Milestone QA" is set at five percent (5%) of the lump sum design fee for each Task [design package] . . . The "Milestone QA" . . . will not be payable until the written review comments on each milestone submittal have been resolved by the ENGINEER following the guidelines in the Quality Assurance Plan. The amount of the invoice that is approved for payment will be based on the . . . thoroughness of the Engineer's responses [to review comments] and the effective resolution of the review comments (Memphis case study).

A similar clause is included that rates the outcome and resolution of construction problems, such as change orders and delays that result from poor design QC. Memphis has since adopted this clause for all its CMR projects and believes its real value is not in the penalty it imposes on the designer but on the collaboration that it encourages between designer and builder. This arrangement creates pain and gain for both parties and an incentive to mutually contribute to the design QC program. A good example of a CMR design contract clause that is designed to require mutual collaboration is used by Arizona State University. The cogent aspect of this clause is the way it includes the CMR's product as a part of the designer's product and asks the designer and builder to present the design submission as a joint product.

> The Design Professional shall submit to the Owner all required Design Submission Documents to describe the Project's essential elements. . . . . The CMAR shall submit to the Owner detailed Construction Cost Estimates *as part of each design submission.* At the time of each scheduled submission, the CMAR, Design Professional, and Owner shall meet and confer about the submission. During the meeting, *the CMAR and Design Professional* shall identify, among other things, the evolution of the design and any significant changes or deviations from previously submitted Design Submission Documents and any changes in the CMAR's Construction Cost Estimate (*Operating Manual* . . . 2006; italics added).

UDOT uses the concept for identifying the amount of required design effort as an "appropriate design." UDOT's definition of design appropriateness is one that is taken to a point where the CMR can confidently generate a GMP. To achieve this requires the CMR to be heavily involved in the design process and again highlights the need for rich collaboration. Essentially, UDOT asks the CMR to track design progress and literally tells the designer when it has enough design detail to adequately develop subcontractor bid packages and to be able to commit to a GMP for a given feature of work. UDOT also uses a progressive GMP to further facilitate this process and allows the department to negotiate the allocation of risks on a package-by-package basis before the GMP is established.

Design Validation Versus Design Review

Design validation is a term that came out of CMR project delivery in the building sector (Carlisle 2006). The content analysis found one document that referred to "validating" the design and four that required "verifying" the design. It differs in purpose from design review, in that design validation does not imply making substantive input to the design as a part of the process. Design validation's purpose is to have the constructor evaluate the design as it is originally intended and compare the scope of work with both the required budget and schedule to determine if the scope can be executed within those constraints. Ultimately, if the CMR finds the design to be valid, it could conceivably have no further preconstruction design review responsibilities. Thus, a validated design is one that can be constructed within the budget and schedule constraints of the project.

Design validation also takes on a constructability review flavor when availability of materials, means, and methods are checked. For example, a given design could be built within the budget and schedule if all the necessary resources are available. If a critical resource cannot be obtained in a timely manner, the design would not be validated, and the CMR would inform the designer and owner as to the nature of the issue. For example, the design for a major bridge that requires marine equipment of a size that is available but must be booked months in advance of the need could only be validated if the lead time on the equipment fell within the project's schedule constraints. If it did not, then the owner and designer would be made aware of the issue and given potential alternatives for resolution.

Design review, on the other hand, is done to identify errors, omissions, ambiguities, and with an eye to improving the constructability and economy of the design submittal. One author describes the process as "more than simply support/assistance . . . [it is done to] manage design-to-cost iterations" (Van Winkle 2007). The content analysis found 6 documents that required "assistance/input to the design," whereas, 26 termed the CMR's role "design review," and 3 stated the CMR should "find design errors." These reviews take on multipurpose forms with the CMR using its most experienced personnel to identify and resolve issues that are found in the design submittal. "The ability of the CM to input constructability reviews, construction phasing, material availability, and cost estimating throughout the design process reduces the probable occurrences of change orders, project construction delays, and increased project costs due to contractor identification of these elements early in the design phase instead of the construction phase" (Kwak and Bushey 2000).

With design review comes the issue of design liability and how it is applied to the CMR's comments and proposed solutions. This issue remains unclear with respect to the output of preconstruction design reviews. Martinez et al. (2007) offers the best solution: "Specific language in the pre-construction agreement is developed to address this issue and create a bright-line separation of responsibilities." The "bright-line separation" is often a clause in the design contract to the effect that the engineer-of-record remains responsible for the performance of the design and that whereas he/she actively considers recommendations made by the CMR, the CMR also evaluates those recommendations and finds them to be sound before incorporating them into the design itself. The CMR also has a responsibility to recognize its limitations and assist the engineer by the way it approaches these reviews.

> The construction manager is not the design professional and should be careful to limit its role to making suggestions that can be either approved or rejected by the A/E [architect/engineer] and owner. When VE [value engineering] includes a significant modification to the design, the construction manager should insist that these changes be reflected in the A/E's construction documents. The construction manager . . . should avoid comments in the constructability reports that would more properly be included in a peer review by design professionals. Problems noted by the construction manager in the design can instead be geared toward industry standards, previous construction experience with similar designs, and previous experience related to re-work or warranty issues (Martinez et al. 2007).

To summarize, it is up to the owner to draw the line in the contracts that it authors, and owners draw the line in a manner that keeps the liability for the entire design squarely on the shoulders of the qualified design professional.

Cost Modeling

Joint development of a cost model that can be used throughout the design process is a preconstruction service that is not well-understood by owners and designers. One author stressed the importance of doing this before design starts when it stated: "cost model then design" (Ladino et al. 2008). A preconstruction cost model is a breakdown of the project's scope of work in dollar terms. Its purpose is to "validate the owner's budget" (Ladino et al. 2008) and to be able to price various alternatives during design in a manner that directly reflects how and when they will be built (Van Winkle 2007). Additionally, the model evolves as the design progresses and is used to support required preconstruction cost estimates at design milestones and budget review points ("Contract for Construction Manager at Risk Design Phase Services" 2007).

It is also used to benchmark cost savings for value engineering alternatives found during design.

UDOT routinely uses cost modeling in its CMR program (R. Alder, "CM/GC Pricing Questions," personal communication, July 1, 2009). The interview revealed that this process allows it to make both design and contingency allocation decisions. One of the contractors who had completed CMR projects with more than one agency mentioned that it offers this up as a preconstruction service whether or not it is specified in their preconstruction services contract. Additionally both the UTA and its contractor emphasized the value of getting the cost model built before major design decisions are made. UTA also includes a clause in the design contract requiring joint development of the preconstruction cost model as an early task.

Constructability Reviews

The literature is rich with information on constructability reviews and their value to highway projects (*Constructability: A Primer* 1986; Gibson et al. 1996; Anderson and Fisher 1997; Jergeas and Van der Put 2001; Dunston et al. 2002; Ford et al. 2004; Carlisle 2006). Essentially, constructability in CMR projects is a review of the capability of the industry to determine if the required level of tools, methods, techniques, and technology are available to permit a competent and qualified construction contractor to build the project feature in question to the level of quality required by the contract. The constructability review also entails an evaluation of the ability of the industry to understand the required level of quality and accurately estimate the cost of providing it. Thus, the level of project risk resulting from subcontractor or supplier misinterpretation inherent to a set of plans and specifications is minimized. When a formal constructability review is combined with a thorough cost analysis, the final design is greatly enhanced and less susceptible to cost and time growth resulting from change orders and claims (Kwak and Bushey 2000).

A survey taken in Canada also found many of the previously cited benefits (Jergeas and Van der Put 2001). Additionally, this study found that "the areas that survey respondents indicated have the greatest potential to yield the benefits are achieved by implementing the following:

- Up-front (early) involvement of construction personnel
- Use of construction-sensitive schedules
- Use of designs that facilitate construction efficiency" (Jergeas and Van der Put 2001).

Thus, CMR project delivery creates the opportunity for agencies to use this powerful tool to improve their projects. A total of 35 of 54 solicitations in the content analysis explicitly cited constructability reviews as one of the required preconstruction services. Normally, other specific tasks such as regulatory review, operability review, and surveys of the market to verify availability and current cost of materials are undertaken at the same time. The other reviews may not use the same personnel on the CMR's staff, but they contribute their findings to the preconstruction deliverables that are due the owner (Van Winkle 2007). A regulatory review is merely a check to verify that the design complies with current codes and will not have difficulty obtaining the necessary permits. Operability reviews are much less common. They involve bringing in the agency's operations and maintenance personnel and providing them with an opportunity to make suggestions that will improve the operations and maintenance of the completed project. Market surveys are undertaken to furnish designers with alternative materials or equipment along with current pricing data and availability to assist them in making informed design decisions early in the process to reduce the need to change the design late in the process resulting from budget or schedule considerations (Martinez et al. 2007).

COST-RELATED PRECONSTRUCTION SERVICES

Early knowledge of project costs was cited by 10 of the 15 papers in Table 1 as an advantage found in CMR project delivery. The advantage is realized through three categories of cost-related services:

- Cost estimating,
- Cost analysis, and
- Cost–risk identification and mitigation.

Cost Estimating in Preconstruction

The major reason for selecting CMR project delivery is to gain access to the contractor's real-time construction pricing data and to have it available throughout the design process to assist in making cost-driven design decisions on the basis of the best possible information rather than on the basis of the engineer or owner's conjecture (Van Winkle 2007). Cost-estimating accuracy is a function of the level of design detail at the time of the estimate (*Cost Estimating Guide* 1997). Early estimates will have parts that run from detailed estimates on those features where quantities can be surveyed to plug numbers or allowances that act as place holders in the estimate until they can be improved. The final portion of the estimate is a contingency, which is discussed in detail in chapter six. The contingency reflects the probable cost of the unknowns at the time of the estimate and will be expected to decline as more design detail becomes available. Often the CMR is asked to validate the project's budget and agency or consultant cost estimates. Six of the solicitation documents require budget validation as a preconstruction service. Again, as with design validation, budget validation is done for the purpose of determining if the available funding is sufficient to cover the scope of work. This requires a much different level of effort on the CMR's part than preparing a project estimate. It essentially consists of comparing the agency/consultant numbers for each feature of work with historical parametric cost factors and identifying those features that appear to be either under-estimated or significantly overestimated. The CMR would then make recommendations as to possible resolution of the issues identified.

It makes sense to have the CMR prepare project cost estimates once it has been hired. Thirty-six solicitation documents included this. Not only does the CMR have a trained and experienced staff along with a current cost database, but it also has experience with working for a variety of owners, executing a variety of design consultants' designs. Therefore, it can furnish the critical reality check that is often missing in DBB projects until the bids are opened. Next, although the CMR wants to keep the owner happy to be competitive for the next project, its motivation is fundamentally different from the designers' in that it builds the project for the amount it committed to in the GMP. Not only does it fear that the owner may cancel the design project and hence the designer's planned revenue if it cannot afford the construction, but the designer's professional reputation will suffer, which might be reflected in the next design contract for which it competes. Therefore, assigning the task of preparing project estimates not only gives the job to the best-qualified and most experienced member of the team, but also relieves the designer of the estimating responsibility so that it can focus on what it does best.

Cost Analysis in Preconstruction

Estimating and analyzing cost data are two different functions. The estimate merely quantifies the scope of work in dollar terms. Cost analysis takes many forms but all are focused on determining if the scope, as reflected in the estimate, is economical. The first type of cost analysis is the cost engineering review. As its title suggests, cost engineering goes beyond merely quantity surveying and unit pricing. The cost engineer is normally a professional engineer who also has construction experience. This review includes not only the aspects of pricing but more importantly focuses on the "time equals money" features in the design. For example, a component that has several possible options is normally selected by picking the option that costs the least. If all options were equally available and equally constructable, then this is the most appropriate design decision. However, if each option takes different amounts of time to procure and install, the cost engineer will identify the option that best suits budget and schedule as well as technical requirements.

During the case study owner interviews, owners were asked to rate the value of various preconstruction services. They rated value analysis as the most valuable among the cost-related services. So, value analysis is an important aspect of preconstruction services. The Department of Energy (DOE) value engineering definition (1997) includes the third form of preconstruction cost analysis, life-cycle cost analysis, which was cited in two of the solicitation documents. When the case study interviewees were asked to rate the value of various preconstruction services, they rated life-cycle cost analysis as the least valuable among the cost-related services, indicating that life-cycle cost analysis does not appear to play a significant part in decisions made on CMR projects. The focus is on achieving the current budget rather than the longer-term costs of operations and maintenance.

Cost–Risk Identification and Mitigation

ODOT uses the CMR to furnish cost–risk analysis preconstruction services (Lee 2008). Three of the solicitation documents also asked for this preconstruction service. This primarily entails furnishing the agency with information regarding those cost items that have the greatest probability of being exceeded. This can come from volatility of construction materials prices or the potential need to work overtime to complete weather-sensitive features if unusually severe weather is encountered. Pinal County, Arizona, asked its CMR to forecast material pricing and uses that information to establish contingencies to mitigate volatility and to rearrange the work sequence to lock down the cost of the critical materials as early as possible. Finally, the use of early work packages is also a cost–risk mitigation tool. The ability to bid early work packages and hence lock in the cost of the materials and services associated with those packages was cited by 10 of the 15 authors listed in Table 1. This ability was also cited as "of highest value" by all but one case study project owner and all the interviewed contractors. Therefore, it appears that CMR projects would benefit if they use this cost–risk mitigation tool wherever it is appropriate.

SCHEDULE-RELATED PRECONSTRUCTION SERVICES

Scheduling is another field where the agency can play to one of the contractor's strengths. No team member is better qualified to develop and control the sequence of work than the constructor. "Contractor experience and expertise can aid the design team in preparing more cost effective traffic control plans, construction staging plans, and perhaps more realistic construction schedules" (Anderson and Damnjanovic 2008). Scheduling involves integrating the design, procurement, and construction schedules into a seamless product that identifies key relationships and accounts for both the administrative and logistics task completion to permit the production tasks to begin. The importance is shown because the owners interviewed on the case study projects rated "schedule validation" as the second most valuable preconstruction service after "value analysis." Nine solicitation documents gave the responsibility for project scheduling to the CMR with clauses such as these two: "Develop an overall management plan and critical path method management schedule of critical design and construction dates in order to accomplish the stated objective" and "Advise city of ways to gain efficiencies in project delivery."

Design Scheduling

"The construction manager is responsible for coordinating and updating the design schedule . . . the construction manager may be asked to perform quick estimates to be used as part of a [design] decision-making process in selecting systems" (Martinez et al. 2007). Developing a realistic and detailed schedule for all design, approval, estimating, and purchasing activities to support the start of construction activities is the primary objective of the preconstruction scheduling (Kuhn 2007). Highway projects such as the ones studied for this report all had the potential to create enormous impacts on the traveling public during construction. Therefore, it is always the unstated goal of a DOT to complete the construction in as short a time as possible and find ways to minimize public impact during construction.

The objective of the design schedule is to ensure that design activities are integrated with procurement and construction activities in a manner that facilitates project work flow. The project schedule "must reflect what is expected of the design team, CM, and owner so that packaging and scoping of the work can be accomplished through documents that address required information at each stage of the design process. . . . it is critical that the preconstruction manager be involved in the project as early as possible to coordinate deliverables and expectations with the design team" (Kuhn 2007). "The construction manager should review the overall project schedule and conduct coordination meetings with the design professionals to make sure the remaining design activities are in compliance with and integrated into the construction schedule" (Martinez et al. 2007). A comprehensive integrated project schedule also "provides for flexibility in the implementation of design changes late in the design process without impacting construction schedules and final delivery dates" (Kwak and Bushey 2000).

Construction Scheduling

The construction schedule developed in preconstruction is a living document and cannot be expected to be as detailed as would be found in a DBB construction schedule. It is better termed a "preliminary construction schedule" (Martinez et al. 2007) because it will grow and become more detailed as the design progresses and more information about the constructed product is known. The focus in preconstruction is the coordination of activities that impact the construction period of performance. For example, the Washington State study identified one benefit of conducting preliminary construction scheduling during preconstruction and that was the ability to manage impact on third-party stakeholders. "The preconstruction [scheduling] process allows discussions between Owner and GC/CM [CMR] to schedule and stage work to minimize the construction impact to our program" (Septelka and Goldblatt 2005). The content analysis counted ten occurrences of the CMR being asked to develop project phasing plans. Two examples of how this was expressed are as follows:

- "Provide a detailed construction phasing plan to possibly accelerate construction and/or potentially reduce associated costs for the street improvements and corresponding infrastructure."
- "Identify construction-phasing issues and educate the designers."

The idea is to plan everything that is known as it becomes known, at a time where changes to the plan will not affect the project delivery period. It is also to furnish schedule analysis for the owner to assist in decision making on aspects that interfere with traffic or cause disruption to affected property owners. It also allows time to evaluate safety requirements and ensure that the schedule supports the safe completion of the project. This theory extends into the quality realm to ensure that the project QA program has been allocated sufficient time to ensure the project's quality. Thus, the CMR involves the project's safety and QA/QC personnel in the development of the preliminary construction schedule.

Schedule Risk Analysis

The same comments about cost–risk analysis in the previous section apply to schedule risk analysis. With schedule validation sitting number two on the owner's list of valued services, identifying and mitigating threats to the schedule necessarily ranks alongside schedule validation. Here the "time equals money" factor comes to play once again. "Traditionally, risk assessments have concentrated on either cost or schedule. While schedule risk assessment can be performed without regards to cost in most cases, calculation of risk costs has to be tied to schedule" (Touran 2006). Thus, the schedule risk analysis also feeds back into the cost–risk analysis. The same author refutes the idea that it is the owner's responsibility to manage risk analysis:

> The CM is the entity who should be performing the risk analysis. The owner can benefit from an experienced construction manager that is present in the project since the beginning and understands the implications of various decisions regarding scope, budget, and schedule . . . Because of the CM's involvement during project development, he may have to conduct the analysis at various stages, e.g., at the end of conceptual design, at the end of preliminary engineering, at the time of the bid, and during construction phase (Touran 2006).

Once schedule risks are identified, the CMR looks for means to mitigate them. "Where there are construction materials and equipment that have relatively long delivery requirements, the construction manager may be asked to purchase or assist the owner in purchasing long lead items" (Martinez et al. 2007). This is an example of mitigating a potential schedule risk. Another example is the allocation of an available float in a manner that creates a time cushion for those activities that need it the most. Regardless, the CMR and its team will have experience from past projects and be able to apply appropriate mitigation strategies.

ADMINISTRATIVE PRECONSTRUCTION SERVICES

The final category from Table 26, "Administrative Preconstruction Services," can be separated into three categories:

- External coordination and information,
- GMP internal procurement, and
- Owner/designer assistance.

External Coordination and Information

External coordination is typically with two groups that are involved or impacted by the CMR project. The first group is third-party stakeholders such as utility companies, railroads, and impacted land owners. Seven solicitation documents indicated the need to coordinate with third parties and four specially mentioned utility coordination. The case study project owners rated coordination of this nature as the third most valuable preconstruction service and the contractors rated it second. Only FDOT did not include this as a required preconstruction service. Coordination with third parties is in itself a form of schedule risk mitigation. By effecting this coordination early in the design process, the CMR effectively reduces the risk that a third-party concern will delay the project. One of the best examples of the positive impact of CMR coordination comes from UDOT:

> One project began *before the railroad right of way issues were cleared* and was able to complete a year early. By careful construction planning the railroad work was saved for last and right of way issues were cleared in time to complete the project on schedule. Choosing a contractor in the design process also helps to clear utility issues. *Utility companies move more quickly to plan and execute solutions when they know the contractor* they will be working with (Alder 2007; italics added).

A second example from Utah is the UTA's Weber County Commuter Line project. "On the Weber County Commuter Rail project, UTA was faced with a potential nightmare of third-party coordination on a project that passed through ten communities and needed to share right-of-way and track with the Union Pacific Santa Fe Railroad. UTA selected CMR project delivery because it allowed them to retain control over the design while engaging the construction contractor in both design development and early coordination with third-party stakeholders" (Touran et al. 2009b). The third-party coordination efforts of the CMR resulted in the project finishing 6 months early without delays resulting from third-party issues.

The second external group is the general public. The Utah and Oregon DOTs specifically cited public relations/information as critical to the success of their CMR projects. Both projects involved Interstate highway bridges and had to be built while maintaining the flow of traffic. The Utah project involved accelerated bridge construction techniques, which required I-80 to be blocked for periods of time when the preassembled bridge was rolled into its final position. This was done multiple times. As there were a number of opportunities to negatively affect the public, UDOT assigned the CMR the task of developing a public information and relations plan and then executing it to first minimize the impact on the traveling public and then ensure that they knew when and for how long the unavoidable impacts were. UDOT's expectations were expressed in this manner in the solicitation for the project.

> The public has been heavily involved in this project for several years. A high level of public satisfaction is expected to continue through the design and construction phases of this project . . . The contractor shall participate in public involvement efforts during preconstruction and construction activities. The contractor will be required to coordinate, provide information, and attend all public meetings during the preconstruction phase (Alder 2007).

ODOT's public relations requirements took a different tone. The Willamette River Bridge on I-5 was located at Eugene. The Willamette River is an important fishery and the community was rightly concerned about the impact of pile driving in the river on the fishery. Additionally, there was also a "community" of homeless that had established a "people's park" under the existing bridge with the tacit approval of the residents of Eugene, who needed to be relocated to safely complete the project. Therefore, the CMR's public relations plan had to be extremely sensitive to the political consequences of disturbing the Eugene community's sense of environmental and social responsibility. As a result, the CMR implemented a public information plan that is being broadcast to the community through a number of different media to keep it abreast of the potential impacts as the design progresses. The lesson learned from both projects is that assigning the responsibility to interact with the public to the CMR makes it become "the face of the project" and allows it to build relationships with external parties that pay dividends during construction.

Guaranteed Maximum Price Internal Procurement

The next administrative preconstruction services are the tasks required for the CMR to advertise and award the subcontractor work packages. These consist primarily of breaking down the project scope of work into bid packages and reviewing the design documents that go with each package to ensure that sufficient information is contained in them to draw competitive pricing (Martinez et al. 2007). Eleven solicitation documents required the procurement of long-lead items. Additionally, many CMR contracts shift the risk of problems inherent to the subcontractors to the CMR as shown in the following contract clause in use by "Request for Proposal, Model, and Guidelines . . ." (2007). "Costs incurred due to conflicts, ambiguities, or inadequate coordination in the trade contractors' bid packages, or due to any other problems arising from trade contractors, in excess of the contingency shall be borne by the CM at Risk."

As previously mentioned the bid packages are often coordinated with the design work packages. This makes the biddability review more efficient and reduces the risk to the subcontractors because they are given the specific design product they need for their bids; not just told to find their work inside the full set of construction documents. Nine solicitations required the CMR to develop the subcontractor bid packages. An example of how this was articulated is as follows: "Recommend divisions of work to facilitate bidding and award of trade contracts, considering such factors as minimizing disruptions to existing facilities, improving or accelerating construction completion, minimizing trade jurisdiction disputes and other related issues."

Before subcontractors are invited to bid, the CMR usually prequalifies the subcontractors that can submit bids. Seven of the ten case study project owners allowed the CMR to manage this process without constraints, as did nine solicitation documents. The other three case study project owners and another nine solicitation documents required that the CMR award to the lowest responsible bidder in a public or semi-public bid opening. Establishing the subcontractor prequalification criteria can be a joint effort with the owner or completely performed by the CMR. If the owner participates, it will often contribute evaluation criteria that it believes will reduce the performance risk for critical trades over the long term. For example, on a bridge seismic retrofit project, the owner required that the subcontractor show past experience in installing the type of retrofit equipment that it proposed to use. If the CMR sets the criteria, it will usually emphasize past business relationships over specific technical experience. For the constructor, the ability to trust its subcontractors is a premium worth paying. Either way, it is important for the agency to decide how much control its wants over subcontractor qualifications before it awards the CMR contract.

Owner and Designer Assistance

The final category of preconstruction services involves those actions that are typically completed by the owner or the designer in most projects. The two primary areas that have been shifted to preconstruction services in CMR are assisting in the acquisition of right-of-way and obtaining permits. Two solicitation documents included right-of-way acquisition and five included permits. The literature on project delivery appears to advise that right-of-way acquisition not be delegated to a contractor (Molenaar 2005). This sentiment is based on the premise that the condemnation process available to public entities can create substantial delays if it becomes politically controversial, and the owner will be required to compensate the contractor for those delays. In CMR, the contractor usually is not asked to actually purchase the right-of-way, but rather is asked to assist the owner/designer during the acquisition period. In the UTA Weber County CMR project (Touran et al. 2009b), the CMR actually identified available right-of-way and negotiated a land trade with the railroad that permitted a substantial cost savings that was identified in a preconstruction value engineering proposal by the CMR. The project's solicitation indicated: "The design team will work with the Contractor to determine critical parcels required for their phasing and approach." The CMR in this project also assisted UTA in obtaining early permits from the 10 municipalities that the project crossed. The main point here is that UTA paid the CMR through its preconstruction services fees for the assistance. Thus, the risk of project delay owing to the inability to obtain right-of-way or permits was entirely on the agency. As a result, UTA received the entire savings generated by the value engineering proposal that was made viable by the CMR's right-of-way swap with the railroad. Therefore, the practice in the CMR does not appear to be contrary to the recommendations voiced in the literature. The construction "cost meter" does not start until a construction notice to proceed is issued. In the UTA project, if the agency had been unable to obtain the necessary right-of-way or permits in a reasonable amount of time it would have merely closed out the preconstruction services and design contracts and halted the project until the requisites for the third parties were satisfied. In other words, UTA had quantified its risk as only the cost of design and preconstruction contracts because it had not yet committed to the construction contract.

The last preconstruction service shown in Table 26 is the preparation and submittal of an application to obtain a national certification of sustainability. This was only found in the Lanier Law Center CMR project, which was required to be certified by the U.S. Green Building Council's LEED® program. Nevertheless, the subject of sustainability was raised in every case study interview and, almost without exception, the interviewees agreed that although certifying the sustainability of transportation projects is not yet required, the mood in the nation indicates that it will probably be in the near future. Therefore, those agencies that are considering implementing CMR project delivery may consider a provision in their regulations/enabling legislation to accommodate a future requirement to certify a project's sustainability.

PRECONSTRUCTION FEES AND DESIGN COST IMPACT

The first question most upper managers in transportation agencies ask when considering a change to their procurement program is: How much is it going cost? CMR project delivery adds a fee for preconstruction services. Both the literature and the case study interviews reported that those services reaped savings in both design and construction costs. The next sections will discuss these important facets of CMR project delivery.

Preconstruction Service Fees

Although CMR project delivery is increasing throughout the United States, there is no standard method to estimate the cost of the preconstruction service fees that are associated with this delivery method (Carlisle 2006). The DBB project delivery method does not typically involve the construction contractor until the design is complete. Therefore, contractors who are competing for CMR contracts for the first time are not accustomed to estimating this type of fee and are trying to use traditional practices for a nontraditional delivery method that has no published standards.

Contractor Rationale

The interviews with experienced CMR contractors indicated that they use a method that is very similar to that used by a consulting engineer to estimate its design fee. Most of the interviewees attempt to estimate the number of hours that preconstruction staff of various pay grades and disciplines will spend on the preconstruction services. These are compiled along with the estimated direct expenses (travel, printing, communications, etc.) to arrive at a total cost. Next, they compare the estimated cost to the size of the project and make a business decision as to what fee would appear to be reasonable. This is particularly important on projects that are being procured using an RFP, where the proposed preconstruction service fee is required as part of a competitive proposal. Interestingly, all the contractors that were interviewed indicated that they do not mark this fee up for profit. Every one of them stated that they intend to earn their profit on the construction itself.

This statement about profit is confirmed in the literature by the following quote:

> Construction managers are in the business of construction . . . As a result, consulting services during pre-construction frequently are *provided at cost without a fee for profit.* If the construction manager believes the proposed construction project could be financially attractive, the direct costs actually incurred by the construction manager [in preconstruction] may have no relation to the compensation [preconstruction fee] (Martinez et al. 2007; italics added).

The winning CMR for the UTA Weber County Commuter Rail project proposed a fee that was less than one-third of the next lowest proposed fee (Touran et al. 2009b). When interviewed, the CMR stated that the firm believed that the value of being able to participate in the design process more than made up for the need to self-finance the preconstruction services contract. The CMR indicated that because the project was completed early owing to the CMR's preconstruction efforts, it had more than made up for any losses it incurred on the preconstruction fee by additional profit gained from being able to demobilize several months early.

The final point learned from the contractor interviews was that they can offer the lowest possible fees to those owners that do a good job of informing them exactly what is required for preconstruction services in the RFP. One contractor made the comment that it had dealt with owners new to CMR who assumed there was an industry standard for preconstruction services scope and that meant anything the contractor was asked to do was covered by its preconstruction fee. The best policy is to treat this like any other contract and describe the scope of work for preconstruction services before executing a contract. "The construction manager's role during the preconstruction phase will vary in accordance with the scope of the services that the owner requests and the construction manager agrees to provide" (Martinez et al. 2007). In other words, what is shown in the contract can be enforced. Services not covered by the contract become discretionary for the CMR.

Preconstruction Fee Status

Actual and estimated preconstruction services fees were obtained from all the interviewees and from examples in the literature. The solicitation documents were silent except to require a proposed fee as part of the CMR proposal. Table 28 shows the information found on this topic. It can be seen that the range runs from 0.0% to 2.84% of construction costs. The mathematical average of the fees in the table is 0.70%. The average preconstruction services fee for each sector is also shown.

Of the figures in the table, the ones found by Septelka and Goldbatt come from the largest population, 108 public projects. Uhlik and Eller and Carlisle's figures are for populations that range from 17 to 74 public and private projects. The remaining figures are for a single project only. The trend is clear; preconstruction services fees appear to run less than 1% of the project's construction cost. There is no explanation available as to why the airport projects are half the fee of the other sectors. However, the paper by Carlisle may shed some light on the possible reason.

Carlisle's study (2006) specifically sought to determine how to estimate preconstruction services in the building sector. It collected information from both public and private CMR projects and attempted to differentiate between them statistically. The study's important finding had little to do with the cost of preconstruction in the public versus private sectors, but rather Carlisle's methodology also included looking to see if the point in design development where the CMR was selected affected the value of the preconstruction service fee.

Figure 17 was developed from Carlisle's raw data and does not come from his paper. It combined both types of projects into a single population. As shown, preconstruction service fees decrease as the percentage of design completion at which the CMR is procured increases. This makes sense in that there is less that the CMR can do to influence the ultimate shape of the project and functionally less time in which it can add value. Therefore, in general, these fees range from a high of 0.75% of construction costs when the CMR is retained at the same time as the designer to a low of 0.05% when the CMR is retained immediately before the design is complete.

TABLE 28
PRECONSTRUCTION FEE HISTORY

Project Location and Type	Source of Information	Cited Preconstruction Service (% of GMP)
Washington State—Building, Water/Waste Water, Local Roads	Septelka and Goldbatt (2005)	0.00% to 2.84%; Mean = 0.89%
Nationwide Federal Projects—Medical Buildings	Uhlik and Eller (1999)	1.0% to 2.0% Mean = 1.49%
Oklahoma, Texas—Buildings	Carlisle (2006)	0.15% to 0.50% Mean = 0.44%
Texas—Buildings	Lanier Center Case Study Project	0.33%
	Building Average	0.79%
Arizona—Highway	Sundt Construction (2008)*	0.80%
Arizona—Highway	Pinal County Case Study Project	0.60%
Arizona—Highway	City of Glendale Case Study Project	1.10%
Utah—Highway	I-80 Case Study Project	0.10%
Arizona—Highway	Kiewit Phoenix District (2008)*	0.70%
Oregon—Highway	Willamette River Bridge Case Study	1.50%
	Highway Average	0.80%
Alaska—Airport	Fairbanks Airport Case Study Project	0.25%
Tennessee—Airport	Memphis Airport Case Study Project	0.35%
Rhode Island—Airport	Rhode Island Airport Corporation 2008	0.29%
	Airport Average	0.30%
Michigan—Seaport	Passenger Ship Terminal Case Study	0.50%
Utah—Rail Transit	Weber County Case Study Project	0.21%
Washington—Utility	Seattle Public Utility Project	1.70%
	Overall Average	0.70%

* "Arizona CM/GC Highway Projects," interview, Nov. 11, 2008.

Looking at the magnitude of the average values, preconstruction services at 0% design are more than twice the amount at 90% design completion.

Preconstruction Impact on Design Costs

Five Table 1 authors cited reduced design cost as an advantage of CMR project delivery. "Reduced design costs, construction, and construction engineering inspection costs" (Anderson and Damnjanovic 2008) is typical of the way authors in the literature described the advantages of implementing CMR. Additionally, several of the case study project owners confirmed what was found in the literature. A UDOT progress report on its CMR program described the reasons it was paying less for design like this:

> The CMGC process has reduced the schedule for most projects. Part of the reason for this is the *time saved in the design effort.* The contractor's participation helps to identify solutions quickly and speeds up the design process. Their participation also *reduces the detail that must be communicated to the contactor in drawings and specifications* (Alder 2007; italics added).

The interview with UDOT indicated that since the 2007 report the trend of design cost savings continued and appeared to be near 40% savings to date. The question then becomes: Where are those savings found?

The previous quotation identifies two design cost saving areas found by UDOT. The first is in time saved during design. Engineering consultants typically develop their fees based on billable hours and multipliers applied to total billable hours (Carr and Beyor 2005). Thus, the less time it takes to arrive

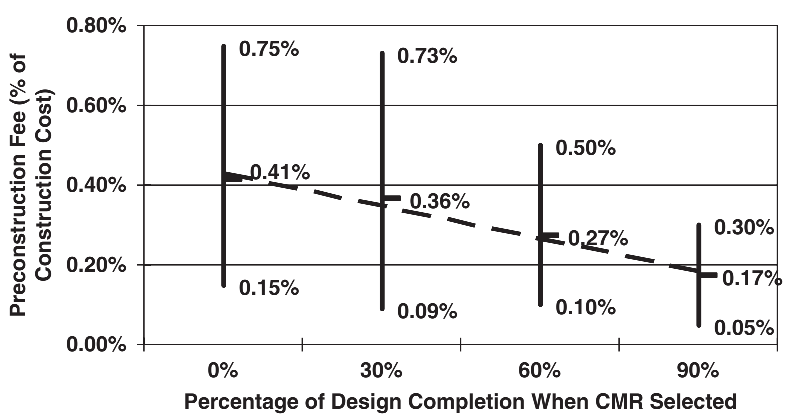

FIGURE 17 Carlisle study (2006) preconstruction fee trends (entire population). Bars show high, average, and low values at each design milestone.

at final construction documents the lower the design fee. However, a survey by the CMAA ("Speed, Communication, and Commissioning Issues . . ." 2003) found that the "demand for increasing speed of project delivery is the top reason for decline in construction document quality." The CMAA survey also reported that "In their responses to questions about the quality of construction documents, more than half of the owners surveyed responded that these documents often have significant amounts of missing information." Specifically, 45% of respondents indicated that construction documents, although sufficient, still had "significant information needed," whereas an additional 12% found that documents were "typically inadequate because of major information gaps" ("Speed, Communication, and Commissioning Issues . . ." 2003). Although the survey was primarily talking about DBB project construction documents, the concern is still valid for CMR projects. However, that the CMR reviews the documents before pricing them appears to provide a means to accelerate the project without a loss in design quality. "Design consultants preferred this method because UDOT controlled the design and innovations selected for the project, and this gave them a greater ability *to develop a quality design*" (Alder 2007; italics added).

To realize the reduced design time, the CMR is typically given responsibility to manage the design schedule (Martinez et al. 2007). The Washington State study measured the impact of implementing CMR on cost and schedule. "Another performance measure is delivery speed, the rate at which the project team designed and built the facility. The higher the intensity of delivery indicates a better outcome in terms of cost and schedule . . . GC/CM projects outperformed DBB projects by 159%" (Septelka and Goldblatt 2005).

The second place to find design costs savings is by reducing the total amount of design detail that goes into a set of construction documents as cited by Alder (2007). During the case study project interviews, one of the owners stated that the engineer did not need to produce a full set of "biddable" construction documents. Elaborating on this statement, he indicated that the CMR controlled the level of detail required to get "biddable" subcontractor packages and that the sum of the total design effort was less than that required to produce a full set of construction documents for a DBB project. UDOT calls this developing an "appropriate design" rather than a "complete" design. UDOT's definition is a design that is taken to a point where the CMR can confidently generate a GMP.

An example of less detail was the use of a note to reference a standard detail rather than copying that detail into the construction plans. "The construction documents are intended to convey, *in as much detail as necessary,* the graphic and quantitative information required by the trade contractors to perform the construction work" (Martinez et al. 2007; italics added). One of the contractors seconded this notion by saying that CMR construction documents are "less messy" than DBB because they only contain the information needed to build the project. Having been involved in the design process by means of the review process, the CMR's staff is more intimately familiar with the construction documents' contents. A different owner stated that in its CMR projects the contractor "understood the design" much better than in DBB. All of the foregoing discussion goes to say that CMR project delivery's impact on the design process appears to be positive.

SUMMARY

Based on the information gleaned from the literature and the case study projects, several conclusions and effective practices can be drawn.

Conclusions

The main conclusion is that preconstruction services are a distinct benefit to the project's cost, schedule, and ultimate quality. "The City of Portland reported that the contractor's early involvement with design review, value engineering, and risk analysis prior to design completion contributed to significant cost and schedule savings on the West Willamette River project" (Gribbon et al. 2003). UDOT expressed the same sentiment in its report:

> The CMGC process gives the contractor more time to understand and improve the design and to learn new construction methods not used before. Constructability is continuously reviewed in the design phase so the design is optimized for construction and project costs are reduced. The contractor is able to inform the team what construction methods would simplify construction and reduce cost and schedule (Alder 2007).

When the cost of preconstruction services is compared with the actual benefits that are cited in this chapter, it appears to be quite reasonable. This debunks the myth that adding another fee and another party to the design phase must cost more (A.M. Solochek, "CM-at-Risk Premium," personal communication, Nov. 23, 2005). Although there is an additional fee and an additional contract to administer, it is an investment to realize quantifiable benefits to the CMR project.

Effective Practices

A number of effective practices were also derived from this chapter's analysis.

- Detailing the specific preconstruction services an agency wants provided in the preconstruction services contract in the solicitation document is critical to getting a reasonable proposal if costs are included in the selection process.
- Assigning the CMR the duties of scheduling for both design and construction during the preconstruction phase creates a point where collaboration is enhanced. This service was rated as the second most valuable

TABLE 29
DIFFERENT GMP TIMING CLAUSES FOUND IN THE CONTENT ANALYSIS

No.	GMP Timing Clause	Source
1	The CMR services will be performed in two phases with two separate contracts. Phase I and the first contract will include the preconstruction services and the preparation and submission of the GMP. Phase II and the second contract will include complete construction services for the construction project.	Gilbert, AZ Road Project
2	At some point before construction, the CMR will assume the risk of delivering the project through a GMP contract.	Glendale, AZ Case Study Project
3	At some point during the design phase the CMR will submit a complete proposal to assume the risk of delivering the project through a GMP contract.	Casagrande, AZ Road Project
4	At the completion of design or at any earlier time as required by the town, the CMR will submit a construction GMP to town.	Gilbert, AZ Road Project
5	At completion of design, or at any point in Phase I before construction, as may be required by the county, the CMR will be requested to provide a GMP.	Pima County, AZ Road Project
6	GMP negotiations will occur sometime between the Design Team's completion of 60% and 90% design.	Seattle, WA Utility Project
7	*The CM's GMP may be *submitted at any time after completion* and approval of the design development phase, but in no case later than 10 days after the designer submits final review construction documents.	Golden, CO Building Project
8	*GMP will be required at the completion of the Design Development phase.	Boulder, CO Building Project
9	**The project team to be bound by the established estimate of construction costs derived by the CM/GC at schematic design level.	Parker, CO Building Project
10	When design documents for the project have been developed in sufficient detail, the CM with the support and assistance of the architect will commit to a GMP for all construction and site development.	Atlanta, GA Building Project

*Completion of the "design development phase" in an architectural project equates to 40% to 50% design completion in a transportation project (Hess and Bales 2007).
**Completion of the "schematic design level" in an architectural project equate to 15% to 30% design completion in a transportation project (Hess and Bales 2007).

preconstruction service by both the case study agencies and contractors, and ability to fast track was cited by 10 of the 15 papers shown in Table 1.

- Joint development of the preconstruction service cost model before commencing design allows the designer and the CMR to be able to leverage it to make design decisions and to benchmark value engineering savings.
- Furnishing a list of the cost categories to be used in the preconstruction cost model as well as articulating where the agency wants various costs, such as fees and contingencies to be accounted for in the CMR contract eliminates ambiguity and assists in all parties being able to understand the cost model output. Table 29 provides a typical format for these costs.

CHAPTER SIX

PROCEDURES FOR ESTABLISHING THE GUARANTEED MAXIMUM PRICE

INTRODUCTION

The term "guaranteed maximum price" (GMP) is often misunderstood. "Most Owners see having a Guaranteed Maximum Price (GMP) as equivalent to having a Stipulated Sum Cost" (Strang 2002). In the eyes of the uninitiated, the word "guaranteed" implies that the owner will *never* have to pay more than the GMP. However, in CMR the GMP amount is a number that corresponds to a quantified scope of work expressed in the design documents at the time the base cost estimate was completed. Therefore, if a substantial change in scope occurs, the CMR is due fair compensation for that cost of increased work. This leads to the impression articulated by Strang that the owner effectively shifts the risk for the total cost of the project to the contractor, regardless of the nature of the realized risks. The literature refutes this idea as patently untrue and supports the idea that it is important to lay out the details of how the GMP will be assembled and ultimately established in both the solicitation documents and the contracts for preconstruction and construction services (Armstrong and Wallace 2001; Strang 2002; Alder 2007; Bearup et al. 2007; Martinez et al. 2007; Trauner 2007; Ladino et al. 2008; Lee 2008).

Kwak and Bushey (2000) furnish a very simple definition for the components of a GMP: "The GMP is composed of work, overhead, profit, and a contingency." Breaking these elements out assists the owner to understand the relative magnitude of each component and furnishes a framework from which the owner can assess the reasonableness and realism of each element. A typical GMP clause from a transportation project RFP reviewed in the content analysis defines the GMP in the following manner:

> The Contractor's Fee as an established percentage shall be applied to the Cost of the Work plus contingency. The sum of the Cost of the Work plus contingency, plus Contractor's fee shall establish the basis of the Guaranteed Maximum Price (GMP) for the project prior to construction start ("CM/GC Fee Structure Sample" 2007).

This definition is the simplest possible GMP: direct cost, contingency, and fee, which includes the contractor's general conditions. Figure 18 illustrates the possible components of a CMR GMP based on those found in the case study projects. The figure is meant to be inclusive not restrictive. Therefore, some of the specific elements shown are not present in every CMR contract. However, the elements that are common to most transportation CMR project GMPs are identified as such. Figure 18 can be turned into a cost model for a specific project. Modeling the costs in context with the available budget before making fundamental design decisions is imperative to the success of horizontal CMR projects (Ladino et al. 2008). The model can then be used to validate the owner's project budget at a point where design effort is not lost and where the CMR can furnish up-to-date market information that will help achieve the project's function within the owner's available funding (Ladino et al. 2008). In Figure 18, the least complicated GMP would have the following elements:

- Project direct costs
  - Subcontract work package costs
  - CMR self-performed work package costs
- Indirect costs: CMR's general conditions/overhead costs
- Profit: Percentage mark-up or lump sum fee
- CMR project contingency.

The industry has a number of variations on the basic GMP. Some add a separate pool for potential subcontractor-installed material purchases by the CMR to lock in the cost of volatile construction materials, such as asphalt, steel, etc., before the design has reached a point where subcontractor bids can be requested. Others divide the total project contingency into two or three parts to furnish additional cost control based on the wishes of the owner. Therefore, having defined the basic components of a CMR GMP, each will be discussed in detail.

PROJECT DIRECT COSTS

Developing the direct cost portion of a CMR GMP is highly dependent on the level of design development that has been completed at the time the GMP is established. These costs directly reflect the quantities of work. A design work package that is nearly finished can be estimated with greater confidence in the quantities shown on the plans than one that has just been started. Additionally, costs are also dependent on whether the work is being performed by the CMR's forces or a subcontractor. It is also dependent on the constraints imposed on the CMR regarding the selection of subcontractors, as well as how much, if any, of the work the CMR is allowed to self-perform.

Guaranteed Maximum Price Timing Issues

Selecting the point in time where a GMP is established is an extremely important decision. A GMP set late in the design

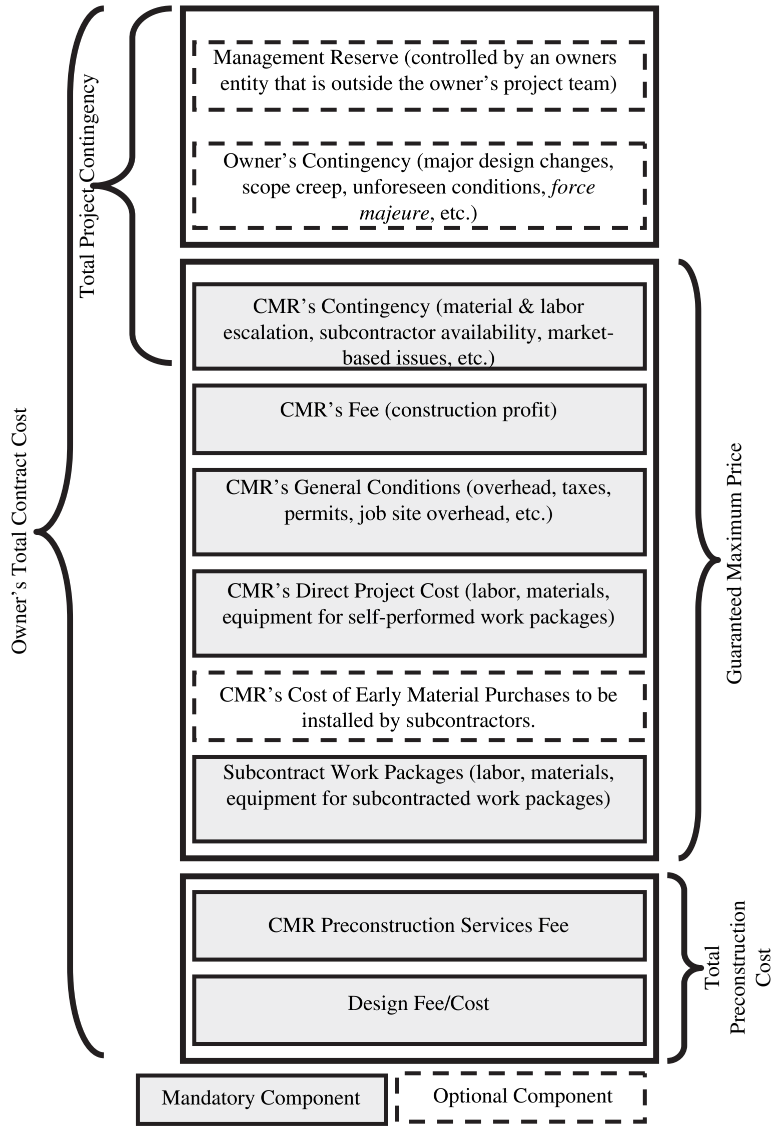

FIGURE 18 Guaranteed maximum price model.

process will have less contingency included than one required early in the design process. One of the reasons cited for using CMR rather than DB project delivery for large complex projects is to reduce the "premium" the owner pays for requiring a firm fixed price at an early stage of design completion (Trauner 2007). The case study analysis found that nine of ten agencies required the GMP before 100% design. However, four waited until subcontractor bids were received on the major packages in the job, and two allowed the CMR to set the timing based on its assessment of the risk of quantity growth in those packages that were not complete. The other four agencies set the timing contractually. Table 29 is a collection of different GMP timing clauses found in the content analysis and is provided to demonstrate the range in possible options in use in the industry. The ten clauses in the table show a range of timing from as early as 15% design in Clause 9 to as late as shown in Clauses 4 and 5, which could be interpreted to mean after 100% design completion.

Construction Manager-at-Risk Subcontracting Issues

Three issues regarding subcontracting were found in the case study analysis. The issues are postulated as the following questions that an agency would answer when it selects CMR project delivery:

- Is the CMR allowed to self-perform a portion of the work?
- If so, is there a limitation/constraint on the amount of the project the CMR can self-perform?
- What constraints will be placed on the CMR's ability to select subcontractors?

The first question is a matter of policy rather than any underlying technical or contractual reason. The case study projects came from 10 different public agencies and only one would not permit the CMR to self-perform; that was the Fairbanks Airport project. The interview found that previous experience in Alaska with non-transportation projects created a perception that allowing the CMR to self-perform created a conflict of interest and was viewed as a disadvantage by the subcontracting community. This was because the CMR had to compete against industry for the work it wanted to self-perform and was thought to have "inside" knowledge. The issue was put to rest by not allowing the CMR to self-perform. Washington State had a successful protest of self-performance by a subcontractor on a building project that led to a change in the law to specifically limit the CMR to self-perform no more than 30% of the project (Septelka and Goldblatt 2005) and a report done by the city of Seattle (Denzel et al. 2004) confirmed the perception of unfairness when it stated: "The City should also recognize that the announcement of the intent to bid for "self-performed" work by a GC/CM can discourage other subcontractors from bidding, either because they perceive the GC/CM has an unfair advantage, or because they do not want to alienate the GC/CM who may provide future work for them. This can undermine the competitive process."

CMR Self-Performance Limits

Another common premise for not allowing the CMR to self-perform is the idea that self-performance degrades the CMR's ability to act in the owner's best interest by imposing an internal need to realize profit on work packages that have not been assigned to subcontractors. Strang (2002) describes it this way: "For the general contractor the change will be the advocacy of the client's position . . . CM At-Risk is still largely a position of representing the Owner's interests, and if it is pursued as simply a general contract it will leave the Owner dissatisfied and the CM without future work." The U.S. construction industry has evolved to a point where some general contractors routinely complete projects where 100% of the work has been subcontracted, whereas others have maintained the ability to self-perform. Thus, a policy or law that either disallows self-performance or caps the percentage of self-performed work creates an artificial constraint on industry and unnecessarily reduces the pool of qualified competitors. The survey response from Washington State indicated that the state's legislated 30% cap on CMR self-performance created industry resistance to using the DOT's CMR authority because most contractors in that state would choose to self-perform a larger proportion of the project. On the other hand, some public agencies have legislation that requires a minimum level of self-performance on construction contracts (Brinkman 2007; "Supplemental Instructions for Form IC 730 . . ." 2008). That effectively eliminates those contractors that sub out all the work.

The content analysis found 17 cases where CMR self-performance was mentioned. Three of those cases included a minimum percentage (45% or 50%) for CMR self-performed work. The others furnished no minimum or maximum limitations. However, limits may have been imposed by reference and as a result would not have been found in the content analysis. The city of Seattle report (Denzel et al. 2004) offers three reasons to permit the CMR to self-perform, terming them "significant benefits":

- The GC/CM can exert better control of the project schedule if they are self-performing parts of the work that are essential to the critical path for the project, especially fundamental structural elements such as concrete or framing on which other subcontractors' work depends;
- Subcontractors may prefer that the GC/CM have a stake in the performance of the work; and
- The ability to self-perform can be part of what makes the job attractive to top-notch GC/CM firms, since they customarily perform the type of work they bid for and have crews on hand to fulfill those responsibilities (Denzel et al. 2004).

The previous discussion leads to the inference that competition can be enhanced if there is no constraint on the level of self-performed work imposed on the competing CMRs. Thus, a single answer that satisfies the first two questions would be: *The CMR be allowed to self-perform as much of the work as it believes is appropriate for a given project.*

The case study results found limits that were both minimum and maximum percentages. Six of the seven case study highway agencies had a limit of some form. The average of these limits without regard to their specific nature is 47%, with a low of 30% and a high of 70%. All of these limitations were imposed by legislation. None of the non-highway cases limited the CMR's self-performance percentage. Therefore, from the information collected in this study, the imposition of a self-performance limit in any form appears to have no impact on the success or failure of the project. All the interviewees expressed the perception that CMR was working well on its respective projects. The city of Phoenix, Arizona, has completed more than 200 CMR projects while requiring a minimum of 45% CMR self-performance (Brinkman 2007). Therefore, if the perception of unfairness was indeed a real danger to competition, then the city of Phoenix would have been unable to attract competent CMRs and would have probably abandoned the project delivery method altogether. The same argument applies to the UDOT, who at this writing has successfully completed 16 CMR highway projects and sees CMR as a major tool in its procurement toolbox (Alder 2007).

Subcontractor Competition/Selection Constraints

The third question in this section deals with the CMR's control over the selection of subcontractors. The answer depends on the enabling legislation as well as state or agency policies regarding competitive bidding. One documented benefit of CMR is the ability to "preserve" competitive pricing by requiring the CMR to solicit bids from the trade subcontractors (Uhlik and Eller 1999; Strang 2002; Alder 2007; Martinez et al. 2007). The case studies ran the gamut from no restrictions on the subcontracting process to requiring the CMR to take competitive bids and award to the low bidder.

Oklahoma has an extreme example of required competitive bidding in its code governing the construction of public buildings:

> Because the construction manager is "at risk" for the total contract amount, they are permitted to self-perform portions of the work, provided that they competitively bid the work as a lump sum (each work package) under the same terms and conditions as the other bidders . . . the construction manager will award to the lowest responsible bidder (Oklahoma 2007).

Under this system, the CMR declares which work packages it wants to perform and literally bid against the industry for the right to self-perform. Thus, the CMR not only bids against its potential subcontractors for the right to self-perform, it also awards to the low bidder without respect to the sub's ability to perform. This creates a problem that may have a detrimental impact on the project in that the code does not permit prequalification of subcontractors. Additionally, this prevents the CMR from seeking expert help during preconstruction because contacting a potential subcontractor for technical information or current pricing creates the perception of unfairness previously discussed. Hence, the CMR's ability to use its professional connections to procure real-time pricing information is virtually eliminated. This policy also exists in Arizona and Florida. One Arizona RFQ contained the following statement: "The CMR may also compete to self perform portions of the work."

Therefore, to put this in perspective, the urge to require the CMR to select subcontractors on a low-bid basis and/or restrict subcontractor prequalification is motivated by the desire to "preserve" competitive pricing for most of the project's work packages because the GC is now selected on a basis of qualifications. Both the literature and the case study output confirm that this motivation is misguided. The Construction Financial Management Association (CFMA) conducted a study in 2000 comparing CMR costs with DBB costs and "showed no significant difference in costs to the owner between CMR and traditional low-bid lump sum GC-based contracts" (*CFMA Annual Financial Survey, 2000* 2000). This study was cited by two other studies that came to the same conclusion (Strang 2002; Cunningham 2005). That eight of ten case study projects allowed the CMR to pick and choose its subcontractors without constraint demonstrates that practitioners have recognized the inherent value to their projects of the CMR's long-standing commercial relationships. Additionally, Table 1 shows that the two significant CMR advantages that are most closely tied to subcontracting ("early knowledge of costs" and "ability to bid early work packages") were each cited by 10 of the 15 authors, whereas "competitive bidding possible" was only cited 4 times. Therefore, the intersection of these three lines of information leads to the conclusion that owners who select CMR project delivery to control costs can allow their CMR the ability to select the subcontractors that it prefers. This is concluded for three reasons:

1. To get real-time pricing information, the CMR is able to communicate with the subcontractors it knows during preconstruction.
2. To obtain real-time technical information about best practices for subcontractor trade means and methods, the CMR is also able to communicate with the subcontractors it knows to be subject matter experts during preconstruction.
3. Studies have shown that competitive pricing is "preserved" without competitive bidding. Therefore, requiring the CMR to award subcontractor work packages to an open field of competitors does not appear to save money.

Amplifying on the third point, agencies are reminded that in a DBB project delivery that GC is typically allowed to select a subcontractor whose price is marginally higher than the lowest quote. This is especially true if a given sub has a strong record of good performance on the GC's past projects. A Massachusetts study that reviewed the cost of a very restrictive procurement law that required subcontractor selection on price alone, mirroring the Oklahoma CMR law, found that DBB construction costs increased as a result of excessive construction cost growth and claims. There were no long-standing relationships between the GC and its subcontractors and as a result, the GC did nothing to discourage the subcontractors' claims (Gransberg 1999). Another study that compared project cost performance in the building construction sector found that CMR costs were marginally less (1.5%) than costs for DBB projects (Sanvido and Konchar 1999). These prove the old adage that "lowest bid does not always equal lowest final cost" (Ellicott 1994). Therefore, this bit of wisdom from DBB could be revised for CMR to state:

> Requiring competitive subcontractor bidding in CMR project delivery <u>does not equal</u> lowest possible GMP.

Construction Manager-at-Risk Self-Performance Costs

First, it is to be noted that if the CMR is not allowed to self-perform work packages that these costs will not necessarily be zero. It is not uncommon for the CMR to furnish certain types of materials and equipment to the project to avoid subcontractor mark-ups on those items. For example, if several subcontractors will require the use of a scissor-lift and scaffolding to complete their work packages, the CMR will furnish those items at its own expense. It is also possible for the CMR to create a small work package for project clean-up and punchlist, planning to do these bits itself at project completion rather than try to police all the subcontractors as they come and go. Therefore, this category of GMP costs might be better thought of as "CMR direct costs" to account for miscellaneous labor, equipment, and materials provided to the project by the CMR that are ultimately incorporated into or used to complete subcontractor work packages.

On projects where CMR self-performed work is not prohibited, these costs will relate to direct costs of labor, equipment, and materials in much the same manner as they would be estimated for a DBB project. The important difference is that the agency delineate between direct costs and the CMR's general conditions and overhead costs. The way to ensure that controversy does not arise during GMP negotiations is to publish a schedule of cost types that shows the CMR in exactly which category the agency wants various costs to be collected. Grand County, Colorado, has an excellent "CM/GC Fee Structure Sample" (2007), which is shown in part in Table 30.

The example is not provided as an all-inclusive and definitive practice, but rather it shows how the agency can reduce the amount of potential controversy during GMP negotiations by structuring the GMP assembly process. This approach will also accrue the benefit of having the agency's historical CMR cost data in a form that facilitates using it to estimate future CMR projects. It also gives upper management decision makers a reliable benchmark against which to measure the realism and reasonableness of the engineer's estimates before advertising CMR projects. Lastly, it permits the agency to be able to quantify the cost impact of management decisions to shed specific risks such as obtaining permits in a manner where standard operating policy can be changed based on hard data rather than perceptions.

Construction Manager-at-Risk Early Material Package Purchases

The final common direct cost in CMR is the purchase of materials at the earliest possible point in design development

TABLE 30
GRAND COUNTY, COLORADO, SAMPLE CM/GC FEE STRUCTURE EXTRACT

Services	Pre-Construction Fee	Construction Fee	General Conditions/ Overhead	CMR Direct Cost	Sub-Work Package Costs	Owner Expense
Contractor Home Office Staff and Services						
Corporate executives	X	X				
Safety manager	X	X				
Contractor Job Site Office Staff and Services						
Project manager		X				
Engineering and layout			X			
Project Cost Control						
Validation of project budget	X					
CPM schedule with updates	X		X			
Subcontractor Selection						
Participate in setting sub prequal.	X					
Set work package plans	X					
Analyze subcontractor bids	X	X				
Contract Document Coordination						
Review for constructability	X					
Coordinate design packages with work packages	X					
Review of proper phasing	X	X				
Quality Control						
Prepare QC plan	X					
Arrange QC testing and inspections			X			
Independent verification testing					X	
Acceptance testing						X
Insurance, Bonds, and Permits						
Builder's risk			X			
Utility development fees				X	X	
State DEQ general permit						X
Job Site Facilities and Services						
Temporary field office				X		
Project signs			X			
Temporary Facilities						
Temporary telephone			X			
Final clean-up				X	X	
Project Work Package #1—Sitework						
Utility relocations				X		
Earthwork—drainage				X		
Project Work Package #2—Bridge A						
Drill piers					X	
Precast concrete installation					X	

After "CM/GC Fee Structure Sample," Grand County, Colorado (2007).
Shows all categories and typical examples of cost types.
DEQ = Department of Environmental Quality.

to fix volatile construction material prices and reduce or eliminate the total amount of escalation contained in the GMP. Often these early material procurement packages are for work that will be completed by subcontractors. The UDOT uses this technique in its CMR contracts. On the I-80 case study project, it established a separate GMP for materials and thereby eliminated the need to add escalation to material pricing in the direct costs. The Memphis Airport did a similar thing for the steel that was in its project and estimates it had a significant savings as a result. The major issue with early material packages is that the associated design features need to be fairly complete to generate the quantities necessary to place the order. Memphis accomplished this by putting "date-certain" milestones for the engineer to bring the design for the steel procurement package to a point where reasonably accurate quantities could be surveyed. They then permitted the CMR to include an item in its contingency to pay for any changes that might occur between the time the steel was ordered and the final steel design. The steel was erected by a subcontractor who furnished labor and equipment only.

Given the successful application of this approach in the case study projects, it appears prudent to consider including early material packages routinely on CMR projects. To do so necessitates a change to standard design contracts. These early packages are only as beneficial as the designer can make them by approaching the design process with a plan to get to the bottom of those features that will require large amounts of price volatile materials. It will also require that the preconstruction services contract be well-coordinated with the design contract. Seven of ten case study projects modified their design contracts to require the engineer to coordinate the design work packages to fit the construction bid packages. Memphis found some resistance from its design consultant who did not want to change its traditional design sequence to accommodate the early steel procurement. Nevertheless, working with the CMR they were able to accelerate the necessary design effort and achieve the owner's desire to lock in the price of steel as early as possible.

CONSTRUCTION MANAGER-AT-RISK'S GENERAL CONDITIONS AND OVERHEAD COSTS

The cost categories in Table 30 provide examples of typical CMR general conditions and overhead costs. The primary issue is determining what types of costs an agency is allowed to reimburse. Every state will have a somewhat different system for identifying these costs, but all federal aid projects will need to comply with federal contracting regulations. The federal model allows general conditions and overhead costs to be reimbursed if they are "allowable, allocable and reasonable" (*Federal Architect–Engineer* . . . 2005). The definitions for these three terms are as follows:

- Allowable: "a normal cost that a firm would incur in the normal operation of that type of business."
- Allocable: "a cost that would be normally charged for the service to be received and benefits the contract."
- Reasonable: "a cost that does not exceed that which would be incurred by a prudent person in the conduct of competitive business" (*Federal Architect–Engineer* . . . 2005).

For example, sending a general superintendent to another state to receive training in accelerated bridge construction would probably qualify because training is a normal cost for construction firms, the contract would benefit from the training, and it is prudent for a competitive business to train their personnel before trying a new technology. The important factor here is to ensure that competing CMR firms are aware of exactly what can and cannot be included in this portion of the GMP. Again, using a system such as the one illustrated in Table 30 is one technique to communicate those facts to the construction community.

CONSTRUCTION MANAGER-AT-RISK FEE

This portion of the GMP is not to be confused with the fee paid for preconstruction services. This is the profit that the CMR will earn by successfully delivering the project. The system shown in Table 30 shows certain types of costs recovered in the fee. This approach is at odds with the idea that fee is a function of both cost and risk and that a business is entitled to a profit on all its costs. Based on a Washington State study of CMR projects, "the average fee for a general contractor can range from 2% to 15% and *the fee amount is contingent on such factors as project risk, contract conditions, competition, and project complexity* . . . the fee percentage is typically larger for smaller projects" (Septelka and Goldblatt 2005; italics added). The salient idea in this quote is that the fee is to be determined on a project-specific basis rather than by some arbitrary selection of a percentage. A simple way to avoid having to negotiate this fairly abstract point is to make it a part of the CMR selection process and set the fees upon award. Half of the case study projects established the construction fee in some manner before the contract was awarded. A typical transportation CMR contract clause for converting the fee to a fixed cost at construction contract award was found in the content analysis:

> At such time the GMP construction contract is executed, the Contractor's Fee shall be converted from a percentage expression to a stipulated sum amount within the GMP. This fee will not be subject to reduction if the Cost of the Work can be reduced through the efforts of the design/construction team via design refinement or procurement efforts. Abandonment or significant reduction in the scope or magnitude of the project will result in a negotiated reduction of the fee. Conversely, the fee shall not be increased for changes in scope which can be absorbed by the Contingency amount. The fee is only subject to increase should a significant additive scope change occur which would necessitate a change order to the GMP ("CM/GC Fee Structure Sample" 2007).

Two agencies (Michigan and Oregon) published a fixed rate in the solicitation documents. Additionally, two of the interviewed contractors had completed projects with non-case study agencies that fix the maximum amount of fee in the same manner and indicated that they had no issues with the practice. One stated that it took one element of uncertainty out of the project; that being how much fee the owner will consider fair and reasonable. The practice reduces the issue to the contractor's business decision as to whether or not the proffered fixed rate of fee is a reasonable amount considering the risks and complexity of the given project. In other words, to fix the rate forces the construction industry to make a "bid-no bid" decision. As a result, the agency will know that those that do propose are willing to accept that profit level and the issue is no longer open to negotiation. Two other case study agencies require that the construction fee be proposed and evaluated in the selection process.

The UDOT does not include a profit factor in its unit price GMP contracts. It requires the CMR to roll this into the unit prices that it furnishes. It also requires competing CMRs to propose unit prices for four to five major pay items as part of the selection process.

The remaining five case study agencies negotiate this factor after award. The contractors interviewed were asked how they set this factor and with only one exception they stated that it was purely a business decision based on what they believed the agency would consider reasonable. This confirms the sentiment expressed by the contractor that believed that the agency fixing the construction fee merely removes one element of uncertainty. Every contractor interviewed remarked that their major motivation was to leave the negotiations on good terms with the agency and thereby enhance their chances of winning the agency's next CMR project.

CONTINGENCY DEVELOPMENT

From the owner's perspective, contingency estimating is probably the least understood piece of the GMP. Most agencies are used to using a standard percentage of mark-up that is added to the engineer's estimate to reach a project budget. For example, the U.S. Army Corps of Engineers mandates a 5% contingency (*Engineering Instructions Construction Cost Estimates* 1997) and the Riverside County, California DOT uses 10% (*Estimating Guidelines for Roadway Construction Projects* 1999). Hence, understanding exactly what a contingency represents is vital to being able to accurately develop one using a logical process. The literature has many definitions for contingencies from a variety of sources. However, there are two that fit the CMR GMP context very well. The first comes from the DOE and binds the contingency issue to the project's characteristics:

> The amount budgeted to cover *costs that may result* from incomplete design, unforeseen and unpredictable conditions, or uncertainties within the defined project scope. The amount of the contingency *will depend on* the status of design, procurement, and construction; and the complexity and uncertainties of the component parts of the project (*Cost Estimating Guide* 1997; italics added).

This definition narrows the contingency to only those costs that *may* occur as a result of uncertainties, not those that *will* occur. Additionally, the amount of contingency is not fixed in this definition, which states that the amount will depend on the project's current status of completion. Thus, a project where no design has been completed would have a larger contingency than one where the construction is ready to commence. A project where 80% of the subcontract work packages have been awarded and the prices of 100% of the self-performed material have been locked in will have an even smaller contingency. This principle is illustrated in Figure 19. Thus, the DOE definition can be construed to mean that a contingency is the probable cost of the unknowns at the time the GMP is established. This is an important distinction and aids in determining how an agency will want to develop its contingency estimating policy.

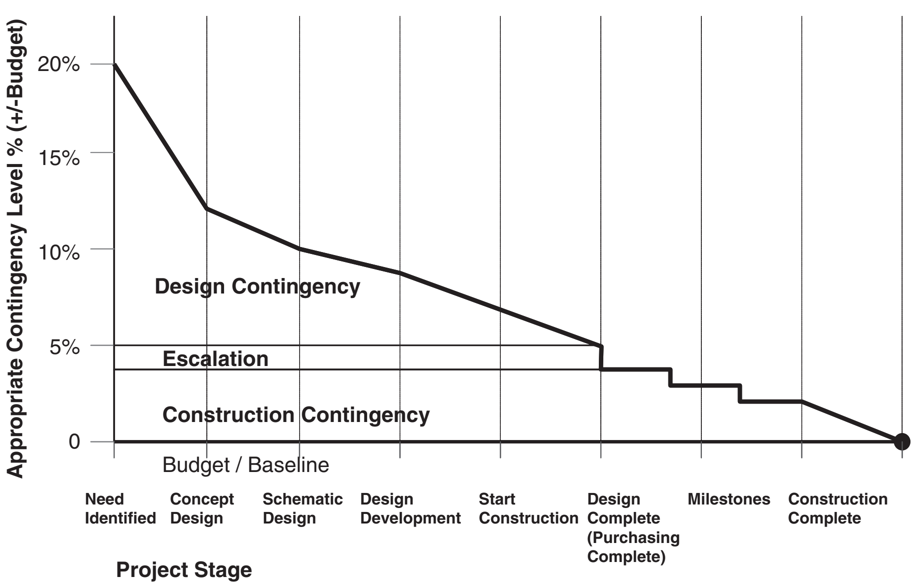

FIGURE 19 Contingency change as project advances to completion (Ladino et al. 2008).

As a CMR contract has three prime players, the owner, the designer, and the builder, it has become customary to split the project's total contingency into logical proportions that relate to the specifics of its status from concept to ribbon cutting. For example, another report adds some CMR specifics to the contingency definition when the authors state:

> Design contingency accounts for estimating inaccuracy due to both quantitative error (take-offs) and qualitative error (design intent). Construction contingency accounts for inaccuracy due to both unforeseen site conditions and contractor risk. Owner contingency accounts for . . . things that are overlooked, scope creep, regulatory change, and so on. Escalation is different. *Contingencies are for what may happen. Escalation is for what shall happen.* Escalation accounts for the persistent inflation of construction costs. The value is reduced to zero when all [subcontractor] bids are in (Spata and Kutilek 2006).

These authors differentiate between contingency and escalation using the DOE discriminator that a contingency covers what might happen, but as construction cost inflation is nearly certain during the design phase money to cover the change in prices resulting from inflation is better termed escalation. In seven of ten case study projects, the agency chose to break up the overall contingency and assign a contingency pool to itself and a separate one to the CMR. This demands that the agency define what uncertainties each contingency can be used to cover. To do this well requires an open books form of accounting for not only contingency expenditure but for the entire GMP.

"Open books" is term that was used extensively in the CMR literature (Gambatese et al. 2002; Doren et al. 2005; Van Winkle 2007; Ladino et al. 2008). It indicates a level of collaboration that includes a sharing of the costs and "[s]haring project information openly, defining risk and profit appropriately, and creating a high level of trust among all the parties" (Doren et al. 2005). It also means that the project execution method is transparent to all parties and it discourages "hidden agendas" (Ladino et al. 2008). This leads back to the joint development of the preconstruction cost model. If all parties understand the intricacies of the cost model, they will more closely understand the impacts as estimated costs are replaced by actual costs. Van Winkle (2007) describes it as follows:

> Open Book accounting is a two-edge sword. Pricing knowledge benefits the owner to confirm cost reasonableness and serves as a basis for change order pricing. However, every variance may be viewed as a change to GMP . . . The solution is to define who owns each risk (Van Winkle 2007).

Another author describes the process as follows:

Open books accounting eliminates hidden agendas and provides the following

- Greater savings opportunities,
- Better planning,
- Designing to contractor's strengths,
- Improved quality and value,
- Shorter project schedules, and
- Creation of a "win-win-win" environment (Ladino et al. 2008).

Contingency Identification and Management

Figure 18 shows three possible contingency options based on the findings of the case study review and the literature review. Those types are:

- CMR's contingency (also termed contractor's contingency or construction contingency)
- Owner's contingency
- Management reserve.

Three of ten case study projects used a single project contingency. Five had separate contingencies for the CMR and the owner and two had all three. The two projects that added a management reserve to the separate owner's and CMR's contingencies were the Fairbanks Airport project and the Miami Intermodal Center. The Alaskan management reserve is a fund controlled by a panel of individuals who are not directly involved in executing the project. Its stated purpose was to furnish resources to take advantage of previously unseen opportunities to improve the overall operations of the airport as well as to resource *force majeure* events resulting from Alaska's challenging climate and the need to import much of the material from the lower 48 (Storm 2007). The Florida management reserve was created to fund specific owner design changes to the GMP scope (Minchin et al. 2007). In all case studies, the contingency accounting system was transparent and there was some system in place to authorize the use of contingency funds for their intended purpose as well as cross balance between contingency pools if necessary.

CMR's Contingency

The CMR's contingency can be the only contingency in the GMP if that is the agency's desire, in which case its purpose is to cover all eventualities. However, if the agency decides to separate the CMR's contingency from an owner's contingency, it effectively turns the CMR's contingency into a construction contingency focused on the uncertainties of the market. This may include a separate escalation component that is reduced, as shown in Figure 19, as material pricing and subcontractor work packages are finalized (Spata and Kutilek 2006; Trauner 2007; Ladino et al. 2008). Typical uncertainties assigned to the CMR's contingency are:

- Labor availability (Ladino et al. 2008).
- Material pricing (Trauner 2007; Ladino et al. 2008).
- Schedule delay costs not attributed to the owner (Touran 2006; Trauner 2007).
- Subcontractor coordination/conflict issues ("Request for Proposal Model . . ." 2007).
- Other items as may be appropriate.

Owner's Contingency

In CMR project delivery the owner holds the design contract and, as a result, the design contingency discussed previously is normally assigned to the owner's pool. Some agencies have chosen to break a design contingency out of this pool of funds (Spata and Kutilek 2006). In this case, the agency might give control of that contingency to the design consultant and use it as a sort of GMP on the design contract to discourage scope creep. None of the case study projects with separate owner's contingencies used this technique. Typical uncertainties assigned to the owner's contingency are:

- Design errors and omissions (*Cost Estimating Guide* 1997).
- Scope creep (*Cost Estimating Guide* 1997; Spata and Kutilek 2006).
- Owner-directed scope enhancements (Minchin et al. 2007; Ladino et al. 2008).
- Force majeure ("Request for Proposal Model . . ." 2007; Storm 2007).
- Regulatory change (Spata and Kutilek 2006).
- Other items as may be appropriate.

Management Reserve

The management reserve can be an interesting feature if used. The fundamental concept is to identify a source of funding to cover the cost of changes, improvements, and operational requirements that affect the project but do not spring from the execution of the project's intended scope of work. In federal procurement jargon, this might be called a "cardinal change contingency. A cardinal change occurs when the proprietor effects alterations in the works so drastic they effectively require the contractor to perform duties materially different from those originally bargained for" (Whitten 2004). Thus, including this form of contingency in a CMR contract gives the owner much wider latitude to take advantage of unforeseen opportunities as they arise. In another author's words, management (owner) reserve is budgeted for discretionary purposes (Van Winkle 2007). An example of this occurred in the Weber County Commuter Rail project in Utah. The CMR was able to create a substantial savings during preconstruction through value engineering. The savings flowed to the owner's contingency where it was used to add park-n-ride structures that were not in the original scope of work; that is, execute a cardinal change to the benefit of the project. Although UTA did not have a separate management reserve fund, its owner's contingency was structured in such a fashion that it could and did function as one. Another example from the building industry shows just how creatively a management reserve can function. A CMR project was nearing design completion and the CMR informed the owner that it could commit to a GMP that was substantially lower than originally estimated. Therefore, there appeared to be no need to use the project's management reserve. The owner decided to release the funding to the CMR with instructions to work with the architect and use the available capital to qualify the building for certification at the highest level of sustainability (Winters 2004).

Another situation in which a management reserve is appropriate is when the agency needs to establish a GMP at an early stage of design. In transportation this sometimes occurs for bond-funded projects. In this case, "a design contingency is often held *outside the GMP* [making it a management reserve] to be drawn against as the exact scope of the work becomes better defined" ("Construction Delivery Approaches" 2007; italics added). Doing this allows the CMR to reduce its contingencies because funds are available from the management to increase the GMP amount for significant scope changes. The Miami Intermodal Center case study project used its management reserve in this manner. Minchin et al. (2007) described the function of this type of contingency as follows:

> There is a contingency *within* the GMP to cover unexpected but justifiable costs, and a *contingency above the GMP allows for owner changes.* As long as the subcontracts are within the GMP, they are reimbursed to the CM, so the CM represents the owner in negotiating inevitable changes with subcontractors. The key element in the CMAR system on this project is the contingency fund (10% on this project). Without that, an adversarial atmosphere would appear on the project. Instead of the prime contractor or the CM looking for changes as on a DBB project, the subcontractors are doing so, but a strong CM insulates the owner from this problem (Minchin et al. 2007; italics added).

A third situation where a management reserve would be helpful is a project where construction has started without a full suite of permits. If one of the permits creates a scope increase or major delay, the management reserve could be established to specifically assign that risk to the owner. Its magnitude might be able to be estimated based on an analysis of possible outcomes from the permit review (Touran 2006). Again, by quantifying the uncertainty and planning to resource it, the CMR will not need to inflate its contingency to cover that risk. There may also be some time savings to the owner in terms of the funding and contracting process by having a "preapproved" source of funding for a possible but not probable scope change.

GUARANTEED MAXIMUM PRICE ADMINISTRATIVE ITEMS

The final establishment of a GMP is a contractual transaction and as such will involve more than just the mere mutual agreement on a number. To effectively monitor and administer the GMP, back-up documentation that defines exactly what is represented by each number accompanies the form that displays the GMP itself. One author furnished a nearly comprehensive list of what is recommended to be included in the GMP documentation:

- "a list identifying drawings and specifications, addenda, and other documents used in preparation of the GMP;

- a list of allowances and definition of materials and labor included in such allowances;
- the construction manager's assumptions and qualifications;
- a breakdown of the GMP into costs of the work (trade categories, holds, general conditions, insurance) and the construction manager's fee;
- alternates included in the GMP and those available (with cut-off dates) for subsequent acceptance by the owner;
- the date of substantial completion and other milestones (if applicable); and
- proposed incentives (if any) for the construction manager's performance" (Martinez et al. 2007).

The point made by Martinez with this list of inclusions is that the GMP represents a cost estimate plus contingencies that were developed at a specific point in time and a specific level of design development. Understanding all the logic behind the numbers becomes extremely valuable if circumstances arise where the numbers need to be adjusted. Having reviewed and approved the items shown previously, as well as others that would be appropriate for a given project, creates a common ground from which to negotiate a fair and equitable adjustment of the GMP. "There has to be an element of trust and some give and take between the owner, designer and general contractor/contract manager [CMR] in order for this process to work" (Storm 2007). Preserving that element of trust is most difficult when changes are being negotiated. Thus, making sure that the administration is both complete and thorough is essential to success. A major aspect of GMP administration is the process of reaching a "final GMP."

Progressive Guaranteed Maximum Prices

Design detail drives the amount of contingency that is contained in the GMP. Some agencies, such as UDOT, use a progressive GMP to keep project contingencies as low as possible. In essence, a progressive GMP is nothing more than breaking the project down into phases or work packages and asking the CMR to generate individual GMPs for each phase/package as its design is completed. The final GMP becomes the sum of the individual GMPs plus any remaining project-level contingencies. This allows the design to progress without undue pressure and allows the CMR to furnish GMPs on phase design packages as soon as they are ready. "Practitioners have recommended that the GMP is more accurate when certain design elements are completed to 100 percent, rather than having all design elements partially completed, allowing the CM to lock in subcontractors and reduce the estimation involved in developing the GMP" (Trauner 2007). The three most experienced case study agencies (UDOT, city of Glendale, and Pinal County) used progressive GMPs. The interviews with these agencies and their contractors confirmed that this was a key feature in controlling costs on CMR projects.

On the Utah project, the phasing associated with the progressive GMP is credited with saving a full construction season (Alder 2007). UDOT asked its CMR to furnish the following three progressive GMPs:

1. "Early Action Package"—consisted of maintenance of traffic, steel, and Mechanically Stabilized Earth wall panels.
2. Eastbound I-80 with Accelerated Bridge Construction costs.
3. Westbound I-80 plus remaining ancillary items.

The city of Glendale project had substantial amounts of utility coordination and a large number of affected commercial businesses. Therefore, it used the progressive GMP to get the CMR started on the utilities, while the consultant sorted out the details of the design with the various business owners and public officials. Again, the CMR was not asked to furnish a GMP for undesigned features of work and this allowed it to keep the project on budget and to finish two months early. Pinal County used the progressive GMP to stay in touch with material price changes. The CMR furnished a forecast of key material prices for each design package and the agency used this to build the CMR's contingency as well as to prioritize the design effort. Given the success of these three cases, the use of a progressive GMP appears to be very attractive. This leads to the conclusion that agencies planning to use CMR seriously consider incorporating a progressive GMP into their procurement package.

Shared Savings Clauses

The literature about GMP contracts discusses the advantages and disadvantages of including a shared savings clause, and a critical reading of it leaves the reader unconvinced as to its real value in influencing contractor behavior to minimize the overall project cost. In one paper written by a consulting engineer, the author advocates the use of shared savings as incentives (Cunningham 2005). In another, coauthored by a construction contractor and a public owner, they discourage shared savings clauses as unnecessary and ineffective (Bearup et al. 2007). Looking deeper, a study of $6.6 billion worth of CMR projects built by the state of Washington found that half the projects included shared savings incentives. However, the average incentive earned was less than 1% of the CMR contract value (Septelka and Goldblatt 2005). A second study of all CMR projects completed by the city of Seattle concluded:

> The City has used incentives in most of its GC/CM [CMR] projects to encourage achievement of "social goals" such as small business participation, as well as cost savings. Some owners feel that offering a portion of the "savings" to the contractor will provide incentive to the contractor to increase diligence and efficiency to reduce costs. However, it is unclear that savings clauses actually result in a lower price at project completion (Denzel et al. 2004).

These two studies tend to substantiate Bresnen and Marshall's (2000) more philosophical conclusion that "clients and contractors are complex social entities, and their behaviors are not necessarily modified simply by the existence of incentive schemes at an organizational level such as pain/gain sharing mechanisms." To use the figures from the Septelka and Goldblatt study (2005), if $3.3 billion worth of CMR projects only generated a fraction of 1% savings, then Bresnen and Marshall are correct in their finding that it takes something more substantial than a contract to modify corporate behavior. Thomsen (2006) summarizes the relative value of shared savings clauses succinctly when he says:

> It's a process and a set of agreements based on incentives vs. consequences, morality vs. legalities . . . There must be a perception that repeat work will follow good performance. By far the *most important incentive that an owner has is the promise of repeat work* (Thomsen 2006; italics added.)

Reviewing the case study project output, six of ten projects included a shared savings clause. In the highway group, three of seven used the shared savings incentive. Once again the three most experienced agencies, UDOT, Glendale, and Pinal County, did not share savings with their contractors. More importantly, the contractors on those projects expressed the view that a shared savings clause took more time to administer and verify than it was worth. One contractor stated that the owner was paying them a preconstruction services fee to find ways to save. Therefore, a shared savings clause created an unintended conflict of interest. The content analysis only found one solicitation with shared savings indicated. Finally, the author of this report was a member of the legislative task force that drafted of the Oklahoma CMR law and was initially surprised when the contractor's association representatives come out forcefully against including shared savings incentives in the act. This also came as a surprise to the state agency and design consultant representatives. The contractors' motivation was to eliminate one obstacle to developing trust in the relationships. The contractors believed that if there was a shared savings clause, the owner would suspect that the CMR would inflate the GMP as a means of making additional profit by means of the incentive. Again, circling back to the two studies in Washington State, little, if any, benefit was realized by the public agencies that used this approach. Thus, if the Oklahoma AGC and the previously mentioned paper by the contractor could be considered representative of the larger construction industry, a conclusion can be reached that shared savings clauses are not as valuable as some would believe. These two lines of information are squarely intersected by the case study project findings that nearly half the cases, including the three agencies with the most CMR experience, omitting shared savings from their CMR contracting program. The lack of shared savings findings in the content analysis validates the notion that shared savings adds little value to a CMR project.

Failure to Reach Agreement on Guaranteed Maximum Price

Negotiating a GMP for a large, complex, fast-moving highway project is not a trivial task. It requires both sides to come to the table prepared to demonstrate the validity of their numbers and their assumptions. Hence, there comes a time on the odd project when agreement is not possible. The final administrative aspect of a GMP contract is the question of what happens if the owner and the CMR are unable to negotiate a final GMP. The case study interviews asked each agency and contractor for their individual policies for this occurrence. The Glendale City Engineer stated that he did not know what they would do as it has never been an issue, an encouraging comment for those agencies who are thinking about trying CMR for the first time. Of all the agencies interviewed, only one had ever had that experience. Its solution was to complete the design and advertise the project as a DBB project. The reason for the failure to reach an agreement was the agency's belief that certain material prices were overstated. When the bids were opened on the project, the lowest bid was higher than the CMR's rejected GMP.

This brings the issue of the owner's lack of real-time pricing information to which the CMR has access to center stage. Most DOTs depend on their bid tabulations as their primary source of estimating data. This information is reasonably current, but is at least 30 days behind the marketplace when published. In the summer of 2008, the price of liquid asphalt doubled inside of two months ("WSDOT Market Analysis" 2008). Therefore, negotiating a CMR paving project during that period would create difficulties if the owner had not kept current on the volatility in asphalt prices. UDOT retains an independent construction estimator to literally develop a parallel GMP using the same documents as the CMR (Alder 2007). This particular consultant is a retired construction contractor who has access to the same sources of pricing information as the Utah contracting community. The ODOT retained a contractor who was not involved in its CMR project to do exactly the same thing for them. This appears to be a redundant service; however, DOTs can recognize the limitations of their staff to approach a cost estimate the way a construction contractor will as well as the limitations of their bid tab estimating database.

Based on the case study outcomes, there appear to be two methods for completing a project where the CMR and owner cannot agree on a GMP. The first is to take advantage of the concept that the owner still controls the design contract and advertise the project for competitive bids. This is the method advocated by UDOT (Alder 2007) and the method used by seven of ten case study agencies. In this manner, the agency would pay off the preconstruction services contract and not award the planned construction contract. The other method that is used by Pinal County is to open negotiations with the contractor who was ranked second by the selection panel. This would appear to be the more expeditious of the two methods in that taking the statutorily prescribed time to advertise and award the construction contract would create a several month delay.

The second method would also not require the designer to complete fully biddable construction documents. One of the verified savings in CMR is in design cost and design time (Uhlik and Eller 1999; Thomsen 2006; Alder 2007). Most of these savings are because the CMR involved in the design process can signal the engineer to stop designing when it has sufficient technical detail to get decent bids from its subcontractors and build the job properly. During the UDOT interview, the agency indicated that it was saving roughly 40% on its design costs compared with DBB. This becomes a two-edged sword if GMP agreement is impossible. The designer may ask for additional compensation to take the design from where it was told to stop to where it needs to be to permit competitive bidding.

SUMMARY

Establishing a GMP in a CMR contract is perhaps the most important aspect, because it quantifies the project's costs for the owner and the potential profit for the contractor. The industry has many different manners in which this critical aspect of CMR contracts can be established.

Conclusions

A number of conclusions are drawn from the analysis.

- Allowing the CMR to self-perform those work packages that it is well-qualified to perform does not increase costs.
- Allowing the CMR to prequalify and select subcontractors without constraint preserves the CMR's ability to use its long-standing commercial relationships for the benefit of the project.
- Progressive GMPs add value to CMR contracts by allowing the CMR to establish incremental GMPs as design packages are ready.
- Shared savings clauses do not appear to create a significant incentive and could possibly create a loss of trust if misunderstood.

Effective Practices

Several effective practices were reported:

- Splitting the contingency between the owner and the CMR appears to make accounting for contingency allocation less onerous.
- An open books approach to contingency calculation and allocation enhances the spirit of trust between the owner and the CMR.
- Those projects where the agency wants to mitigate material cost escalation risk can include an early work package to allow the CMR to procure volatile construction materials as early as design progress allows. This also argues for a progressive GMP that includes as a minimum the early materials package and the remainder of the job.

CHAPTER SEVEN

QUALITY MANAGEMENT PROCEDURES

INTRODUCTION

There are two key issues that are of great concern to all public transportation agencies: project quality management and project delivery method. With the growth of alternative project delivery methods in the past few decades, the issues have become interrelated. It is important to understand how agencies that are using CMR project delivery are approaching the quality management issue on their projects. In project delivery methods where the contractor is selected before the design is complete and is expected to make a contribution to the design, the agency might consider the impact of that shift on quality management planning and execution at every phase of project development. Table 31 compares the potential for meeting three quality objectives among three project delivery methods based on an analysis of federal projects (Uhlik and Eller 1999). This study concludes that CMR project delivery has a high likelihood of delivering two of three quality objectives. The third objective, single point of responsibility, can only be achieved by DB project delivery. The chart indicates that CMR may be the preferred project delivery method for projects where ensuring quality is difficult. Another author reached the same conclusion and stated: "CMR improves quality and value . . . [by keeping] focus on quality and value—not low bid" (Ladino et al. 2008).

A high-quality highway project needs high-quality designers and constructors to build it. The synthesis asked both the agencies and the contractors to comment on the impact of various aspects of CMR on a project's final quality (see Table 32). There was unanimous agreement by both the owners and their contractors that the aspects that have the greatest impact on project quality are the qualifications of the CMR's personnel and its past project experience. ODOT interviewee stated that "qualifications are critical to achieving quality." This corresponds with the information cited in the literature with regard to the value of these aspects. Taken together, it leads to the conclusion that tailoring the CMR RFQ/RFP to fit the project's specific technical and management requirements will attract the kinds of contractors who have the correct set of personnel and experiences.

All the advantages of CMR project delivery cited in Table 1 are lost if the quality of the constructed project is poor. An AASHTO international scan team concluded that international transportation agencies use project delivery methods that might reduce pricing competition, but that the benefits of improved quality offset any marginal increase in design and construction costs. The report went on to recommend that U.S. agencies "apply more contractor quality management . . . [and] enhance qualification-rating processes" (DeWitt et al. 2005). CMR project delivery provides a method to implement these recommendations. To do so will require the agency to evaluate and implement quality management policies and procedures for every phase in a project's delivery cycle. Chapter five covered quality in the procurement phase. Therefore, this chapter will detail its findings in the design and construction phases of highway CMR projects.

QUALITY MANAGEMENT IN DESIGN PHASE

"The design phase . . . is the phase where the ultimate quality of the constructed facility is quantified through the production of construction documents . . . the point of the project where quality is defined . . . it is imperative that the design quality management responsibilities be clearly defined in the solicitation documents" (Gransberg et al. 2008). Much of what is said in this section regarding the CMR preconstruction services contract ought to be coordinated with the design contract as well. The Memphis case study highlighted the need to alter the standard DBB engineering design contract to accommodate effective collaboration between the agency's consultants and the CMR. That being noted, the remainder of the discussion will be restricted to the CMR's roles, responsibilities, and actions during design as related to quality management.

Enhancing Design Quality Through Collaboration

CMAA commissioned a study in 2005 to survey owners about their perceptions on how project quality can be improved (Doren et al. 2005). The study's top five responses all relate to enhancing the project's quality during design by collaboration between the designer and builder.

- A/Es [designers] need to be more conscious of the cost to build their designs
- More coordination/collaboration among team members
- Need quality reviews from CMs
- Needs a thorough review of the technical design details
- Need to bring contractors, subcontractors, and suppliers on board in the design phase (Doren et al. 2005).

The UDOT CMR report confirmed the same notions specifically for design quality. It also indicated agreement

TABLE 31
QUALITY MANAGEMENT COMPARISON OF PROJECT DELIVERY METHODS

Quality Objectives	Likelihood of Meeting Objective DBB	CMR	DB
A system of checks and balances exists between design and construction	High	High	Low
Input on quality is provided during design by someone with construction expertise	Low/medium	High	High
Single point of responsibility for design and construction quality	Low	Low	High

Source: Uhlik and Eller (1999).

from both the design and construction industries in Utah. The report stated:

> The program managers and AGC representatives agree that contractor participation in design minimized risk and improved schedule. Design consultants preferred this method because UDOT controlled the design and innovations selected for the project. This gave them a *greater ability to develop a quality design* (Alder 2007).

Another public agency report on its CMR project found that "[d]esign and peer review of the 30%, 60%, and 90% detail designs are required to ensure quality and constructability" (Kwak and Bushey 2000). This agency points to constructability as a measure that goes hand and hand with quality. Design reviews are an integral part of any design QA program. They ensure the constructability of the project, and they ensure that the design meets the contract requirements (Dunston et al. 2002). A survey on the benefits of constructability reported the following responses regarding its impact on a project:

- Minimizes contract change orders and disputes,
- Reduces project cost,
- Enhances project quality,
- Reduces project duration,
- Increases owner satisfaction, and
- Enhances partnering and trust among project team (Pocock et al. 2006).

An NCHRP Project 20-7 report (Dunston et al. 2002) reviewed at the costs and benefits of constructability reviews. Its findings apply to CMR project delivery and can be summed up as follows:

> *Quality documents facilitate quality construction* . . . Review of the constructability of transportation facilities in the planning and design phases, specifically [for] deficiencies in quality and clarity of construction plans is critical . . . Constructability reviews . . . *are the key mechanism for insuring that plans and specifications fulfill these quality objectives* (Dunston et al. 2002; italics added).

Gauging Effective Impact on Project Quality

The case study structured interviews contained a list of 22 project outcomes and asked each to compare the change in quality seen in the CMR case study project from a traditional DBB project on a Likert scale of 1 to 5 on each outcome, with 1 = "worst quality" and 5 = "best quality." The scores were then summed and an average was calculated. Twelve of the outcomes were related to the quality of the design. Table 33 presents the results of the owners compared with the contractors. The Likert scale in this analysis had a neutral value of 3 (no change). Therefore, a rating above 3 would indicate that those outcomes could expect to improve in quality in a CMR project versus a DBB project. All 12 outcomes received average scores of between 4.0 (better quality) and 5.0 (best

TABLE 32
IMPACT ON CMR FINAL PROJECT QUALITY OF PROCUREMENT PHASE COMPONENTS

	Agency Ratings			Contractor Ratings		
Procurement Phase Component	Very High or High Impact	Some or Slight Impact	No Impact	Very High or High Impact	Some or Slight Impact	No Impact
Qualifications of CMRs staff	100%	0%	0%	100%	0%	0%
CMR's past project experience	100%	0%	0%	100%	0%	0%
Early contractor involvement in design	90%	10%	0%	100%	0%	0%
Preconstruction services	80%	20%	0%	100%	0%	0%
GMP contract	70%	30%	0%	67%	0%	33%
Level of detail expressed in the procurement documents	60%	40%	0%	0%	83%	17%
Level of agency involvement in the QA process	50%	50%	0%	33%	67%	0%
Use of performance criteria/specifications	50%	40%	10%	67%	33%	0%
Quality management plans	40%	60%	0%	83%	17%	0%
Warranty provisions	40%	40%	20%	33%	50%	17%
Use of agency specifications and/or design details	20%	60%	20%	17%	67%	17%

TABLE 33
CMR IMPACT ON DESIGN QUALITY OUTCOMES—AGENCY AND CONTRACTOR RATINGS

Project Quality Outcome	Average Agency Rating (5 max.)	Average Contractor Rating (5 max.)
Cost growth during design	4.8	4.3
Accuracy of design calculations	4.6	3.5
Completeness of final design deliverables	4.5	4.2
Acceptance of design deliverables	4.5	4.2
Accuracy of preconstruction cost estimates	4.5	4.5
Accuracy of preconstruction schedules	4.5	3.7
Accuracy of quantities	4.4	4.2
Accuracy of specifications	4.3	3.2
Maintainability	4.3	4.2
Aesthetics	4.1	4.8
Sustainability	4.1	4.3
Operability	4.0	4.3

quality) from the agencies. Looking at the raw interview data, there was only one case study that rated any of the design-related outcomes less than neutral. That was ODOT, which rated cost growth during design as a 2 but qualified the answer by saying that in this project, their first CMR, all the cost growth was the result of owner-directed scope improvements that were missed during the procurement phase. The contractor rating had a greater range, but all were above 3, indicating agreement with the agencies regarding the perceived impact of CMR on design quality.

QUALITY MANAGEMENT IN CONSTRUCTION PHASE

CMR construction quality management will not differ greatly from that seen in DBB. The owner still occupies the same contractual position with respect to the designer and builder. Therefore, the systems in use in DBB projects will directly apply to CMR projects with little alteration. The key difference is the change in motivation of the constructor. In DBB, it has no input to the design and builds what is shown in the construction documents. In CMR, the contractor has assisted in developing the final design and as a result has assumed a significant degree of ownership in the design product. One of the case study project contractors described the idea of having "buy-in" to the design, making the CMR less prone to submit a claim for additional compensation for design problems in features of work for which the CMR had been paid to review and furnish input. This notion was also found in the literature (Kwak and Bushey 2000). Additionally, the presence of contingencies further ameliorates the motivation to cut corners on quality as a means of recovering financial losses resulting from contractor or subcontractor error (Trauner 2007). Finally, the issue of remaining competitive for future work with the agency is a strong motivator to achieve the requisite construction quality and satisfy the owner. "CM At-Risk is still largely a position of representing the Owner's interests, and if it is pursued as simply a negotiated general contract it will leave the Owner dissatisfied and the CM without future work" (Strang 2002).

Construction Phase Quality Assurance and Quality Control

Construction phase quality management relationships are established in the procurement phase, nurtured during the design phase, and applied when work begins on the project. The roles of the agency's QA personnel as well as the designer's responsibilities during construction are known and understood by the contractor before starting work. "It is also recognized that, because of constrained staffing and budgets, it is not possible for state agencies to 'inspect' quality into the work. Therefore, a procurement process is needed that considers value-related elements in awarding contracts" (Scott et al. 2006). The value found in CMR is the in-depth knowledge of the design that the constructor gained during the preconstruction when it starts construction. The case study interviews revealed that eight of ten agencies did not change their DBB QA program to accommodate CMR project delivery. The two that did were Alaska and Michigan and their reason was to adapt the quality management process to the vertical component of the construction.

The case study projects were asked to describe the assigned roles and responsibilities for construction quality management.

TABLE 34
DISTRIBUTION OF CONSTRUCTION QUALITY MANAGEMENT TASKS IN CASE STUDY PROJECTS

	Assigned Responsibility*				
Construction Quality Management Tasks	Does Not Apply	Agency	Designer	CMR	Independent Consultant
Technical review of construction shop drawings	0	1	9	1	6
Technical review of construction material submittals	0	2	7	0	7
Checking of pay quantities	1	4	3	0	6
Routine construction inspection	0	3	3	4	4
Quality control testing	0	0	2	10	1
Establishment of horizontal and vertical control	0	0	3	6	2
Verification testing	0	3	3	2	4
Acceptance testing	0	7	2	0	3
Independent assurance testing/inspection	0	3	3	0	5
Approval of progress payments for construction	0	9	0	0	3
Approval of construction post-award QA/QC plans	0	8	1	0	2
Report of nonconforming work or punchlist	0	7	1	0	4
Total responses	1	47	37	23	47

*Total can be > 10, as some agencies assign dual responsibilities for the same QM task.

The purpose was to identify trends in how the projects allocated the various tasks. The four possible entities to which these responsibilities were assigned are shown in Table 34. The independent consultant is not the same as the designer. The Alaska, Florida, Michigan, and Utah DOTs, as well as the UTA and the Memphis Airport, all retained consultants to perform construction QA services. The sum of the number of times a given entity was assigned a task is at the bottom and gives an indication of the distribution of construction quality management responsibilities in the case study CMR projects. The agency and its independent consultant share the most responsibility, followed by the design consultant and the CMR in that order. The CMR's assigned roles appear to line up almost with what one would expect to see in a DBB construction QC plan. The only anomalies are one instance of shop drawing review and two instances of verification testing. The shop drawing review occurred in Michigan where the CMR was required to conduct joint reviews with the designer of certain subcontractor submittals. The CMR verification testing was done jointly with the agency's staff in the Pinal County project and the UTA assigned this responsibility to the CMR exclusively. The Utah project put 4% of the construction fee at risk on each monthly progress payment (Touran et al. 2009b). The decision as to how much was awarded was made by a panel and included the evaluation of quality performance. No pertinent information was derived from the content analysis on this subject.

QUALITY OUTCOMES

NCHRP Synthesis 379 (Anderson and Damnjanovic 2008) evaluated the potential for and impact of alternative construction methods to accelerate completion. CMR was one of the methods that was included in this study. The authors found that quality was not reported to be degraded by the use of nontraditional contracting methods such as CMR and also made this observation:

> The majority of respondents stated that quality was the same for the contracting methods evaluated as compared with typical projects. This result seems to counter the perception that accelerating project completion negatively impacts quality, which was cited as a perceived disadvantage for some contracting methods (Anderson and Damnjanovic 2008).

Sorting Out Fact from Fiction on Quality

The *NCHRP Synthesis 379* comment by Anderson and Damnjanovic aptly points out the "popular mythology" that appears to surround the culture shift from traditional project delivery to something different. There are always champions that promote the new method with evangelistic zeal and opponents that can see all sorts of unsolvable problems being spawned by the change in contractual relationships. Degraded quality appears to be one of the disadvantages cited by opponents to change and the champions cite reasons why quality is actually enhanced. The real issue with regard to quality is not how to guarantee that it will improve but rather to ensure that the change does not create a set of circumstances that causes it to decline. This quality issue was effectively debunked by the FHWA "Design-Build Effectiveness Study" (2006). The FHWA study team found that:

> On average, the managers of design-build projects surveyed in the study estimated that design-build project delivery reduced the overall duration of their projects by 14 percent, reduced the total cost of the projects by 3 percent, and *maintained the same level of quality as compared to design-bid-build project delivery* ("Design-Build Effectiveness Study" 2006; italics added).

Strang (2002) holds that public owners who "are not bold enough" to implement DB will be drawn to CMR as a more palatable alternative to DBB. Design consultants that work for UDOT have indicated a preference for CMR over DB because UDOT controls the details of the design (Alder 2007). Other agencies have found that CMR furnishes a good option to both DBB and DB project delivery. "The performance to date of Tri-Met's [Portland, Oregon] two major CM/GC contracts for the Interstate MAX light rail line is exemplary from the perspective of keeping the project on schedule and maintaining good quality" ("Tri-Met's Construction Manager . . ." 2003). The same report goes one to say:

> With a more cooperative working partnership between the owner, the designer, and CM/GC contractor—Tri-Met calls these entities the CM/GC team—work quality improves. The contractor has been selected on factors other than just price, many of which are strong indicators of ability to complete the job successfully. Also, the CM/GC contractor has increased responsibility for quality control over all aspects of the job under this method ("Tri-Met's Construction Manager . . ." 2003).

Quality Outcomes in Washington State Construction Manager-at-Risk Projects

Unfortunately the only comprehensive study of quality performance on CMR was done primarily in the building sector. Nevertheless, it serves to furnish a good background for what changes might occur in transportation as the CMR delivery method proliferates and matures. The Washington State report evaluated quality information from 80 of 104 public projects constructed over 14 years and summarized its findings in this manner.

> Ninety-eight percent of the completed projects met or exceeded standards. Only GA/DOC's Stafford Creek Corrections Center project did not meet standards (Septalka and Goldblatt 2005).

That literally means that *only one project in over a decade of CMR usage failed* to achieve the standards established in the CMR contract. Although details of this project were not available, transportation agencies considering CMR need to know that a large percentage of the projects covered by this study were school buildings where local school boards that normally have few if any technical professionals on staff advertised, evaluated, awarded, and accepted the contracts. The hidden message in this statistic is that CMR project delivery induces a culture shift in the construction contractor's organizations as well. One of the advantages often cited about CMR in building construction is that it furnishes a technically unsophisticated owner, such as a school board, a means to bring the necessary technical expertise to its projects (Carlisle 2006). The report contains this testimonial about CMR construction quality:

> Our GC/CM has *worked with us to tailor testing and mockups* and included [the] Owner in MEP [mechanical-electrical-plumbing] coordination meetings and all subcontractor preconstruction meetings *to set quality standards early.* Our school district has a design standard specification manual incorporated into the contract documents. Working with the *GC/CM during preconstruction challenged our standards* and resulted in more cost effective ways of meeting our needs. The preconstruction process also allowed us to identify critical areas and subtrades and review with [the] team to manage our [quality] risk (Septalka and Goldblatt 2005).

The Washington State CMR experience can be described as a success with regard to furnishing a project delivery method that "improves quality and value . . . [by keeping the] focus on quality and value—not low bid" (Ladino et al. 2008).

SUMMARY

This chapter strove to present the requirements of quality management in CMR projects chronologically with the project's life cycle. The changes needed to transition from DBB to CMR are required in the procurement, design, and construction phases. Investing management time, effort, and creative energy to structure quality management in the procurement phase pays dividends in design and construction. The overarching conclusion found here is that ensuring quality in CMR is really about selecting the right contractor and clearly delineating the owner's quality expectations from concept to ribbon-cutting. As with other project delivery methods, CMR requires a certain element of trust between all parties in the project. However, the process starts at the agency and by selecting CMR project delivery, the agency gets to pick its contractor on a basis of qualifications and its record of past quality performance. Therefore, the risk of ending up with an incompetent contractor is greatly diminished, and if the winning firm does not satisfy the agency's quality expectations, it can use that as a reason to not give that firm another chance to fail.

Conclusions

The following conclusions are drawn:

- The agency and contractor ratings shown in Table 33 indicate that implementing CMR project delivery furnishes the same quality as DBB and indeed may improve quality (Armstrong and Wallace 2001; Gambatese et al. 2002; Uhlik and Eller 2005; Alder 2007; Rojas and Kell 2008).
- The qualifications of the CMR's personnel and its past project experience are the aspects that have the greatest perceived impact on project quality ("CM/GC Peer Review Meeting" 2003; DeWitt et al. 2005; Qaasim 2005).

Effective Practices

Two effective practices can be identified in the analysis in that chapter.

- Based on the conclusion that CMR qualifications and past experience have the greatest perceived impact on project quality, the CMR selection process evaluation plan could consider giving the greatest weight in the award algorithm to qualifications of the CMR's personnel and its past project experience ("CM/GC Peer Review Meeting" 2003; DeWitt et al. 2005; Qaasim 2005).
- Eight of ten case study agencies used the same QA program for CMR as they do for DBB. Therefore, it appears that no modification is necessary to a DOT's QA program to implement CMR project delivery.

CHAPTER EIGHT

BARRIERS TO IMPLEMENTATION

INTRODUCTION

Barriers to implementing CMR project delivery can occur on several different levels: legislative, organizational, and project. The barriers at each level also take the form of factual barriers and perceptional barriers. Factual barriers are laws, policies, and procedures that do not permit the agency to use CMR. These are easy to identify and their resolution results in a final disposition of the barrier. The agency either can or cannot revise the law. Perceptional barriers are less clear and often are the most difficult to surmount. Perceptional barriers are typically hurdled before the factual ones can be challenged.

Changing a system that has been in place for decades requires changing the organization's procurement culture and that will inevitably encounter resistance from both internal and external stakeholders that are both comfortable with the status quo and believe that change is truly unnecessary (Ellicott 1994). A previous *NCHRP Synthesis 376* (Gransberg et al. 2008) measured the magnitude of the impact of perceptions on the ability to change the procurement paradigm for transportation projects. The procurement change in that study was the shifting of some QA responsibilities to the contractor in DB projects. That study found that in spite of quantitative evidence that the change would not be deleterious to ultimate project quality, 50% of the public officials still believed that the change was dangerous. It also found that 86% of the members of the construction industry who would be directly affected by the procurement system change believed that the change would ultimately be beneficial.

The difference in the two groups' perceptions was both interesting and important. The study showed that the greatest resistance to change came from *within the highway agencies* that are the ultimate decision makers on procurement system change. Thus, it is important to consider the issue of perceptional barriers to implementation of CMR project delivery in addition to the factual barriers found in the study.

LEGISLATIVE-LEVEL BARRIERS

As discussed in chapter three there are legislative barriers to the implementation of CMR. For some states other public agencies are allowed to use CMR, whereas the DOT is not and in other states there is no use of CMR by public agencies. The method to addressing this barrier may differ depending on the state and level of opposition. In addition to changing the regulations regarding project delivery, closely associated legislation and regulations may need to change; these include professional licensing, procurement, funding, permitting, and contracts. The survey identified 22 state DOTs that believed that they had no legal authority to use CMR project delivery. This is a factual legislative barrier.

Two of the case study projects (Alaska and Michigan) needed to receive a waiver from their agency procurement regulations to use CMR. The Oregon and Utah DOTs filed SEP-14 applications to receive permission to use CMR project delivery on their federally funded CMR projects. All four cases show a means to overcome a legislative barrier to using CMR for a specific project: requesting an exception to policy or a waiver of law. The contractor interviews included a question about the "single largest barrier to implementation" and revealed one who believed that state and/or local laws were the major barrier. Another selected DOT organizational procurement regulations as the major barrier. One survey response indicated that its state CMR authority capped CMR self-performance at 30% and its industry partners did not want to be constrained by such a low percentage.

The survey identified a perception barrier at this level as well. Of the 47 responses, 15 indicated that they did not know what CMR is. Thus, the barrier here is formed by the lack of knowledge. This synthesis is an example of the type of tool that is needed to eliminate this perceptional barrier to CMR. A second perceptional barrier at this level is political opposition. The survey found one DOT that had the authority to use CMR but cited political opposition to its use. The survey also found eight states that indicated industry opposition to CMR would make implementation difficult. There were also seven states that were unsure of support from the construction and design industries. These perceptions are probably a greater barrier than the lack of clear legal authority to use CMR because they will be the most difficult to change.

ORGANIZATIONAL-LEVEL BARRIERS

Chapter three indicated that some states have the authority to implement CMR but are not using it. There were six states in this category as noted from the survey responses. This may be for several reasons, including organizational barriers.

"For organizations such as departments of transportation, other public agencies, or private companies, adopting a new approach to procure services for delivery of construction projects requires significant organizational changes; modifications to both their work processes and existing organizational structures may be needed" (Gibson et al. 2007). One such state commented that it did not believe that CMR "is the right tool for linear construction." Another state echoed this attitude in the following comment:

> CM-at-Risk works quite well in vertical construction where frequently a very small percentage of the project work is self performed by the general contractor and historic sub-contracting packages are well defined and understood. In highway work, the Federal Highway Administration requires that a minimum of 30% of the work be self performed.

The surveys were sent to the state construction engineers, and although the responses were anonymous, the potential exists that these perceptions are held by the upper managers that make the project delivery method decisions. The second response clearly demonstrates the power of perception to stifle implementation. Five of the seven highway case study projects were federally funded and approved by the FHWA through SEP-14. Thus, in one state, the only thing stopping it is the erroneous perception that federal requirements cannot be met.

In a 2001 study for the TxDOT looking at alternative project delivery systems, primarily DB, the authors suggest some changes within TxDOT to make the change to a new delivery method. These include:

- Developing process guidelines and a delivery process;
- Assessing the availability of skills required within TxDOT for implementation;
- Training members of TxDOT for the delivery system;
- Optimizing communication among the parties involved within TxDOT;
- Optimizing the pre-project planning process;
- Selecting the right projects;
- Ensuring selection of qualified contractors;
- Developing succinct criteria specifications;
- Developing a systematic way to evaluate project results;
- Adjusting the policies and procedures that govern the everyday operations;
- Changing the administrative, managerial, and operational areas (Walewski et al. 2001); and
- Partnering.

These recommendations, although made to one DOT for the use of DB, suggest strategies to consider for all DOTs considering using different project delivery systems.

One clear benefit to the use of CMR is increased constructability. A study of barriers to implementing constructability processes with owners, designers, contractors, and construction managers found seven "problematic barriers to effect construction ability improvement among companies that are claiming to have active constructability programs" (O'Connor and Miller 1994). These barriers are:

- Complacency with the status quo,
- Reluctance to invest additional money and effort in early project stages,
- Limitations of lump-sum competitive contracting,
- Inadequate construction experience in design organizations,
- Designer's perceptions that "we do it,"
- Lack of mutual respect between designers and constructors,
- Construction input requested too late to be of value, and
- Belief that there are no proven benefits of constructability (O'Connor and Miller 1994).

Another barrier is the desire of DOT design engineers to continue to complete the design with in-house assets. Although there is no technical reason not to do this, there are several issues to be addressed before using CMR with in-house design. First, the in-house designers are not bound to a contract schedule as a consultant would be. Thus, a commitment to follow the CMR's design schedule would need to be made and honored. UDOT hand picks its in-house design team when it uses internal assets. However, the interview found that design schedule execution is still an issue. Next, the internal design force is used to develop full construction documents. Thus, training for these designers is required to ensure that they understand the appropriate level of design established by the CMR. Finally, using internal design assets will necessitate a very thorough partnering immediately after the CMR is selected to develop the level of trust that is necessary for CMR project delivery.

Barriers similar to those previously mentioned are not restricted to DOTs or even the highway construction industry. The barriers listed previously in the literature are a combination of factual and perceptional barriers. The Memphis airport case confirmed two of these perceptional barriers: "Designer's perceptions that 'we do it' " and "lack of mutual respect between designers and constructors." The solution was to modify the design contract to give the designer an incentive to collaborate with the constructor. Chapter four discussed the issue of timing the selection of the CMR and identified a point of action before significant design decisions are made. This confirms the factual barrier of "construction input requested too late to be of value," provided by O'Connor and Miller. Additional barriers identified in the concurrent engineering research for the process industry that would most likely be similar to the barriers seen in instituting CMR in highway construction include:

- Lack of continuity (interruption),
- Lack of clear guidance,
- Lack of success measures, and
- Lack of balance between construction and design (Eldin 1997).

Organizational barriers are handled from inside the organization. Thus, an agency planning to change its procurement culture is best served by appointing a champion that can identify and resolve factual and perceptional barriers to implementation. Both the Utah and Oregon DOTs have done this and their CMR projects are testimony to the concept that organizational barriers can be removed.

PROJECT-LEVEL BARRIERS

One of the organizational changes suggested in the previous section regards the selection of the right project and training personnel. Not all projects and all employees are suitable for all project delivery methods. Chapter three discusses the project criteria that promote the use of CMR. One study's findings

> suggest that project representatives institutionalize practices and routines connected to the new approach by adapting to new challenges, rather than 'overwriting' previously existing practices. Consequently, the institutionalization of innovative approaches to project delivery happens concurrently with a deinstitutionalization of the previous approaches. This concurrency produces different effects on the project environment, depending on the mediating action of some emerging practices and the perspective of the involved parties (Gibson et al. 2007).

Four of the contractors interviewed stated that internal DOT policies would be the major barrier to implementation. Often this manifests itself as a single project manager who is unwilling or unable to change the way business is done at the project level. "The capability and compatibility of individuals assigned to project management teams can have a significant impact on project results" (Eldin 1997). This synthesis concluded that the qualifications and past experience of the CMR's staff had the greatest impact on quality based on the case study outcomes. This finding is applied to the DOT's staff as well. Unqualified or inexperienced owner personnel can nullify the benefit of a highly qualified contractor merely by their unwillingness to make decisions in a timely manner. The solution to project-level barriers is to assign the best and brightest personnel to the project on the owner's, designer's, and constructor's teams. Until CMR is institutionalized like DBB, its success will be fundamentally dependent on the quality of the people.

CONCLUSIONS

There is one conclusion that can be drawn from the previous discussion that meets the protocol established in chapter one. Four sources all essentially point to wide-spread confusion about CMR project delivery as the major barrier to address before its benefits can be made available on a national scale. This is found from two sources intersecting in legislative barriers: 22 survey responses indicating no legal authority and 4 case study projects that obtained waivers. The previously stated source intersection along with the two lines of information that intersected at the organizational level: perception from the survey that CMR could not be used on federally funded projects and five of seven federally funded highway case studies. Combining the two satisfies the chapter one protocol for at least three intersecting sources to qualify as a conclusion.

Surmounting this barrier will require research on the advantages and disadvantages of this process. The research will need to focus on quantifying the performance of CMR projects in terms of cost, time, and quality. The research results can be used to develop education and training programs for agency engineers and decision makers. Once that group truly understands the technical, financial, and contracting features of CMR, it will then decide whether or not to seek legal authority to use CMR project delivery where its use is appropriate.

This topic does not lend itself to effective practice identification or lessons learned. Therefore, none are offered.

CHAPTER NINE

CONCLUSIONS

INTRODUCTION

A number of conclusions regarding the state of the practice of Construction Manager-at-Risk (CMR) were reached in this synthesis. The following protocol was used to reach a conclusion. To be included, the conclusion needed to be the result of triangulation between three or more of the sources used in the report. The source study instruments were the literature, the national survey, the solicitation document content analysis, and the case study projects with structured interviews of owners and contractors. The contractor interviews were used in two ways. First, they were a source of information such as the agency interviews, and second, the contractor interviews served as a loose validation of the conclusions and effective practices developed in the synthesis. The contractors confirmed that the information and opinions collected in the agency interviews, the literature, and the content analysis were actually present in practice. They also served as a second opinion with regard to the relative effectiveness of each practice.

A number of lessons learned and effective practices for implementing CMR project delivery were also identified. These effective practices and lessons learned are drawn from the intersection of the literature and one of the other study instruments. Thus, the rationale for developing conclusions and effective practices is to be able to map them back to two or three sources on which all agree and further validate them by indicated construction industry confirmation. Finally, gaps in the body of knowledge were also identified and are presented in this chapter as recommendations for further research on CMR project delivery.

CONCLUSIONS

The first conclusion aligns with the one reached by the Utah Department of Transportation (DOT) in its "2007 CMGC Annual Report" on CMR contract performance. This is furnished first because the Utah DOT is the leading DOT in developing and implementing CMR project delivery, having decided to use it on 13 federally funded highway projects and an additional 16 state funded projects. Those DOTs that intend to implement this project delivery method would do well to review the Utah experience when developing individual policies and procedures. One DOT employee stated:

> Use CMGC as the primary delivery method unless schedule is the principle driver. When a shortened delivery schedule is the primary motivation design build is preferable. If the contractor cannot deliver the project for a fair price then the fall back position is [Design] Bid Build [DBB]. I make this recommendation because we should always want the contractor's input to reduce risk, cost, and construction time. We should only go to [Design] Bid Build [DBB] when we cannot get a fair price. We should not go to CMGC to reduce schedule because it commits us to the contractor too quickly and drives up our costs.

The intent here is not to advocate the use of CMR as the default project delivery method, but rather to demonstrate that it can be implemented successfully by a typical DOT and that there are benefits, such as "the contractor's input to reduce risk, cost, and construction time." Therefore, as aptly put by the above interviewee, CMR is not a one-size-fits-all solution, but rather a solution for highway project issues *that require the constructor's input during design.* That input can and does take the many forms discussed in chapter five. The important point here is that involving the construction contractor in the design process has proven to be beneficial. It was cited in the literature (12 times, Table 1). The impact of all the 12 possible preconstruction services furnished during design had an average rating between "high impact" (four of five) and "very high impact" (five of five) in the agency interviews. Constructability reviews were the most often cited preconstruction service in transportation Request for Qualifications/Request for Proposals in the content analysis. Early contractor involvement was rated as "of highest value" in six of ten case studies and the owner's response on this item was validated by the same rating from all the interviewed contractors. Thus, the output from five study instruments intersects to confirm the earlier DOT employee's conclusion:

> *CMR project delivery's major benefit is contractor input to the preconstruction design process.*

The other synthesis conclusions are more specific in nature. Each, where appropriate, is presented with the study instruments that intersected to form the conclusion noted.

The conclusions developed in this study are presented in the order of the CMR project delivery process chronology. They are not numbered in order of importance.

1. The following characteristics are reported to apply to agencies seeking to use CMR project delivery:
   - Sophisticated construction experience;
   - Adequate level of resources for current projects; and
   - Minimal policy, statutory, and political constraints on implementing CMR project delivery method.

2. Based on the literature and case studies, the project characteristics that make it a good candidate for CMR project delivery are shown in Table 16 and are as follows:
   - Sophisticated construction experience—agency has built complex or phased projects of the same order of magnitude as the project in question and has experienced personnel.
   - Benefit from integrated design—agency's design-bid-build (DBB) design contract can be modified to coordinate it properly with the preconstruction services contract.
   - Constructability essential for project success—design is not fixed.
   - Financial constraints—tight budget/sufficient funding authority.
   - Needs flexibility during construction—minimize disruptions to traffic and other impacted parties/has authority to begin construction activities before 100% completion (permitting, etc.).
   - Phased construction.
   - Opportunity to explore innovation or technology—design is not fixed; agency can deviate from standard materials or design features.
   - Opportunities for value engineering—funding rules allow transferring funds from one use to another within the project.
   - Third-party concerns—issues early in process (utilities, railroads, business impact, public relations, etc.)—project has more than the "usual" stakeholders and they are willing to facilitate progress.
3. The case study agency and contractor ratings shown in Tables 33 and 34 lead to the conclusion that implementing CMR project delivery will not change design quality and may actually improve it.
4. The qualifications of the CMR's personnel and its past project experience are the aspects that have the greatest perceived impact on project quality.
5. The timing of CMR selection relative to designer selection is important. The literature and interviews indicate that selecting the CMR at a point in time where it can influence fundamental design decisions before they are made adds value to the project. Table 1 contains ten citations each for "ability to fast-track," "early knowledge of costs," and "ability to bid early work packages," all of which require bringing the contractor on board early in the design process. Four content analysis documents cited design completion as between 30% and 50%. Case study output found that four of ten projects selected the CMR as soon as possible after the designer and the remaining six cases made the selection before 30% design completion. This was validated by the contractor interviews.
6. The agency DBB design contract can be modified to specifically require the designer to coordinate its efforts with the CMR.
7. If cost or fee factors are going to be included in the selection process, then selecting the CMR after enough design progress to reasonably quantify and price the preconstruction scope of work would be indicated. If direct construction cost information is required, then CMR selection is better timed to happen when the agency has sufficient design detail to permit reasonable numbers to be submitted for the indicated costs that do not contain excessive contingencies.
8. Protests of CMR selection decisions are reportedly rare. Three protests were identified in the study and all were unsuccessful.
9. Preconstruction services are a distinct benefit to the project's cost, schedule, and ultimate quality. The cost of preconstruction is a reasonable investment that accrues tangible returns.
10. CMR services furnished during preconstruction reduce design costs by permitting the designer to produce an appropriate design rather than a biddable design. In other words, the CMR can tell the designer when it has sufficient design detail to properly construct a given feature of work. Achieving these savings requires a high level of collaboration and strong spirit of partnering.
11. The study found that nine of ten case studies allowed the CMR to self-perform work packages of its choice.
12. The study found that nine of ten case studies allowed the CMR to have unlimited ability to self-perform as little or as much work as it finds appropriate.
13. The study found that eight of ten case studies did not constrain the CMR's ability to prequalify and/or select subcontractors for the following reasons:
    - To get real-time pricing information, the CMR is allowed and expected to communicate with the subcontractors it knows during preconstruction.
    - To obtain real-time technical information about best practices for subcontractor trade means and methods, the CMR is allowed and expected to communicate with the subcontractors it knows to access subject matter experts during preconstruction.
    - Studies have shown that competitive pricing is "preserved" without competitive bidding; therefore, requiring the CMR to award subcontractor work packages to an open field of competitors does not appear to save money.
14. Progressive guaranteed maximum prices (GMPs) are reported to add value to the CMR project by reducing the total amount of contingency in the GMP and by allowing an orderly method to price early work packages and/or construction phases.
15. Incorporating a shared savings clause does not create a significant incentive to the CMR and may add a layer of administration whose cost is not recovered in its actual benefit.
16. Early work packages can be used to mitigate cost risk by locking in the cost of the materials, and services associated with those packages were cited by ten of

the papers listed in Table 1. This ability was also cited as "of highest value" by all but one case study project owner and all the interviewed contractors.

17. The major barriers to CMR implementation are confusion about its mechanics and whether enabling legislation exists to use it.

LESSONS LEARNED

There were three primary lessons learned. All deal with the administration and approval of fees earned by the CMR and the designer. These three were selected because they all furnish solutions to three major issues that an agency seeking to implement CMR will face. Thus, it is hoped that these will allow agencies new to CMR to start a bit higher on the learning curve based on the experiences discussed in this section.

Coordinate Design and Construction Manager-at-Risk Contracts

The first lesson comes from the Memphis Airport case study project and deals with modifying the DBB contract and structuring the design fee in a manner that creates an incentive for the engineer to willingly participate in the preconstruction process. Memphis did not modify its standard design contract for its first CMR project and found that obtaining the necessary collaboration with the CMR was not as effective as was hoped. The root of the problem was that the designer had not priced the number of design reviews required and was using up burning billable hours faster than it was used in a DBB design contract. The agency modified the design contract for the next phase of the project to coordinate design milestones with budget review points. It added an explicit requirement to coordinate the design work with the CMR's construction work packages and mandated joint coordination with third parties. This gave the designer a chance to propose a fee that reflected the changed scope of design coordination that is present in a CMR contract.

Memphis also created an incentive for the engineer to willingly cooperate with the contractor during preconstruction. Its modified contract included a clause that put 10% of the design fee at risk for the final quality of the construction documents. The at-risk portion was divided into 5% for design quality and 5% for construction issues owing to design quality problems. The contract clause extends from preconstruction and rates the outcome and resolution of construction problems, such as change orders and delays that result from poor design quality control (QC). This changed the relationship from one of unwanted interference to one where the consultant saw the CMR reviews as a benefit to its design QC process and solved the issue of preconstruction collaboration in a manner that not only facilitated the budget and schedule but more importantly enhanced the design QC program. Arizona State University's CMR design contract has a clause to coordinate the efforts of the CMR as a part of the designer's product and requires the designer and builder to jointly present the design submission. The lesson learned here is summarized as follows:

> *Preconstruction collaboration does not happen automatically by merely deciding to use CMR project delivery. The requirements to collaborate are included in BOTH the design and preconstruction services contracts.*

Empowering Third Parties to Incentivize the Construction Manager-at-Risk

The Utah Transit Authority (UTA) Weber County Commuter Rail case study project furnished an innovative way to increase the trust of third-party stakeholders and hence increase their cooperation on a major CMR project. The project ran through ten different municipalities and had to share active track and right-of-way with the Union Pacific Railroad's most heavily trafficked freight route. There were significant numbers of utilities to deal with and many environmental and drainage issues to be solved, not to mention impacts on the public during construction. To deal with the monumental challenge created by the sheer number of third-party stakeholders, UTA assigned the responsibility of coordinating to the CMR and created a stakeholder panel to furnish feedback on a monthly basis.

The panel included the impacted municipalities, the state environmental quality agency, and representatives from the railroad and the FTA. UTA empowered this panel through a clause in the CMR's contract that put half the CMR's construction fee at-risk. The panel met monthly to review the issues that arose in the past pay period and made a recommendation to UTA as to how much of the at-risk fee would be awarded in the monthly progress payment based on the contractor's performance. This created an incentive for the contractor to maintain good public relations and be responsive to the concerns of the affected third parties. The system was effective in not only inspiring the CMR to act promptly and aggressively on corrective action to resolve issues as they arose, but it was also effective in giving the third-party stakeholders a sense of substantive involvement, which greatly reduced the number of third-party issues that needed to be solved. The lesson learned here is summarized as follows:

> *The CMR contract can be used to not only create an incentive for good performance by the contractor but also can assist in third-party issue resolution by giving these parties a voice in the CMR's actual profit.*

Simplify the Guaranteed Maximum Price Negotiation Process Up Front

UDOT is the most experienced DOT in the country at delivering highway projects using CMR. As a result, its CMR process has undergone a series of revisions as UDOT incorporated the lessons it learned and experimented with different variations on the CMR theme. When the case study agency interviews were complete, the study team was left with the impression that the least understood portion of the process was negotiating the GMP. UDOT uses different GMP structures for projects with different requirements. Its suite of CMR options includes a unit price GMP, unit price with no GMP, and preconstruction services only followed by hard bid for construction. In a unit price GMP, there is no reason to negotiate a construction fee because the contractor's profit and general conditions are contained in the unit prices. Therefore, this leaves the GMP negotiation to consist of verifying quantities of work and determining if the unit prices are reasonable. UDOT further simplifies this process by requiring the unit prices for four or five major pay items in the CMR's proposal. This nails down a significant piece of the GMP before the CMR contract is awarded.

Attempting to estimate a given contractor's profit is impossible for anyone but the contractor itself. Profit is a business decision that reflects everything from how much risk a given contractor sees in a project to how badly they need the work. The same thing can be said for estimating the general conditions as a separate line in the GMP. UDOT's solution is elegant in that it uses the best features of its DBB project delivery process to simplify its CMR project delivery process. It also manages risk by applying the unit pricing in a progressive GMP. The effect is to reduce the contingencies by not requiring pricing for work packages that have insufficient design detail. Therefore, for an agency that is trying CMR for the first time, the UDOT CMR approach is a relatively minor shift from DBB. The only essential differences are the preconstruction services contract and not getting all the contract costs in a single bid envelope. The lesson learned here is summarized as follows:

> *Simplify the process of establishing a reasonable and realistic GMP as much as necessary by putting many of its components into unit prices.*

Effective Practices

Several effective practices were also reported.

1. The case study interviews noted that agencies can develop a documented procedure for selecting CMR as the project delivery method based on project characteristics. Additionally, a similar policy can be developed for selecting the CMR contractor based on the same project characteristics.
2. A CMR selection process that is transparent, logical, and defensible appears to be less likely to be susceptible to protest.
3. Eight of ten case study agencies use the same quality assurance (QA) program for CMR as they do for DBB. Therefore, it appears that no modification is necessary to a DOT's QA program to implement CMR project delivery.
4. The two most often cited preconstruction services in transportation projects were design reviews and constructability reviews. Both of these are essential components of the design QC program. Thus, detailing the roles and responsibilities for design QC for both the designer and the CMR in the procurement phase facilitates collaboration.
5. Joint development of the preconstruction service cost model before commencing design allows the designer and the CMR to be able to leverage it to make design decisions and to benchmark value engineering savings.
6. Splitting the contingency between the owner and the CMR appears to make accounting for contingency allocation less onerous.
7. An open books approach to contingency calculation and allocation enhances the spirit of trust between the owner and the CMR.
8. Detailing the specific preconstruction services the agency wants to be provided in the preconstruction services contract in the solicitation document leads to responsive proposals. This is critical to getting a reasonable proposal if costs are included in the selection process.
9. Including the submittal of an outline of the proposed CMR project quality management plan with the statement of qualifications or proposal allows the agency to evaluate each competitor's understanding of the QA challenges in the project.
10. Assigning the CMR the duties of scheduling for both design and construction during the preconstruction phase enhances collaboration between the parties. This service was rated as the second most valuable preconstruction service by both the case study agencies and contractors, and the ability to fast track was cited by 10 of the 15 papers shown in Table 1.
11. The agency can furnish a list of the cost categories to be used in preconstruction and where it wants various costs, such as fees and contingencies, to be accounted for in the CMR contract. Doing so eliminates confusion as to where each cost is to be allocated and facilitates the GMP negotiations. Table 29 provides a typical format for these costs.

FURTHER RESEARCH

One purpose of this synthesis was to identify gaps in the knowledge about CMR and indicate possible research to address them. Five major research needs are presented.

- Development of agency understanding and knowledge of CMR versus DBB and design-build (DB).
- Investigating effective use of in-house design assets in CMR project delivery.
- Development of a guide for CMR preconstruction cost modeling.
- Estimating CMR preconstruction services fees.
- Documenting and administering the GMP in CMR.

Increased Department of Transportation Construction Manager-at-Risk Knowledge

In the national survey, 15 respondents indicated that they did not know what CMR project delivery was. The answers given by the two that used "other" as their reason for not using CMR appear to indicate that the real number is 17 of 47 states, or 36% of the sample. Another 22 indicated that they do not have legal authority. Although the study cannot determine why the authority does not exist, because DB is permitted in some form in 48 states infers that a lack of knowledge about the potential benefits and the mechanics of CMR project delivery may play an important part. Therefore, a short-term project to develop a "Primer on CMR Project Delivery for DOTs" would furnish a means to quickly disseminate the necessary information to transportation managers to make an informed decision as to whether or not the effort necessary to obtain authority was worthwhile. Two reports reviewed in the synthesis (Doren et al. 2005 and Strang 2002) furnished pragmatic political motivations to pursue the proposed research.

- "Quasi-public and government organizations predominately use the DBB method, but clearly many have tried other methods and most would consider either CMR or DB to be the best-value alternatives. Changing the delivery methods used, in the case of these organizations, will often require changing laws and politics, but that is happening too, because the public is best served when it gets the best value for its tax dollars . . . *CM-at-risk will likely become the more dominant delivery method for this group as long as the experience is positive*" (Doren et al. 2005; italics added).
- "The great advantage to CM-at-Risk for most public owners is that their governing bodies accept it . . . The choice then for most public Owners is between CM-at-Risk and the traditional [DBB] system. If they do not want to use the traditional method because of past poor results, and are not bold enough to try DB, they are encouraged in this direction" (Strang 2002).

Once the barrier to implementation resulting from agency confusion about CMR is addressed by this short-term project, a second project may be developed to furnish the quantitative information that will be needed to remove legislative barriers to implementing CMR project delivery by those agencies that choose to add it to their procurement toolbox. This project would compare CMR with DBB and DB project delivery for transportation in the same manner as Sanvido and Konchar (1996) did for the vertical sector. That study developed a robust set of project performance metrics and then applied them to a large sample of projects drawn from the three project delivery methods. To achieve the level of statistical significance necessary to present data that will be used to change legislation, the study will need to extend itself to include the horizontal portions of rail transit and airport experiences as well as the standard highway projects. The prime deliverable will be a comparative analysis of project performance by delivery method that can be reduced to a form that is suitable to inform the legislative and agency decision makers that will ultimately decide whether or not to authorize CMR project delivery for their jurisdictions. The two studies could be combined into one, with the CMR primer as an early deliverable.

Incorporating In-House Design in Construction Manager-at-Risk Project

In the literature, there was no information regarding the use of in-house design professionals to accomplish the design. Most models found assumed that the owner would outsource the design. UDOT does both depending on the project's requirements. Most DOTs have a robust in-house design capacity and use it on DBB projects. The synthesis found that there appears to be no need to change the construction QA program to implement CMR project delivery; much of that work is done by DOT designers. Therefore, there appears to be no reason to not use these design professionals to complete the entire design as well. Finally, the anecdotal information found on the topic indicates that the major barrier to overcome is developing a method where state employees can be held to the same scheduling standards as a design consultant.

The research would be based on the California DOT's design-sequencing program, which appears to be the "next best" analog outside of UDOT's actual experience. The study would reach out to the municipal engineering community, as well as look overseas for possible solutions that occur in Alliancing and Early Contractor Involvement programs in use in the United Kingdom, Australia, and New Zealand. To make sure that the entire cost of the process is determined, the research would specifically look at the cost of in-house design and perhaps develop a methodology to estimate its costs. Additionally, it would document the changes necessary to implement in-house design with respect to scheduling and design product turnaround. The major deliverable would be a guide for using in-house design on CMR contracts.

Preconstruction Cost Modeling

Ladino's "cost model then design" is a new process to most DOTs. Although contractors have extensive experience with this process, agencies typically depend on their bid tabulation-based estimating systems to do estimate after design. This study found that robust cost modeling actually drives design decisions and facilitates the value engineering process. Additionally, it provides a foundation for controlling scoop creep and assisting design engineers' understanding of the impact of design assumptions such as factors of safety. Therefore, a standardized procedure for developing CMR cost models could also be extended to DBB projects during design as well.

The proposed project would take the cost modeling theory developed for DB projects and adapt it to CMR projects. It could build on the work done by the Washington State DOT's Cost Estimate Validation Process, which has been found to be very effective for developing early estimates. Additionally, there could be an investigation of the use of the stochastic estimating methods recommended by FHWA (*Life Cycle Cost Analysis in Pavement Design* 1998) to apply Monte Carlo simulation to quantify the uncertainty of construction costs. The deliverable would be a guide for developing these models for CMR projects, along with a commercial spreadsheet template that could be adapted by DOTs for use in their CMR programs.

Preconstruction Fee Estimating

The final proposed research need could develop a rational methodology for estimating preconstruction service fees. The contractors in this study were asked how they estimate the cost of preconstruction and each had its own method. However, regardless of the method, all stated that they then looked at the number and altered it to a value that they thought would be acceptable to the owner. This business decision was more pronounced in projects that evaluated fees as part of the selection process. One of the case study agencies (MDOT) stipulates the preconstruction services fee in its solicitation and treats it much like a DB proposal stipend. Michigan and Oregon both stipulated a fixed percentage of costs as well. When the contractors that competed for these projects were asked their feelings on this feature, they offered no complaints. Another case study contractor that had worked for non-case study agencies with similar policies indicated that it preferred this policy because it focused the selection process on "quality and value" rather than money.

Therefore, the notion of developing a methodology that could be used by public agencies to estimate a fair and reasonable preconstruction services fee would appear to not only be helpful but also welcomed by industry. Most DOTs have a system to estimate the cost of design services for outsourced engineering contracts that could be adjusted to serve this purpose if they had reliable input data to populate their cost database. Thus, the study would produce a parallel method and representative input data to allow this fee to be estimated. Additionally, the research could do a broad survey of the construction industry to confirm the impressions found in this synthesis, as well as to identify the full suite of possible preconstruction services. The study might also include a pilot of the method with an experienced DOT such as Utah.

Documenting and Administering Guaranteed Maximum Price in Construction Manager-at-Risk

The synthesis did not collect information on how the various case study agencies documented and administered their GMPs. In addition, the literature was silent on that subject. Therefore, it is suggested that a synthesis be conducted on this topic. The synthesis would need to take a multi-modal scope to find sufficient CMR experience and uncover the various options for dealing with this issue. The study would look at not only how the GMP is configured and contractually promulgated but also on how payments are made to the CMR from this source. It could also review requirements to audit the contingencies. Finally, the synthesis could do a more detailed study of contingencies that extends the finding of this study.

SUMMARY

CMR project delivery is not the proverbial "silver bullet" any more than DB was. However, it furnishes an attractive option for public highway agencies to deliver their projects in a manner that is less adversarial and more constructive by involving the contractor during design. It also furnishes an option where the agency does not have to relinquish control of the details of design to be able to accelerate the schedule or receive the benefits of real-time cost-estimating data. This report found that CMR can be successfully implemented and that there are documented cost and time benefits with no degradation in quality. The barriers to implementation are primarily legislative and perceptional. A public agency that has an interest in adding this tool to their procurement tool box may investigate the possibility, communicate with those agencies such as UDOT that have experience, and begin to develop the policies and procedures that will permit their initial project to be successful. This synthesis report essentially finds that an agency that has the proper characteristics and selects a project where tangible benefits can be accrued will probably be successful.

REFERENCES

Alder, R., "UDOT Construction Manager General Contract (CMGC) Annual Report," Engineering Services and Bridge Design Section, Utah Department of Transportation Project Development Group, Salt Lake City, 2007, 39 pp.

Anderson, S.D. and I. Damnjanovic, *NCHRP Synthesis 379: Selection and Evaluation of Alternative Contracting Methods to Accelerate Project Completion,* Transportation Research Board of the National Academies, Washington, D.C., 2008, 77 pp.

Anderson, S.D. and D.J. Fisher, *NCHRP Report 390: Constructability Review Process of Transportation Facilities,* Transportation Research Board, National Research Council, Washington, D.C., 1997.

Armstrong, W.G. and R.M. Wallace, "A Case Study of Construction Management on the Boston Harbor Project, Reflections at Project Completion," *CM E-Journal,* Construction Management Association of America, McLean, Va., Jan. 2001, 22 pp.

Bearup, W., M. Kenig, and J. O'Donnell, "Alternative Delivery Methods, a Primer," *Proceedings, Airport Board Members and Commissioners Annual Conference,* Airports Council International–North America, Chicago, Ill., 2007.

Bresnen, M. and N. Marshall, "Motivation, Commitment, and the Use of Incentives in Partnerships and Alliances," *Construction Management and Economics,* Vol. 18, 2000, pp. 587–598.

Brinkman, G., "City of Phoenix Work Plan for SEP (Special Experimental Project) 14 Construction Manager at Risk Contract Historic Streetlight Restoration," July 3, 2007 [Online]. Available: http://www.fhwa.dot.gov/programadmin/contracts/sep14azstreetlight [accessed May 15, 2009].

Carlisle, J.B., *Estimating Costs of Pre-Construction Services for Construction Management-at-Risk,* Masters Thesis, University of Oklahoma, Norman, 2006, 52 pp.

Carr, P.G. and P.S. Beyor, "Design Fees, the State of the Profession, and a Time for Corrective Action," *Journal of Construction Engineering and Management,* ASCE, Vol. 21, No. 3, 2005, pp. 110–117.

CFMA Annual Financial Survey, 2000, Construction Financial Management Association, Princeton, N.J., p. 53 [Online]. Available: http://www.cfma.org/pubs/docs/AnnualReport2000.pdf [Oct. 14, 2008].

"CM/GC Fee Structure Sample," Grand County, Colorado, Apr. 6, 2007, pp. 1–3 [Online]. Available: http://co.grand.co.us/GM-GC/Fees_&_Agreements_Updated_4-6-07/CMGC_Sample_Fee_Structure_Grand_County.pdf [accessed May 19 2009].

"CM/GC Peer Review Meeting," memorandum, Utah Transit Authority, Salt Lake City, Aug. 12, 2003, 34 pp.

Constructability: A Primer, Publication 3-1 (July), Construction Industry Institute, Austin, Tex., 1986.

"Construction Delivery Approaches," Construction Management Association of America, McLean, Va., Dec. 13, 2007 [Online]. Available: http://www2.mvr.usace.army.mil/WaterControl/Districts/MVR/SAME/construction/ConstructionDeliveryApproaches.pdf [accessed May 21, 2009].

Construction Project Management Handbook, Federal Transit Administration, Washington D.C., 2006, pp. 3–7.

"Contract for Construction Manager at Risk Design Phase Services," Division of Engineering, City of Tempe, Arizona Public Works Department, 2007 [Online]. Available: http://www.tempe.gov/Engineering/docs/ZNewCM@Risk.pdf [accessed June 28, 2009].

Cost Estimating Guide, DOE G 430.1-1, Department of Energy, Washington, D.C., Mar. 28, 1997, p.11.1.

Cunningham, G., "Commissioning Large Public Projects Using Construction Manager at Risk," National Conference on Building Commissioning, New York, N.Y., May 4–6, 2005, pp. 1–14.

Denzel, M., M. Sumitani, and S. Cohen, *General Contractor/Construction Manager Form of Contracting: Issues and Recommendations,* Seattle, Wash., 2004, 26 pp. [Online]. Available: http://www.cityofseattle.net/audit/report_files/2004-05_GCCM_Report.pdf [May 15, 2009].

"Design-Build Effectiveness Study," Final Report to Congress as Required by TEA-21, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 2006, pp. 4–9 [Online]. Available: http://www.fhwa.dot.gov/reports/designbuild/designbuild0.htm [accessed Aug. 30, 2008].

DeWitt, S., et al., *Construction Management Practices in Canada and Europe,* FHWA-PL-05-010, Federal Highway Administration, Washington, D.C., May 2005, 72 pp.

Doren, D., M. Bridgers, and M. Napier, FMI/CMAA Sixth Annual Survey of Owners, Construction Management Association of America, McLean, Va., 2005 [Online]. Available: http://cmaanet.org/user_images/owners_survey_6.pdf [accessed Nov. 16, 2008].

Dunston, P.S., J.F. McManus, and J.A. Gambatese, *Cost/Benefits of Constructability Reviews,* NCHRP Project 20-7, Task 124, Transportation Research Board, National Research Council, Washington, D.C., 2002, p. 2.

Early Contractor Involvement Contract Guidance Manual, United Kingdom Highways Agency, London, England, Aug. 2, 2004, 47 pp.

Eldin, N.N., "Concurrent Engineering: A Schedule Reduction Tool," *Journal of Construction Engineering and Management,* ASCE, Vol. 123, No. 3, 1997, pp. 354–362.

Ellicott, M.A., "Best-value Contracting," *Proceedings,* Area Engineers Conference, TransAtlantic Division, U.S. Army Corps of Engineers, Winchester, Va., Jan. 15–17, 1994, pp. 17–21.

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

Engineering Instructions Construction Cost Estimates, CEMP-E/CECW-E EI 01D010, U.S. Army Corps of Engineers, Washington, D.C., 1997, p. 121.

Estimating Guidelines for Roadway Construction Projects, Transportation Department, County of Riverside, Riverside, Calif., 1999, p. 8.

Federal Architect–Engineer Contracting Cost Principles Workbook, Naval Facilities Institute, Department of the Navy, Port Huenme, Calif., 2005, 78 pp.

Fellows, R. and A. Liu, *Research Methods for Construction,* 3rd ed., Wiley–Blackwell, Boston, Mass., 2008.

Ford, D.N., S.D. Anderson, A.J. Damron, R. de Las Casas, N. Gokmen, and S.T. Kuennen, "Managing Constructability Reviews to Reduce Highway Project Durations," *Journal of Construction Engineering and Management,* Vol. 130, No. 1, 2004, pp. 33–43.

Gambatese, J., K. Dettwyler, D. Rogge, and L. Schroeder, *Oregon Public Contracting Coalition Guide to CM/GC Contracting,* Oregon Public Contracting Coalition, Portland, 2002, p. 13.

Gibson, G.E., C.I. McGinnis, W.S. Flanigan, and J.E. Wood, "Constructability in the Public Sector," *Journal of Construction Engineering and Management,* ASCE, Vol. 122, No. 3, 1996, pp. 274–280.

Gibson, G.E., G.C. Migliaccio, and J.T. O'Connor, "Changing Project Procurement Strategy: An Implementation Framework," *Sloan Industry Studies Working Paper Series,* Sloan Foundation Industry Studies Annual Conference, Apr. 26–27, Cambridge, Mass., 2007, p. 20.

Gordon, C.M., "Choosing Appropriate Construction Contracting Method," *Journal of Construction Engineering,* ASCE, Vol. 120, No. 1, 1994, pp. 196–210.

Graham, P., *Evaluation of Design-Build Practice in Colorado,* Research Report IR(CX) 70-4(143), Colorado Department of Transportation, Denver, 1997.

Gransberg, D.D., "The Cost of Inaction: Does Massachusetts Need Public Construction Reform?" *White Paper No. 7,* Pioneer Institute for Public Policy Research, Center for Restructuring Government, Boston, Mass., Sep. 1999, 28 pp.

Gransberg, D.D., J.E. Koch, and K.R. Molenaar, *Preparing for Design-Build Projects: A Primer for Owners, Engineers, and Contractors,* ASCE Press, Reston, Va., 2006, p. 26.

Gransberg, D.D. and J.B. Carlisle, "Estimating Preconstruction Services Fees for CM-at-Risk Projects," *2008 Transactions,* AACE, International, Toronto, ON, Canada, July 2008, pp EST.09.1–EST.09.10.

Gransberg, D.D., K.R. Molenaar, and J.N. Datin, *NCHRP Synthesis 376: Quality Assurance in Design-Build Projects,* Transportation Research Board of the National Academies, Washington, D.C., 2008, 281 pp.

Gransberg, D.D. and C. Riemer, *NCHRP Synthesis 390: Performance-Based Construction Contractor Prequalification,* Transportation Research Board of the National Academies, Washington, D.C., 2009, 114 pp.

Gribbon, P., G. Irwin, G. Colzani, G. Boyce, and J. McDonald, "Portland, Oregon's Alternative Contract Approach to Tackle a Complex Underground Project," presented at 2003 Rapid Excavation and Tunneling Conference, New Orleans, La., June 15–18, 2003.

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

Jergeas, G. and J. Van der Put, "Benefits of Constructability on Construction Projects," *Journal of Construction Engineering and Management,* Vol. 127, No. 4, 2001, p. 281.

Ketcham, M. and M. Epps, "How to Hire a Construction Manager for Your Energy Efficiency Project," *Energy Efficiency Project Management Handbook,* Manual P400-00-001E, California Energy Commission, Sacramento, May 2000, pp. 2–4.

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

Koppinen, T. and P. Lahdenperä, *The Current and Future Performance of Road Project Delivery Methods,* VTT Publications 549, Helsinki, Finland, Espoo 2004, p. 63.

Kuhn, S., "Preconstruction Services: Add Value with More than Just Estimating," *Construction Business Owner,* Feb. 2007 [Online]. Available: http://www.constructionbusinessowner.com/topics/accounting-and-finance/preconstruction-services-add-value-with-more-than-just-estimating.html [accessed Aug. 1, 2008].

Kwak, Y.H. and R. Bushey, "Construction Management at Risk: An Innovative Project Delivery Method at Stormwater Treatment Area in the Everglades, Florida," *Proceedings,* Construction Congress VI, Orlando, Fla., 2000, pp. 477–482.

Ladino, M.J., K.A. Reedy, and J.E. Carlson, "Alternate Project Delivery in Horizontal Construction," presentation, Annual Meeting, Associated General Contractors of America, Las Vegas, Nev., Mar. 2008, 25 pp.

Leahy, R.B., et al., *Transportation Research Circular E-C137: Glossary of Highway Quality Assurance Terms,* Transportation Research Board of the National Academies, Washington, D.C., May 2009, 44 pp.

Lee, J., "CM/GC at Oregon DOT," presentation, WASHTO Conference, Portland, Ore., 2008, 14 pp.

Life Cycle Cost Analysis in Pavement Design, Pavement Division Interim Technical Bulletin, Draft, Federal Highway Administration, Washington, D.C., Mar. 1998, 114 pp.

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

Martinez, P.H., Y. Rashida, and V. MacMurray, "Construction Manager's Responsibilities: Pre-Design, Design and Pre-Construction Phase," American Bar Association, Chicago, Ill., Jan. 2007, 58 pp. [Online]. Available: http://www.abanet.org/abastore/productpage/5570099PDF [accessed June 9, 2009].

Migliaccio, G.C., G.E. Gibson, and J.T. O'Connor, "Changing Project Delivery Strategy, an Implementation Framework," *Public Works Management & Policy,* Vol. 12, No. 3, Jan. 2008, pp. 483–502.

Minchin, E., K. Thakkar, and R. Ellis, "Miami Intermodal Center—Introducing CM-at-Risk to Transportation Construction," In *Innovative Project Delivery Systems,* K.R. Molenaar and G. Yakowenko, Eds., ASCE Press, Reston, Va., 2007, pp. 46–59.

Mitchell, B.P., "The Applicability of the Spearin Doctrine: Do Owners Warrant Plans and Specifications?" Find Law for Legal Professionals, 1999 [Online]. Available: http://library.findlaw.com/1999/Aug/1/128038.html [accessed Mar. 24, 2007].

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

"Nationwide CM at-Risk Survey Results," Associated General Contractors of America and National Association of State Facilities Administrators, 2009 [Online]. Available: http://www.agc.org/galleries/projectd/CMatRiskSurveyData.pdf [accessed July 8, 2009].

Neuendorf, K.A., *The Content Analysis Guidebook,* Sage Publications, Thousand Oaks, Calif., 2002, 300 pp.

O'Connor, J.T. and S.J. Miller, "Barriers to Constructability Implementation," *Journal of Performance of Constructed Facilities,* ASCE, Vol. 8, No. 2, 1994, pp. 110–128.

Oklahoma, State of Oklahoma Administrative Code Section 580:20-17-9, Fee Negotiations and Contracts, Oklahoma City, June 25, 2007.

Operating Manual for Construction Manager at Risk Projects (*Single Project Form*), Arizona State University, Tempe, June 2006 edition, pp. 1–99.

"Owner's Tool for Project Delivery and Contract Strategy Selection," *Research Summary 165,* Construction Industry Institute, Austin, Tex., 2003.

Parvin, C., "Design-build: Evaluation and Award," *Roads and Bridges,* Vol. 38, No. 12, Feb. 2000, p. 12.

Pocock, J.B., S.T. Kuennen, J. Gambatese, and J. Rauschkolb, "Constructability State of Practice Report," *Journal of Construction Engineering and Management,* ASCE, Vol. 132, No. 4, Apr. 1, 2006, p. 375.

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

Project Delivery Systems for Construction, Associated General Contractors of America, Washington, D.C., 2004.

Qaasim, H.A., "Comprehensive Quality Assurance for Transit," *Proceedings, American Society for Quality World Conference on Quality and Improvement,* Milwaukee, Wis., Vol. 59, 2005, pp. 299–308.

Reinschmidt, K. and D. Trejo, "Economic Value of Building Faster," *Journal of Construction Engineering and Management,* ASCE, Vol. 132, No. 7, July 1, 2006, p. 759.

"Request for Proposal, Model, and Guidelines for Construction Manager at Risk with Guaranteed Maximum Price," Office of Capital Planning, Design, and Construction, California State University, Long Beach, May 20, 2007, pp. 1–13 [Online]. Available: http://www.calstate.edu/cpdc [accessed Sep. 22, 2008].

"Request for Proposals General Contractor/Construction Manager (GC/CM) Anacortes Multimodal Terminal," Washington State Ferries Project No. XL 1714, Washington State Ferries, Terminal Engineering, Seattle, Feb. 2005, 11 pp.

Rojas, E.M. and I. Kell, "Comparative Analysis of Project Delivery Systems Cost Performance in Pacific Northwest Public Schools," *Journal of Construction Engineering and Management,* Vol. 134, No. 6, June 1, 2008, pp. 387–398.

Russell, J.S., S.D. Anderson, D. Trejo, and A.S. Hanna, *NCHRP Web Document 51: Construction Engineering and Management Research Program,* Project D10-58, Transportation Research Board, National Research Council, Washington, D.C., 2002, 51 pp.

Sanvido, V. and M. Konchar, *Selecting Project Delivery Systems: Comparing Design-Bid-Build, Design-Build, and Construction Management at Risk,* The Project Delivery Institute, State College, Pa., 1999, pp. 13–18.

Scott, S., K. Molenaar, D. Gransberg, and N. Smith, *NCHRP Report 561: Best-Value Procurement Methods for Highway Construction Projects,* Transportation Research Board of the National Academies, Washington, D.C., 2006, 167 pp.

Septelka, D. and S. Goldblatt, "Survey of General Contractor/Construction Management Projects in Washington State," State of Washington Joint Legislature Audit and Review Committee Report, Olympia, 2005, 117 pp.

Shane, J.S., D.D. Gransberg, K.R. Molenaar, and J.R. Gladke, "Legal Challenge to a Best-Value Procurement System," *Journal of Leadership and Management in Engineering,* ASCE, Vol. 5, No. 1, Jan. 2006, pp. 1–6.

Songer, A.D. and K.R. Molenaar, "Selecting Design-Build: Private and Public Sector Owner Attitudes," *Journal of Engineering Management,* ASCE, Vol. 12, No. 6, 1996, pp. 47–53.

Spata, S. and F.A. Kutilek, "Solutions to Managing Construction Cost Escalation Tools, Strategies, and 'Selective Scoping' Help Manage Risk," Tradeline, Inc., June 14, 2006 [Online]. Available: http://www.tradelineinc.com/reports/B045DC52-2B3B-B525-8F91436EBCDCEA9B [accessed May 20, 2009].

"Speed, Communication, and Commissioning Issues Are Top Owner Concerns, FMI/CMAA Survey Finds," Construction Management Association of America, McLean, Va., 2003 [Online]. Available: http://cmaanet.org/owners_survey.php [accessed Nov. 24, 2008].

Storm, G., "New Contracting Experience Guides Fairbanks Airport Project," *Pacific Builder and Engineer,* Oct. 1, 2007 [Online]. Available: http://www.acppubs.com/article/CA6480230.html?industryid=48546 [accessed Sep. 22, 2008].

Strang, W., "The Risk in CM at-Risk," *CM eJournal,* Construction Management Association of America, McLean, Va., 2002, pp. 1–9.

"Supplemental Instructions for Form IC 730 (SF 4351) Request for Approval of Subcontractor," Indiana Department of Transportation, Indianapolis, Feb. 4, 2008 [Online]. Available: http://www.in.gov/dot/div/contracts/standards/IC-730instruc.pdf [accessed May 15, 2009].

Thomsen, C., "Project Delivery Processes," Parsons Corporation, Apr. 2, 2006 [Online]. Available: http://www.3di.com/rnd/Files/Essays/Project%20Delivery%20Strategy.pdf [accessed Nov. 22, 2008].

Touran, A., "Owners Risk Reduction Techniques Using a CM," *CMAA Research Report,* Construction Management Association of America, Washington, D.C., 2006, 55 pp.

Touran, A., D.D. Gransberg, K.R. Molenaar, K. Ghavamifar, and P. Bakhshi, *ACRP Report 21: A Guidebook for Selecting Airport Capital Project Delivery Methods,* Transportation Research Board of the National Academies, Washington, D.C., 2009a, 90 pp.

Touran, A., D.D. Gransberg, K.R. Molenaar, K. Ghavamifar, D.J. Mason, and L.A. Fithian, *TCRP Report 131: A Guidebook for the Evaluation of Project Delivery Methods,* Transportation Research Board of the National Academies, Washington, D.C., 2009b, 240 pp.

Transportation Research Circular 386: Innovative Contracting Practices, Transportation Research Board, National Research Council, Washington, D.C., 1991, pp. 1–74.

Trauner Consulting Services, "Innovative Procurement Practices Alternative Procurement and Contracting Methods," California Department of Transportation Report No. 53A0104, Sacramento, 2007, pp. 10–12.

"Tri-Met's Construction Manager/General Contractor Approach Lessons Learned 44," *Publication 1363,* Federal Transit Administration, Washington D.C., 2003 [Online]. Available: http://www.fta.dot.gov/printer_friendly/publications_1363.html [accessed June 1, 2009].

Uhlik, F.T. and M.D. Eller, "Alternative Delivery Approaches for Military Medical Construction Projects," *Journal of Architectural Engineering,* ASCE, Vol. 5, No. 4, 1999, pp. 149–155.

"Using Structured Interviewing Techniques," GAO/PEMD-10.1.5, Government Accounting Office, Washington, D.C., June 1991, 191 pp.

Van Winkle, H., "Alternate Project Delivery Systems," *Proceedings,* 2007 ACI Annual Conference, Airports Council International, Kansas City, Mo., Sep. 30–Oct. 3, 2007, pp. 7–41.

Venturato, T. and J. Schroeder, "Owner-Controlled Accelerated Project, Unique Project Delivery Method for Light Rail," *Transportation Research Record: Journal of the Transportation Research Board, No. 2006,* Transportation Research Board of the National Academies, Washington, D.C., 2007, pp. 60–66.

Walewski, J., G.E. Gibson, Jr., and J. Jasper, *Project Delivery Methods and Contracting Approaches Available for Implementation by the Texas Department of Transportation,* Report No. FHWA/TX-0-2129-1, Center for Transportation Research, Austin, Tex., 2001, 116 pp.

"WSDOT Market Analysis," Washington State Department of Transportation, Olympia, 2008, WWW Document [Online]. Available: http://www.wsdot.wa.gov/biz/contaa/construction/CostIndex/CostIndexPdf/2008Q1Market%20Analysis.pdf [accessed Feb. 18, 2009].

Weber, R.P., *Basic Content Analysis,* Sage Publications, Beverly Hills, Calif., 1985.

Whitten, M., "Cardinal Change," *Construction Law Section Seminar Workbook,* The Commercial Bar Association, London, England, Apr. 22, 2004, pp. 1–14 [Online]. Available: http://new.vicbar.com.au/pdf/CLE_Seminar22042004.pdf [accessed May 21, 2009].

Winters, S., "LEED Cost Study," Report GS-11P-MAD-0565, Order No. P-00-02-CY-0065, General Services Administration, Washington, D.C., Oct. 2004, 578 pp.

Yin, R.K., *Case Study Research: Design and Methods,* Sage Publications, Thousand Oaks, Calif., 1994, 289 pp.

BIBLIOGRAPHY

American Association of State Highway and Transportation Officials, "Primer on Contracting for the 21st Century," White paper, Subcommittee on Construction–Contract Administration Task Force, American Association of State Highway and Transportation Officials, Washington, D.C., 1996, 38 pp.

American Association of State Highway and Transportation Officials, *AASHTO Guide for Design-Build Procurement,* American Association of State Highway and Transportation Officials, Washington, D.C., Jan. 2008, p. 58.

American Council of Consulting Engineers, "Qualifications-Based Selection," Presentation, European Federation of Engineering Consultancy Associations Conference, Brussels, Belgium, Oct. 2004, 40 pp. [Online]. Available: http://www.efca.be/downloads/archive/e4b52f1d-0d94-4e10-ac66-f3d38a410ecb.ppt [accessed Nov. 22, 2008].

"Briefing—FHWA Initiatives to Encourage Quality Through Innovative Contracting," Practices: Special Experimental Projects No. 14 (SEP-14), Federal Highway Administration, Washington, D.C., 2008 [Online]. Available: http://www.fhwa.dot.gov/programadmin/contracts/sep_a.cfm [accessed June 7, 2009].

Carter, R., O. Tomeh, G. Darido, D. Schneck, and F. Waesche, *Quality Assurance and Quality Control Guidelines*, Federal Transit Administration, Washington, D.C., 2002 [Online]. Available: http://www.fta.dot.gov/1311_ENG_HTML.htm [accessed Jan. 24, 2007].

DeBacker, M., "Greener Transportation Infrastructure," *Benchmark Magazine*, Vol. 1, No. 2, 2008, pp. 9–13.

Drennon, P.W., "Utah's I-15, a Transportation Case Study: Role of the Owner's Design Professional in Design/Build and in the Provisions for Quality," *Quality Congress, ASQ's . . . Annual Quality Congress Proceedings*, Milwaukee, Wis., 1998, p. 166.

Grinder, R.D., "U.S. Department of Transportation, a Brief History," Office of the Department of Transportation Historian, Washington, D.C., 2003 [Online]. Available: http://dotlibrary.dot.gov/Historian/history.htm [accessed June 7, 2009].

Handbook on Project Delivery, California Council, American Institute of Architects, Sacramento, 1996.

Hess, S.A. and J.V. Bales, *Design Professional and Construction Manager Law,* American Bar Association, Chicago, Ill., 2007, 293 pp.

Kessler, F., "Managing Your Money: Project Delivery Methods," Nossaman, Guthner, Knox & Elliot LLP, White Paper, 2005 [WWW document] [Online]. Available: http://www.nossaman.com/db30/cgi-bin/news/FWK_MassTransit_04.05.pdf [accessed March 20, 2007].

Migliaccio, G.C., G.E. Gibson, and J.T. O'Connor, "Changing Project Delivery Strategy, an Implementation Framework," *Public Works Management & Policy*, Vol. 12, No. 3, Jan. 2008, pp. 483–502.

"MnDOT's Response to National Transportation Safety Board Recommendations, I-35W Bridge in Minneapolis," Minnesota Department of Transportation, St. Paul, Nov. 2008 [Online]. Available: http://www.dot.state.mn.us/i35wbridge/ [accessed Dec. 22, 2008].

Nickerson, R.L. and S.A. Sabol, *NCHRP Research Results Digest 274*: *Quality Assurance of Structural Materials*, Transportation Research Board, National Research Council, Washington, D.C., Aug. 2003, 21 pp.

Oppenheim, A.N., *Questionnaire Design, Interviewing and Attitude Measurement*, Continuum, London, England, 1992.

Richter, W.L., *Transportation in America*, ABC–CLIO, Inc., Santa Barbara, Calif., 1995, 631 pp.

Shadan, K., R. Dawson, and S. Zeevaart, *Construction Project Management Handbook*, Federal Transit Administration, Washington, D.C., 2006, 128 pp.

Sheet Metal and Air Conditioning National Association, "The United States Green Building Council's Leadership in Energy and Environmental Design," Technical Resources Department Background Paper, Chantilly, Va., June 24, 2005 [Online]. Available: http://www.smacna.org/pdf/LEED%20Background.pdf [accessed May 25, 2009].

University of Washington, "UW: Greenroads," 2009 [Online]. Available: http://pavementinteractive.org/index.php?title=UW:Green_Roads [accessed May 25, 2009].

Washington State Department of Transportation, *Guidebook for Design-Build Highway Project Development*, Olympia, June 20, 2004, 85 pp.

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

Yates, J.K. and J. Duran, "Utilizing Dispute Review Boards in Relational Contracting: A Case Study," *Journal of Professional Issues in Engineering Education and Practice*, ASCE, Vol. 132, No. 4, Oct. 2006, pp. 334–342.

GLOSSARY

Acceptance testing—process of deciding, through inspection, whether to accept or reject a product, including what pay factor to apply (Leahy et al. 2009).

Allocable cost—cost that would normally be charged for the service to be received and that benefits the contract (*Federal Architect–Engineer* . . . 2005).

Allowable cost—normal cost that a firm would incur in the normal operation of that type of business (*Federal Architects–Engineer* . . . 2005).

Case study—in-depth investigation of particular instances within the research subject through interviews with key actors in the subject of study (Fellows and Liu 2008).

Construction Manager-at-Risk (CMR)—project delivery system that entails a commitment by the construction manager to deliver the project within a guaranteed maximum price (GMP), in most cases. The construction manager acts as consultant to the owner in the development and design phases and as the equivalent of a general contractor during the construction phase (Leahy et al. 2009).

Construction Manager/General Contractor (CM/GC)—see Construction Manager-at-Risk.

Construction Manager as Constructor (CMc)—see Construction Manager-at-Risk (Veterans Administration term).

Construction Manager as Agent (CMa)—Veterans Administration term.

Content analysis—research method that in its simplest form requires counting the number of times an activity or topic occurs in the material being analyzed (Fellows and Liu 2008).

Contingency—amount budgeted to cover costs that may result from incomplete design, unforeseen and unpredictable conditions, or uncertainties within the defined project scope. The amount of the contingency will depend on the status of design, procurement, and construction, and the complexity and uncertainties of the component parts of the project (*Cost Estimating Guide* 1997).

Design-bid-build (DBB)—project delivery system in which the design is completed either by in-house professional engineering staff or a design consultant before the construction contract is advertised (Leahy et al. 2009).

Design-build (DB)—project delivery system in which both the design and the construction of the project are simultaneously awarded to a single entity (Leahy et al. 2009).

Early work package—specified feature of work or its materials that is procured before its design is complete to lock in the price of the package and mitigate escalation risk.

Guaranteed maximum price (GMP)—sum of money that represents the cost of work, overhead, profit, and a contingency in a CMR project (Kwak and Bushey 2000).

General Contractor/Construction Manager (GC/CM)—see Construction Manager-at-Risk (Washington State term).

Letter of Interest (LOI)—solicitation document that asks contractors to respond by indicating their desire to compete for the project without requiring them to submit a list of specific qualifications.

Literature review—critical review of literature in area of interest (Fellows and Liu 2008).

Performance specification—specifications that describe how the finished product should perform over time (Leahy et al. 2009).

Preconstruction Cost Model—breakdown of the project's scope of work in dollar terms. In CMR project delivery, the contractor's first preconstruction task is typically the development of this tool in collaboration with the designer. Its purpose is to "validate the owner's budget" (Ladino et al. 2008) and to be able to price various alternatives during design in a manner that directly reflects how and when they will be built (Van Winkle 2008). Additionally, the model evolves as the design progresses and is used to support required cost estimates ("Contract for Construction Manager at Risk Design Phase Services" 2007).

Preconstruction services—activities conducted by the CMR during the design phase.

Preconstruction services fee—amount the CMR earns for its preconstruction services.

Procurement—method of obtaining services for portions of the contracted project (i.e., low bid, best value) (Bearup et al. 2007).

Project delivery method (or system)—contractual arrangement of the parties involved in a construction project (i.e., construction management at risk, DBB) (Touran et al. 2009).

Progressive GMP—alternate way to establish a GMP by breaking the project down into phases or work packages and asking the CMR to generate individual GMPs for each phase or package. The final GMP becomes the sum of the individual GMPs plus any remaining project-level contingencies.

Quality—(1) degree of excellence of a product or service, (2) degree to which a product or service satisfies the needs of a specific customer, (3) degree to which a product or service conforms to a given requirement (Leahy et al. 2009).

Quality acceptance (QA)—all those planned and systematic actions necessary to provide confidence that the product or facility will perform satisfactorily in service (Leahy et al. 2009).

Quality control (QC)—those QA actions and considerations necessary to assess and adjust production and construction processes so as to control the level of quality being produced in the end product (Leahy et al. 2009).

Reasonable cost—cost that does not exceed that which would be incurred by a prudent person in the conduct of competitive business (*Federal Architect–Engineer* . . . 2005).

Request for Qualifications (RFQ)—solicitation documents requiring contractors to submit specific information on qualifications, which does not include any cost or pricing information.

Request for Proposals (RFP)—solicitation documents requiring contractors to submit specific information, which may include but is not limited to qualifications, key personnel, past experience, and cost or pricing information.

Risk—(1) also called statistical risk, the probability of suffering harm or loss; (2) also called engineering risk, a function that represents the expected cost associated with a risk event (Leahy et al. 2009).

Risk allocation—distribution of engineering risk among the various participants in a project (Leahy et al. 2009).

Risk transfer—process of shifting engineering risk from one party to another who is more willing to bear the risk, often accomplished by the use of contracts or insurance (Leahy et al. 2009).

Shared savings—amount of money left in the project's contingency that is then split between the owner and the CMR in accordance with the terms of the contract.

Solicitation document—document produced to solicit a response from the construction industry to furnish services for a specific project. It includes LOIs, RFQs, and RFPs.

Triangulation—use of two or more research techniques together to study the topic; can be a powerful means to gain insights and results, and to assist in making inferences and in drawing conclusions (Fellows and Liu 2008).

Value analysis—process that takes place during preconstruction where the CMR identifies aspects of the design that either do not add value or whose value may be enhanced by changing them in some form or fashion. The change does not necessarily reduce the cost; it may actually decrease the life-cycle costs.

Value engineering (VE)—systematic review by qualified agency and/or contractor personnel of a project, product, or process so as to improve performance, quality, safety, and life-cycle costs (Leahy et al. 2009).

Verification testing—process of testing the truth, or of determining the accuracy of test results, by examining the data or providing objective evidence, or both (Leahy et al. 2009).

Warranty specifications—type of performance specification that guarantees the integrity of a product and assigns responsibility for the repair or replacement of defects to the contractor (Leahy et al. 2009).

APPENDIX A

National Survey Questionnaire

NCHRP Synthesis Topic 40-02: Construction Manager-at-Risk Project Delivery

INTRODUCTION/BACKGROUND

The purpose of this questionnaire is to identify which state highway agencies have used, are using, or plan to use Construction Manager-at-Risk (CMR), also commonly called Construction Manager/General Contractor (CM/GC) project delivery and from that baseline, identify experienced state highway agencies on which to develop case studies reflecting their process for implementing this project delivery method. The results of the study will be a synthesis of highway agency CMR procurement procedures for agencies that are interested in using this alternative project delivery method to procure their construction projects.

DEFINITIONS

Construction Manager-at-Risk (CMR) or Construction Manager/General Contractor (CM/GC): A project delivery method where the owner selects the General Contractor to act as the CM on a basis of qualifications and awards a preconstruction services contract to assist the engineer-of-record during the design phase. Once the design is complete, the subcontractor work packages are bid out and the CM becomes the GC to complete the construction on a guaranteed maximum price basis.

Design-bid-build (DBB): A project delivery method where the design is completed either by in-house professional engineering staff or a design consultant before the construction contract is advertised. Also called the "traditional method."

Design-build (DB): A project delivery method where both the design and the construction of the project are simultaneously awarded to a single entity.

General Information:

1. U.S. state in which the respondent is employed:
2. You are employed by what type of organization?
   ☐ State department of transportation
   ☐ Other public transportation agency; name of agency:
   ☐ Federal agency; name of agency:
   ☐ Other, please describe:
3. What group/section do you work in?

☐ Design group/section	☐ Alternative project delivery group/section
☐ Construction group/section	☐ Materials group/section
☐ Operations group/section	☐ Contracts/procurement group/section
☐ Maintenance group/section	☐ Other, please specify:

4. What project delivery methods is your organization allowed to use?
   ☐ DBB ☐ CMR CM/GC ☐ DB ☐ Other, please specify:
5. Do other public agencies in your state have authority to use CM-at-Risk?
   ☐ Yes ☐ No Please explain if necessary:
6. If you do not use CM-at-Risk, why not?
   ☐ No legal authority
   ☐ Have authority but have not yet found a project where it makes sense
   ☐ Have authority but political/policy issues prevent its use
   ☐ Have authority but agency upper management is unwilling to use it
   ☐ Have authority but industry opposition prevents its use
   ☐ Other, please specify:
7. Do you want to be able to use CM-at-Risk?
   ☐ Yes ☐ No Please explain if necessary:
8. Does/would the construction industry in your region support the use of CM-at-Risk?
   ☐ Yes ☐ No Please explain if necessary:
9. Does/would the consulting engineering industry in your region support the use of CM-at-Risk?
   ☐ Yes ☐ No Please explain if necessary:
10. Are there other transportation-related public agencies in your region that use CM-at-Risk (CM/GC) project delivery?
   ☐ Yes ☐ Not that I know of
11. If yes, what type of agency?
   ☐ Transit agency
   ☐ Airport authority/operator
   ☐ Sea/lake port authority/operator
   ☐ Railroad company
   ☐ Other, please specify:
12. If you have used CM-at-Risk (CM/GC) project delivery, would you be willing to allow the consultants to contact you to do a structured interview and collect case study information?
   ☐ Yes ☐ No
   Please furnish contact information:
   Contact name:
   Phone number:
   E-mail address
13. Do you have anything else you would like to share regarding CM-at-Risk?

APPENDIX B

Case Study Project Questionnaire

Two types of structured interviews were conducted in conjunction with this research. The first was with the case study project agency personnel. The second was with the contractors that built the case study CMR projects. The questionnaires are provided in the following sections to this appendix.

CASE STUDY PROJECT AGENCY STRUCTURED INTERVIEW

NCHRP 40-02: Agency Structured Interview Questionnaire

CONDITIONS: This interview can either be conducted in person or via telephone. The following protocol shall be followed during its administration:

1. The questionnaire shall be sent to the respondent at least 2 weeks prior to the interview via e-mail.
2. Two days prior to the interview, a follow-up message with the questionnaire attached will be sent to confirm the date and time of the interview.
3. To maximize the quality and quantity of information collected, the primary respondent should be encouraged to invite other members of his/her organization to be present during the interview. Thus, a single transportation agency response can be formulated and recorded.
4. The interviewer will set the stage with a brief introduction that emphasizes the purpose of the research, the type of information expected to be collected, and the ground rules for the interview.
5. Once the interviewees indicate that they understand the process at hand, the interview will commence.
6. The interviewer will read each question verbatim and then ask if the interviewee understood the question before asking the interviewee to respond.
7. Each question contains a specific response that must be obtained before moving to the next question. Once that response is obtained, the interviewer can record as text additional cogent information that may have been discussed by the interviewees in working their way to the specific response.
8. Upon conclusion of the interview, the interviewer will ask the interviewees if they have additional information that they would like to contribute and record those answers as text.
9. The interviewer will assemble a clean copy of the final interview results and return them to the interviewee for verification.

STRUCTURED INTERVIEW

I. General Information:

1. City and state in which the respondent agency is headquartered:
    a. Name of agency:

2. What type of organization do you work for?

3. ☐ State DOT ☐ Other public transportation agency ☐ Other, please describe:

4. Annual construction budget:

5. Average annual number of projects:

6. Project monetary size range: $ to $

7. Average monetary size of a typical project: $

8. Percentage of out-sourced design effort versus in-house design: %

9. Does your agency use CM-at-Risk contracting to augment its existing workforce during program funding spikes?
   a. ☐ Yes ☐ No Please explain if necessary:

10. Do other public agencies in your state have authority to use CM-at-Risk?
    ☐ Yes ☐ No Please explain if necessary:

Agency CM-at-Risk Project Delivery Experience

Project Delivery Experience	CM-at-Risk
1 Has your agency awarded a project under one of these project delivery methods?	☐ *Yes* ☐ *No*
❑ A. If yes, how many projects?	A. ☐ 1–5 ☐ 6–10 ☐ >10
❑ B. If yes, what percentage of your total construction budget?	B. ☐ <10% ☐ 11–25% ☐ 26–50% ☐ >50%
❑ C. How long have you used these methods?	C. ☐ < 2 years ☐ 3–5 years ☐ > 5 years
2 Is your agency restricted on the use of these project delivery methods?	☐ *Yes* ☐ *No*
❑ A. If yes, what is the restriction? Explain "other"	A. ☐ Legislative ☐ Regulation ☐ Policy ☐ Other
❑ B. If yes, are you able to obtain a waiver for CM-at-Risk? Explain "other"	B. ☐ Yes ☐ No ☐ Other

General remarks about agency program that might affect use of CM-at-Risk:

II. Case Study Agency Project Delivery Method Decision-making Information:

1. Who ultimately makes the project delivery method selection decision:
   ☐ Agency design personnel ☐ Agency construction personnel
   ☐ Agency upper management
   ☐ Entity outside the agency's organization; Explain:

2. What project factors are considered when making the project delivery method decision?

Project Factor	Considered in decision	Drives use of CMR
Project monetary size	☐	☐
Project budget control issues	☐	☐
Project schedule issues	☐	☐
Project technical complexity	☐	☐
Project type (typical agency project vs. non-typical agency project)	☐	☐
Project type (bridge vs. road project)	☐	☐
Project technical content (i.e., ITS, seismic features, tolling equipment, etc.)	☐	☐
Project location (urban vs. rural)	☐	☐
Project environmental issues	☐	☐
Project third party interface issues (utilities, business access, railroads, etc.)	☐	☐
Project traffic control issues	☐	☐
Project quality assurance requirements	☐	☐
Project life cycle issues (maintenance/operations)	☐	☐
Project sustainability issues	☐	☐
Incentives for obtaining federal or state funding	☐	☐
Project generates revenue (tolls, special taxes, etc.)	☐	☐
Agency staff design review/construction inspection requirements	☐	☐
Agency staff experience with delivery method	☐	☐
Agency staff availability to oversee project development	☐	☐
Desire to include specific innovation	☐	☐
Other	☐	☐

3. Which of the following were reasons that your agency uses to select CMR delivery methods? Check all that apply. Which of the below is the single most significant reason for selecting CMR delivery method? (*Interviewer circle the check box.*)

Reasons	CM-at-Risk
Reduce/compress/accelerate project delivery period	☐
Establish project budget at an early stage of design development	☐
Constrained budget	☐
Get early construction contractor involvement	☐
Encourage innovation	☐
Facilitate Value Engineering	☐
Encourage constructability	☐
Encourage price competition (bidding process)	☐
Complete different design solutions through the proposal process	☐
Redistribute risk	☐
Complex project requirements	☐
Flexibility needs during construction phase	☐
Third party issues (permits, utilities, etc.)	☐
Reduce life cycle costs	☐
Provide mechanism for follow-on operations and/or maintenance	☐
Innovative financing	☐
Encourage sustainability	☐
Project is a revenue generator	☐
Reduced agency staffing requirements	☐
Reduced agency review/inspection requirements	☐
Other (explain below)	☐

4. Please explain the process that you use to choose of the project delivery method for a typical project.

5. Is a formal risk analysis conducted on a typical project in any of the following areas?
   ☐ Project scope
   ☐ Project schedule
   ☐ Project cost
   ☐ Contracting risk

6. Do your project cost estimates involve an analysis of uncertainty (i.e., was a range cost estimate developed)?
   ☐ Yes ☐ No

7. Do you employ any formalized risk allocation techniques to draft the contract provisions?
   ☐ Yes ☐ No If yes, please describe:

Interviewer: Collect sample copies of the provisions referred to in this question. Review them with the interviewee.

III. Case Study Agency CM-at-Risk (CMR) Procurement Process Information:

1. At what point in the project design development process is the project delivery method decision made?
   ☐ 0% ☐ 1%–30% ☐ 31%–50% ☐ 51%–80% ☐ >80% actual percent

2. What type of procurement process do you use to advertise a CMR project?
   ☐ Request for Qualifications (RFQ) only [no proposed fees] ☐ Request for Proposals (RFP) [includes some or all fees] only ☐ RFQ + RFP ☐ Request for letters of interest
   ☐ Other, please explain:

Interviewer: Collect sample copies of the documents referred to in this question. Review them with the interviewee.

3. Once CM-at-Risk project delivery has been selected, who does the design?
   ☐ In-house design personnel ☐ Consulting engineers ☐ Combination of both

4. Once CM-at-Risk project delivery has been selected, which entity is brought to the project first?
   ☐ the designer (including in-house design) ☐ the CMR

5. If the answer to 4 is "the designer," does the designer assist in the CMR selection process?
   ☐ Yes ☐ No ☐ Other, please explain:

6. If the answer to 5 is yes, which of the below tasks is the designer involved in?
   ☐ Evaluation of CMR qualifications ☐ Checking/validating CMR references
   ☐ CMR interviews/presentations ☐ Developing short list
   ☐ Voting member of CMR selection panel ☐ Evaluation of CMR fees
   ☐ Non-voting member of CMR selection panel ☐ Negotiation of CMR fees
   ☐ Other, please explain:

7. If the answer to 4 is "the CMR," does the CMR assist in the designer selection process?
   ☐ Yes ☐ No ☐ Other, please explain:

8. If the answer to 7 is yes, which of the below tasks is the CMR involved in?
   ☐ Evaluation of designer qualifications ☐ Checking/validating designer references
   ☐ Designer interviews/presentations ☐ Developing short list
   ☐ Voting member of designer selection panel ☐ Evaluation of design fees
   ☐ Non-voting member of designer selection panel ☐ Negotiation of design fees
   ☐ Other, please explain:

9. In your CMR selection process, do you develop a shortlist?
   ☐ Yes ☐ No

10. If the answer to 9 is yes, how many CMRs are on your typical shortlist?
    ☐ 1 ☐ 2 ☐ 3 ☐ >3

11. If the answer to 9 is no, why don't you develop a shortlist?
    ☐ Legislation prohibits shortlist ☐ Agency policy prohibits shortlist ☐ Avoid possible protest

    ☐ Other, please explain:

12. Which of the following pieces of information are required to be submitted in response to a typical RFQ/RFP/advertisement?

Question 12 Matrix

Do either the RFQ or the RFP require the following to be submitted as part of the CMR's statement of qualifications or proposal?	Required submittal?		If YES: Is it evaluated to make the CMR award decision?		If NO: Is it a required submittal after contract award?	
	Yes	No	Yes	No	Yes	No
Organizational structure/chart	☐	☐	☐	☐	☐	☐
Past CMR project experience	☐	☐	☐	☐	☐	☐
Past related project experience (non-CMR)	☐	☐	☐	☐	☐	☐
References from past projects	☐	☐	☐	☐	☐	☐
Qualifications of the CMR's Project Manager	☐	☐	☐	☐	☐	☐
Qualifications of the CMR's preconstruction services manager	☐	☐	☐	☐	☐	☐
Qualifications of the CMR's general superintendent	☐	☐	☐	☐	☐	☐
Qualifications of the CMR's estimator/scheduler	☐	☐	☐	☐	☐	☐
Qualifications of the Construction Quality Manager	☐	☐	☐	☐	☐	☐
Qualifications of other key personnel (*list below*)	☐	☐	☐	☐	☐	☐
Construction quality management plan	☐	☐	☐	☐	☐	☐
Construction traffic control plan	☐	☐	☐	☐	☐	☐
Other key project plans (*list below)*	☐	☐	☐	☐	☐	☐
Preliminary project schedule	☐	☐	☐	☐	☐	☐
Declaration of self-performed work	☐	☐	☐	☐	☐	☐
Subcontracting plan	☐	☐	☐	☐	☐	☐
DBE plan	☐	☐	☐	☐	☐	☐
Proposed preconstruction services fee	☐	☐	☐	☐	☐	☐
Proposed post-construction services fee (profit)	☐	☐	☐	☐	☐	☐
Proposed general conditions fee	☐	☐	☐	☐	☐	☐
Rates for self-performed work	☐	☐	☐	☐	☐	☐
Critical analysis of project construction budget	☐	☐	☐	☐	☐	☐
List of proposed subcontractors	☐	☐	☐	☐	☐	☐
Do either your RFQ or your RFP contain the following?						
Description of scope of work	☐	☐	☐	☐	☐	☐
Preliminary plans/specifications	☐	☐	☐	☐	☐	☐
Construction testing matrix	☐	☐	☐	☐	☐	☐
Quality management roles and responsibilities	☐	☐	☐	☐	☐	☐
Design criteria checklists	☐	☐	☐	☐	☐	☐
Other critical material (*list below*)	☐	☐	☐	☐	☐	☐

13. Do you interview CMRs as part of the selection process?
    ☐ Yes, in person
    ☐ Yes, remotely (video teleconference or other means)
    ☐ No

14. If the answer to 13 is yes, what of the following are parts of your interview process? (Check all that apply.)
    - ☐ Formal presentation of corporate qualifications/past projects
    - ☐ Formal presentation of qualifications/past project experience for key CMR personnel
    - ☐ Formal presentation of project-specific issues (right-of-way availability, schedule compression, bid packaging, etc.)
    - ☐ Formal presentation of preconstruction services components (constructability process, estimating process, scheduling process, etc.)
    - ☐ Review and discussion of checklists/documents used by the CMR in preconstruction services components (constructability process, estimating process, scheduling process, etc.)
    - ☐ Informal review/discussion of any of the above. (*interviewer: circle the appropriate items above*)
    - ☐ Other, please explain:

15. When selecting a CMR, what method do you use to identify the winner?
    - ☐ Direct point scoring in <u>unweighted</u> categories published in the RFQ/RFP/advertisement
    - ☐ Direct point scoring in <u>weighted</u> categories published in the RFQ/RFP/advertisement
    - ☐ Adjectival rating in <u>unweighted</u> categories published in the RFQ/RFP/advertisement
    - ☐ Adjectival rating in <u>weighted</u> categories published in the RFQ/RFP/advertisement
    - ☐ Cost-technical trade-off (proposed fees compared to qualifications/other factors and best value selected)
    - ☐ Comparative evaluation (i.e., "CMR A is more experienced than CMRs B and C" etc. for each category)
    - ☐ Unscored selection panel consensus (i.e., panel discusses evaluation results and makes selection on consensus view)
    - ☐ Unscored selection panel vote (i.e., each panel member selects his/her choice and CMR with most votes wins)
    - ☐ Other, please explain:

16. Is price used as a selection criterion in your CMR award method?
    ☐ Yes ☐ No

17. If price is used as a selection criteria, what weight is assigned to construction related-price factors compared to all other factors?
    ☐ 0–25% ☐ 26–50% ☐ >50% Actual percentage:

18. If price is a selection factor, how are the construction-related price factors incorporated in the GMP? Please explain:

19. Have you ever had a protest of your CMR selection process? ☐ Yes ☐ No

20. If the answer to 19 is yes, what was the basis of the protest and how was it resolved? Basis of protest: (*interviewer: collect details of protests including any documents that may be available*)
    ☐ Protest was sustained (in favor of the protestor) ☐ Protest was denied (in favor of the agency)

21. What type of contract do you use for the CMR contract?
    - ☐ Lump sum GMP ☐ Lump sum, fixed price (no GMP) ☐ Unit price GMP
    - ☐ Unit price (no GMP) ☐ Cost plus fee with G-Max
    - ☐ Preconstruction services only with hard bid construction packages
    - ☐ Other, please explain:

22. If you out-source the design, do you modify the design contract to include CMR-specific clauses?
    ☐ Yes ☐ No

23. If the answer to 22 is yes, what types of CMR-specific clauses are included? (Check all that apply.)
    - ☐ Design packages to be reviewed by CMR
    - ☐ Design milestones to facilitate preconstruction services package
    - ☐ Requirements to incorporate/respond to CMR review comments
    - ☐ Budget review points
    - ☐ Requirement to notify CMR of significant design changes
    - ☐ Value engineering with CMR
    - ☐ Coordination of design packages with construction bid packages
    - ☐ Material availability/selection decisions
    - ☐ Construction means and methods decisions ☐ Coordination with 3rd party
    - ☐ Other, please explain:

24. At what point in the process is the GMP negotiated/established?
☐ Before 100% final design ☐ After 100% final design
☐ As early as possible, given the risk analysis (agency's call)
☐ As early as possible, given the risk analysis (CMR's call)
☐ After subcontractor bid packages are awarded by CMR
☐ Other:

25. Do you use a progressive GMP?
☐ Yes ☐ No

26. Does your GMP include transparent contingencies?
☐ Yes ☐ No

27. If the answer to 26 is yes, which types are included?
☐ Single project contingency ☐ Separate owners and CMR's contingencies
☐ Management reserve in addition to contingencies

28. Does your contract contain a shared savings below the GMP incentive?
☐ Yes ☐ No

29. If the answer to 28 is yes, does the incentive include all contingency funds?
☐ Yes ☐ No Explain if necessary:

30. What process do you use to award the construction if the you and the CMR are unable to agree on the GMP?
☐ Convert to DBB and bid publicly ☐ Other, please explain:

31. If you convert to DBB, is the CMR allowed to bid for the construction contract?
☐ Yes ☐ No

32. Do you allow the CMR to prequalify subcontractors?
☐ Yes, CMR is free to pick and choose its own subs
☐ No, CMR is required to accept bids from all subs and award to lowest bidder
☐ Other, please explain:

33. Do you allow the CMR to self-perform any of the construction? ☐ Yes ☐ No

34. If the answer to 33 is no, why not?
☐ Legislation prohibits self-performance
☐ Agency policy prohibits self-performance
☐ Avoid possible protest due to potential conflict of interest ☐ Other:

35. If the answer to 33 is yes, how do you determine what work the CMR may self-perform?
☐ CMR declares bid packages it wants to self-perform & there are no further constraints
☐ CMR declares bid packages it wants to self-perform & must bid against industry to win them
☐ Other, please explain:

36. If the answer to 33 is yes, are limits (%) on the amount of work the CMR may self-perform?
☐ Yes limit is: % ☐ No

37. What preconstruction services are included in your CMR contracts? (Check all that apply.)
☐ Validate agency/consultant estimates ☐ Validate agency/consultant schedules
☐ Validate agency/consultant design ☐ Prepare project estimates
☐ Prepare project schedules ☐ Assist/input to agency/consultant design
☐ Constructability review ☐ Cost engineering reviews
☐ Market surveys ☐ Value analysis
☐ Assist in right-of-way acquisition ☐ Coordinate with 3rd party stakeholders
☐ Other, please explain: ☐ Assist in permitting actions

38. How do you establish the fee for preconstruction services?
    - ☐ Agency has fixed rate
    - ☐ CMR proposes fee as part of selection process (winner's fee is accepted as best value)
    - ☐ CMR proposes fee as part of selection process and final fee is negotiated after contract award
    - ☐ Fee is negotiated with winner after contract award (no proposed fee prior to award)
    - ☐ Other, please explain:

39. How do you establish the CMR's fee for post-construction services (i.e., profit on construction project)?
    - ☐ Agency has fixed rate
    - ☐ CMR proposes fee as part of selection process (winner's fee is accepted as best value)
    - ☐ CMR proposes fee as part of selection process and final fee is negotiated after contact award
    - ☐ Fee is negotiated with winner after contract award (no proposed fee prior to award)

40. Does your agency have a specific training or certification program for Project Managers engaging in CMR projects?
    ☐ Yes ☐ No

41. Does your agency encourage or require a formal partnering process on CMR projects
    ☐ Yes ☐ No

IV. Case Study Quality Assurance Program for CM-at-Risk Projects:

1. Do you use a different QA program for CMR projects than you do for DBB projects?
   ☐ Yes ☐ No If yes, what is the major difference?
2. Have you used CM-at-Risk to reduce the size of your construction inspection staff?
   a. ☐ Yes ☐ No Please explain if necessary:

3. Have you used CM-at-Risk to reduce the size of your design review staff on out-sourced design?
   a. ☐ Yes ☐ No Please explain if necessary:

4. Who performs the following construction quality management tasks in your CMR projects?

Check all that apply	**Does not apply**	**Agency personnel**	**Designer's staff**	**CMR's constr. Staff**	**Agency-hired consultant**
Technical review of construction shop drawings	☐	☐	☐	☐	☐
Technical review of construction material submittals	☐	☐	☐	☐	☐
Checking of pay quantities	☐	☐	☐	☐	☐
Routine construction inspection	☐	☐	☐	☐	☐
Quality control testing	☐	☐	☐	☐	☐
Establishment of horizontal and vertical control on site	☐	☐	☐	☐	☐
Verification testing	☐	☐	☐	☐	☐
Acceptance testing	☐	☐	☐	☐	☐
Independent assurance testing/inspection	☐	☐	☐	☐	☐
Approval of progress payments for construction progress	☐	☐	☐	☐	☐
Approval of construction post-award QM/QA/QC plans	☐	☐	☐	☐	☐
Report of nonconforming work or punchlist	☐	☐	☐	☐	☐

5. How do you rate the final quality of work on CMR projects compared to DBB projects?
   ☐ Better ☐ Same ☐ Worse ☐ No opinion

6. If the answer to 5 is either Better or Worse, explain primary reason for difference:

7. Do you formally evaluate the CMR's performance quality and use that for future CMR selections?
☐ Yes ☐ No

8. If the answer to 7 is yes, do you believe that the performance rating creates an incentive to achieve quality?
☐ Yes ☐ No, Why?

9. Please rate the following factors for their impact on the quality of the CMR project.

Factor	Very High Impact	High Impact	Some Impact	Slight Impact	No Impact
Qualifications of the CMR's staff	☐	☐	☐	☐	☐
CMR's past project experience	☐	☐	☐	☐	☐
Quality management plans	☐	☐	☐	☐	☐
Level of agency involvement in the QA process	☐	☐	☐	☐	☐
Use of agency specifications and/or design details	☐	☐	☐	☐	☐
Level of detail expressed in the procurement documents	☐	☐	☐	☐	☐
Use of performance criteria/specifications	☐	☐	☐	☐	☐
Early contractor involvement in design	☐	☐	☐	☐	☐
GMP contract	☐	☐	☐	☐	☐
Preconstruction services	☐	☐	☐	☐	☐
Warranty provisions	☐	☐	☐	☐	☐

V. Achieving Value through Project Delivery Method Selection:
This section's purpose is to collect expert opinions on each project delivery system's ability to add value to the agency operator's capital project delivery process. If there is more than one person in the interview, the interviewer should require the group to achieve a consensus opinion for the impact of each project delivery system on the agency's final constructed product.

1. In your opinion how does CMR project delivery method impact the quality of the following project aspects for typical projects at your agency?

For each method, assign one of the following ratings based on the agency consensus: Worst = 1; Worse = 2; Neutral = 3; Better = 4; Best = 5	
Project aspects	**CM-at-Risk**
Completeness of final design deliverables	
Accuracy of design calculations	
Accuracy of quantities	
Acceptance of design deliverables	
Accuracy of specifications	
Accuracy of as-built documents	
Accuracy/applicability of O&M manuals, etc.	
Implementation of approved QA/QC plans	
Accuracy of preconstruction cost estimates	
Ability to achieve post-award budgets	
Cost growth during design (scope creep, claims, etc.)	
Accuracy of preconstruction schedules	
Ability to achieve post-award schedules	
Material quality	
Workmanship quality	
Aesthetics	
Sustainability	
Maintainability	
Operability	
Security during construction	
Impact on property owners during construction	
Traffic flow during construction	
Interest to potential bidding community	

2. In your opinion how does CMR project delivery method impact the value of the following preconstruction services for typical projects at your agency?

For each method, assign one of the following ratings based on the agency consensus: Not valuable = 1; Some value = 2; Valuable = 3; Very valuable = 4; Of highest value = 5	
Preconstruction service	**CM-at-Risk**
Conceptual estimating	
Value analysis/value engineering	
Design charrettes	
Design reviews	
Regulatory reviews	
Security impact studies	
Environmental studies	
Early contractor involvement	
Scope definition/clarification	
Cost engineering reviews	
Budget validation	
Constructability reviews	
Biddability reviews	
Operability reviews	
Life cycle cost analysis	
Subcontractor bid packaging	
Schedule validation	
Coordination with 3rd party stakeholders	
Early awards for critical bid packages (i.e., asphalt materials, steel, etc.)	
Size of plan set	
Other	

3. Is there anything else about the CMR process that you would like to share?

CASE STUDY PROJECT CONTRACTOR STRUCTURED INTERVIEW

Contractor Structured Interview Form

Name:____

Location:____

Annual Volume:____

Specialization, if any:____

Construction Manager-at-Risk Experience Information:

6. How many CMR projects has your company completed?
   ☐ 1–5 ☐ 6–10 ☐ 11–20 ☐ >20

7. What percentage of your workload are CMR projects in dollar terms?
   ☐ 1–5% ☐ 6–25% ☐ 26–50% ☐ >50%

8. Do the owners your organization works for require some form of contractor prequalification to be able compete for a CMR project?
   ☐ Yes ☐ No If you answered "No" skip to question 10

9. Please check those prequalification factors that are used in a typical contractor prequalification program in the matrix below. Check all that apply

Prequalification Factor		**Prequalification Factor**	
Financial capability	☐	Past illegal behavior	☐
Calculated capacity factor from financials	☐	Performance evaluations	☐
Bonding capacity	☐	Claims history	☐
Surety statements	☐	Past project experience	☐
Detailed financial analysis	☐	Timely completion of past projects	☐
Bank statements	☐	Quality of material and workmanship	☐
Insurances	☐	Workman's compensation modifier	☐
Managerial ability	☐	Quality assurance plans	☐
Resumes for key personnel	☐	Safety plans	☐
Professional licensing for key personnel	☐	Environmental plans	☐
Key personnel past project experience	☐	Traffic control plans	☐
Equipment and plant	☐	Level of subcontracting	☐
Technical ability	☐	Use of DBEs	☐
Calculated ability factor from financials	☐	Other	☐

Please use this space to elaborate on any of the above responses:

10. Please list those aspects of CM-at-Risk contractor prequalification programs that you are familiar with that you think are particularly effective.

Contractor CM-at-Risk Project Execution Information:

Project Title: ____

General Composition: ☐ Road construction ☐ Road rehabilitation
☐ Bridge construction ☐ Bridge rehabilitation
☐ Other:____

Contract GMP Value: $____

Contract Duration: ____

Preconstruction services fee: $ or % ______________________________

1. What type of solicitation documents were used to advertise the CMR project?
   ☐ Request for Qualifications (RFQ) only [no proposed fees]
   ☐ Request for Proposals (RFP) [includes some or all fees] only
   ☐ RFQ + RFP ☐ Request for letters of interest ☐ Other, please explain:

2. At what point in the project design development process was the CM-at-Risk selected?
   ☐ 0% ☐ 1%–30% ☐ 31%–50% ☐ 51%–80% ☐ >80%

3. At what point in the process is the GMP negotiated/established?
   ☐ Before 100% final design ☐ After 100% final design
   ☐ As early as possible, given the risk analysis (agency's call)
   ☐ As early as possible, given the risk analysis (CMR's call)
   ☐ After subcontractor bid packages are awarded by CMR
   ☐ Other, please explain:

4. Did the GMP include transparent contingencies?
   ☐ Yes ☐ No

5. If the answer to the previous question is yes, which types were included?
   ☐ Single project contingency ☐ Separate owners and CMR's contingencies
   ☐ Management reserve in addition to contingencies

6. Did the contract contain a shared savings below the GMP incentive?
   ☐ Yes ☐ No

7. If the answer to the previous question is yes, does the incentive include all contingency funds?
   ☐ Yes ☐ No Explain if necessary:

8. Were you allowed to prequalify subcontractors?
   ☐ Yes, CMR is free to pick and choose its own subs
   ☐ No, CMR is required to accept bids from all subs and award to lowest bidder
   ☐ Other, please explain:

9. Were you allowed to self-perform any of the construction?
   ☐ Yes ☐ No

10. If the answer to the previous question is no, why not?
    ☐ Legislation prohibits self-performance
    ☐ Agency policy prohibits self-performance
    ☐ Avoid possible protest due to potential conflict of interest
    ☐ Other, please explain:

11. If the answer to 9 is yes, how did the agency determine what work the CMR may self-perform?
    ☐ CMR declares bid packages it wants to self-perform & there are no further constraints
    ☐ CMR declares bid packages it wants to self-perform & must bid against industry to win them
    ☐ Other, please explain:

12. If the answer to 9 is yes, were limits (%) on the amount of work the CMR may self-perform?
    ☐ Yes limit is: _________% ☐ No

13. What preconstruction services are included in the CMR contract? (Check all that apply.)
    ☐ Validate agency/consultant estimates ☐ Validate agency/consultant schedules
    ☐ Validate agency/consultant design ☐ Prepare project estimates
    ☐ Prepare project schedules ☐ Assist/input to agency/consultant design
    ☐ Constructability review ☐ Cost engineering reviews
    ☐ Market surveys ☐ Value analysis
    ☐ Assist in right-of-way acquisition ☐ Coordinate with 3rd party stakeholders
    ☐ Other, please explain: ☐ Assist in permitting actions

14. How do you establish the fee for <u>preconstruction</u> services?
    ☐ Agency has fixed rate ☐ Estimated hours similar to a design fee estimate
    ☐ Historical cost data from previous CMR jobs
    ☐ Business decision based on what the agency would consider reasonable
    ☐ Other, please explain:

15. How do you establish your fee for <u>post-construction</u> services (i.e., profit on construction project)?
    ☐ Agency has fixed rate
    ☐ Historical cost data from previous CMR jobs
    ☐ Business decision based on what the agency would consider reasonable
    ☐ Other, please explain:

16. Did the agency encourage or require a formal partnering process on the project?
    ☐ Yes ☐ No

17. If the answer to the above is yes, do you believe that formal partnering adds value to the CMR process?
    ☐ Yes ☐ No

18. How do you rate the final quality of work on CMR projects compared to DBB projects?
    ☐ Better ☐ Same ☐ Worse ☐ No opinion

19. If the answer to 18 is either better or worse, explain primary reason for difference:

20. Does the agency formally evaluate your performance quality and use that for future CMR selections?
☐ Yes ☐ No

21. If the answer to 20 is yes, do you believe that the performance rating creates an incentive to achieve quality?
☐ Yes ☐ No, Why?

22. Please rate the following factors for their impact on the quality of the CMR project.

Factor	**Very High Impact**	**High Impact**	**Some Impact**	**Slight Impact**	**No Impact**
Qualifications of the CMR's staff	☐	☐	☐	☐	☐
CMR's past project experience	☐	☐	☐	☐	☐
Quality management plans	☐	☐	☐	☐	☐
Level of agency involvement in the QA process	☐	☐	☐	☐	☐
Use of agency specifications and/or design details	☐	☐	☐	☐	☐
Level of detail expressed in the procurement documents	☐	☐	☐	☐	☐
Use of performance criteria/specifications	☐	☐	☐	☐	☐
Early contractor involvement in design	☐	☐	☐	☐	☐
GMP contract	☐	☐	☐	☐	☐
Preconstruction services	☐	☐	☐	☐	☐
Warranty provisions	☐	☐	☐	☐	☐

Legal and Political Barriers to Implementing Construction Manager-at-Risk

1. Is the construction industry in the areas where you operate opposed to CM-at-Risk project delivery?
☐ Yes ☐ No ☐ Don't know
If yes, please explain:

2. What is the single largest barrier to implementing CM-at-Risk project delivery in the areas where your organization works that don't already use it?

☐ State/local laws	☐ Public opposition
☐ Organizational procurement regulations	☐ Political opposition
☐ Internal organizational policies	☐ Don't know
☐ Industry opposition	☐ Other; please specify:

3. In your opinion, how does the construction industry in your area of operations view CM-at-Risk project delivery?
☐ They support it ☐ They are neutral to it ☐ They oppose it ☐ No opinion

4. In your opinion, how do the subcontractors in the construction industry in your area of operations view CM-at-Risk project delivery?
☐ They support it ☐ They are neutral to it ☐ They oppose it ☐ No opinion

5. Do the CMR projects on which your organization does work utilize contractor quality assurance acceptance testing on any of its projects?
☐ Yes ☐ No

6. If the answer to the previous question is yes, do they use a performance-based prequalification process in conjunction with the contractor acceptance testing program?
☐ Yes ☐ No

7. **Based your experience with CMR**, in your opinion what impact does CMR project delivery have on the following project aspects?

Project Aspect	Better	No Change	Worse	No Opinion
Number of bidders	☐	☐	☐	☐
Material quality	☐	☐	☐	☐
Workmanship quality	☐	☐	☐	☐
Safety	☐	☐	☐	☐
Maintenance of traffic	☐	☐	☐	☐
Level/amount of agency inspection required	☐	☐	☐	☐
Timely project completion	☐	☐	☐	☐
Timely construction submittal completion	☐	☐	☐	☐
Timely punchlist completion	☐	☐	☐	☐
Personnel experience	☐	☐	☐	☐
Personnel competence	☐	☐	☐	☐
Number of contractor initiated change order requests	☐	☐	☐	☐
Number of claims/disputes	☐	☐	☐	☐
Responsiveness on warranty call-backs	☐	☐	☐	☐
Achievement of DBE goals	☐	☐	☐	☐
Environmental compliance	☐	☐	☐	☐
Contractor cooperation with agency	☐	☐	☐	☐
Contractor cooperation with property owners	☐	☐	☐	☐
Contractor cooperation with third party stakeholders	☐	☐	☐	☐
Contractor cooperation with public concerns	☐	☐	☐	☐
Other	☐	☐	☐	☐
Other	☐	☐	☐	☐
Other	☐	☐	☐	☐

Final Comments:

APPENDIX C

Case Study Projects

CASE STUDY PROJECT DETAILS

The following sections relate the details of each case study project. The objective of this section is to portray the breadth and depth of the case study project population in a manner that gives the reader the background to understand how each project's features contributed to the analysis reported in subsequent chapters.

The format has been standardized for each project to permit the comparison of each project with all other projects in the sample. The following sections are included:

- Location—location of the project
- Value—cost of the project
- Scope—brief description of the project scope
- Rationale—explanation of why the owner decided to use Construction Manager-at-Risk (CMR) for this project
- Procurement—narrative regarding the procurement process for CMR selection
- Project administration—account of the contract type, establishment of the guaranteed maximum price (GMP), and self-performance of work by the CMR
- Preconstruction services—listing of the preconstruction services included as part of the contract by the CMR to the owner
- Quality management—discussion of the quality control (QC) and quality assurance (QA) responsibilities for the project
- Summary—any unique information not covered in the previous sections.

Very little analysis of the information is contained in this chapter, as each succeeding chapter will synthesize the information found in the case study projects on a topic-by-topic basis for the sample as a whole. In all cases, the details shown in this chapter were obtained through structured interviews (either in-person or telephonically) with the agency and the project's at-risk construction manager and then supplemented as required by specifics found about the project from the literature.

Case 1—Alaska DOT&PF—Fairbanks International Airport

Location: Fairbanks, Alaska
Value: $99 Million
Scope: New construction of an 80,000-square-foot addition to the existing terminal in Fairbanks, Alaska, and included reconfiguration of roadways, parking, and the airside terminal area. It also involved renovating 65,000 square feet of existing terminal, which included demolition of the structure, reconfiguring the mechanical and electrical systems, and adding seismic upgrades to the building. Additionally, the project entailed the demolition of those portions of the terminal built before 1985 and the construction of an employee parking lot.

Rationale: The Alaska DOT&PF decided to use CMR project delivery on this project and another airport expansion project because they were non-typical agency projects being primarily vertical construction. The decision was made before 30% design development, and it also considered budget control and the specialized technical content required in an airport project to be other factors for selecting CMR. The major reasons for making the decision were to reduce the project delivery period, get early contractor involvement in the design process, and ensure flexibility during construction for the airport's operational constraints. Less important reasons for selecting CMR were cited as follows:

- Establish project budget at an early stage of design development
- Gain better control over a constrained budget
- Encourage constructability in Alaska's challenging environment
- Redistribute risk
- Gain assistance in dealing with complex project requirements
- Shift the responsibility for dealing with third-party issues, primarily the airlines, to the contractor.

Procurement: The project was designed by a consultant who was selected before the CMR and assisted the agency with the CMR selection process by evaluating CMR qualifications and references. The CMR was selected from a Request for Qualifications (RFQ) asking for qualifications only. It planned to evaluate all responses (i.e., no short listing). However, they only got responses from three firms. The solicitation documents were short and contained only a description of the scope of work. Competing CMRs were required to submit the following information:

- Organizational structure/chart
- Past CMR project experience
- Past related project experience (non-CMR)
- Qualifications of the Construction Quality Manager.

The agency interviewed each candidate in person. The interview consisted of the formal presentation of qualifications, past projects, and key personnel. The winner was determined by the output from the selection panel's direct point scoring in weighted categories published in the RFQ advertisement. Price was not considered in the selection. Additionally, there were no protests of the decision.

Project Administration: This project used a lump sum GMP contract. The GMP was established before 100% design completion. The GMP contained a single transparent project contingency and a management reserve that was controlled by the management above the project level. There was no shared savings incentive. The consultant design contract was modified to include CMR specific clauses on design review by CMR, design milestones coordinated with preconstruction services, coordination of design and subcontractor bid packages, selection of materials in concert with the CMR, and joint coordination with third parties (in this case primarily the airlines). The CMR was not allowed to self-perform any work, but there are no restrictions on the CMR regarding subcontractor selection.

Preconstruction Services: The following preconstruction services were provided:

- Validate agency/consultant estimates, schedules, and design approach
- Prepare project estimates and schedules
- Assist/input to agency/consultant design
- Constructability reviews
- Value analysis
- Coordinate with third-party stakeholders.

The preconstruction services fee was negotiated after award. The CMR's post-award construction fee was also negotiated after award. No specific training of the CMR's personnel was required and no formal partnering was conducted.

Quality Management: Table C1 shows the distribution of quality management responsibilities among parties to the contract. Alaska DOT&PF hired a consultant to assist it on this project and that consultant essentially represented the DOT across the QA/QC spectrum. The DOT was satisfied with the consultant and believed that the CMR produced better quality than the DBB because the CMR wanted to be rated in a favorable light as this acts as an incentive for future work.

Summary: The interviewee indicated that the project accrued benefits in both cost and time savings as a result of the CMR's involvement in the design process. Alaska DOT&PF is also delivering a similar project at the Anchorage airport through CMR and, based on the outcomes of these two projects, has interest in applying this project delivery method on its traditional road and bridge projects.

Case 2—City of Glendale, Arizona, Downtown Pedestrian Improvements

Location: Glendale, Arizona
Value: $16.2 million
Scope: The project involved rebuilding the primary downtown road network to accommodate increased pedestrian traffic. It included upgraded lighting, landscaping, sidewalk, curb and gutter, utility relocations, and pavement rehabilitation/replacement. Traffic control was a major portion of the project, as well as coordination with impacted property owners and utility companies.

Rationale: The city of Glendale Public Works Department has extensive CMR experience, having completed a variety of vertical and horizontal CMR projects. It makes the project delivery method selection decision before starting design. On this project, the major reason for selecting CMR was to have a single entity to deal with the myriad of third-party entities that ranged from utilities to business owners. The project, although seemingly simple, was quite complex and had a tight budget and schedule as well as significant traffic control issues that drove the city to use CMR and get the contractor involved in the design process as early as possible. Additionally, the city believed that CMR would also reduce the workload on their in-house engineers, technicians, and inspectors. Less important reasons for selecting CMR were cited as follows:

- Establish project budget at an early stage of design development
- Encourage innovative solutions to conflicting requirements

TABLE C1
FAIRBANKS INTERNATIONAL AIRPORT CMR PROJECT QUALITY MANAGEMENT RESPONSIBILITIES

Quality Assurance/Quality Control Tasks	Does Not Apply	Agency	Designer	CMR	Agency-Hired Consultant
Technical review of construction shop drawings					X
Technical review of construction material submittals					X
Checking of pay quantities					X
Routine construction inspection					X
Quality control testing					X
Establishment of horizontal and vertical control on site					X
Verification testing					X
Acceptance testing					X
Independent assurance testing/inspection					X
Approval of progress payments for construction progress					X
Approval of construction post-award QM/QA/QC plans					X
Report of nonconforming work or punchlist					X

- Encourage constructability, facilitate value engineering, and reduce life-cycle costs
- Redistribute risk
- Gain assistance in dealing with complex project requirements.

Procurement: A consultant furnished all design services and was selected before CMR. It assisted the city with the CMR selection process by evaluating qualifications as a non-voting member of panel. The CMR is selected as early in the process as possible, immediately after selection of the consultant. The CMR was selected from an RFQ asking for qualifications only. The city put all qualified firms on the short list and had more than three firms. The solicitation documents were short and contained only a description of the scope of work. Competing CMRs were required to submit the following information:

- Organizational structure/chart
- Past CMR project experience
- Past related project experience (non-CMR)
- References from past projects
- Qualifications of the CMR's project manager
- Construction quality management plan.

The agency interviewed each candidate in person. The interview consisted of the formal presentation of qualifications, past projects, and key personnel. The winner was determined by the output from the selection panel's direct point scoring in weighted categories published in the RFQ advertisement. Price was not considered in the selection. Additionally, there were no protests of the decision.

Project Administration: This project used a progressive lump sum GMP contract. The final GMP was established before 100% design completion. However, each work package GMP is established after sub bids are determined. The GMP contained transparent project contingencies for both the owner and CMR. There was no shared savings incentive. The consultant design contract was modified to include CMR specific clauses on design review by CMR, budget review points in the design schedule, coordination of design and subcontractor bid packages, selection of means and methods in concert with the CMR, and joint coordination with third parties. The CMR is allowed to self-perform up to 50% of the work; however, there are no restrictions on the CMR regarding subcontractor selection.

Preconstruction Services: The following preconstruction services were provided:

- Validate agency/consultant estimates, schedules, and design approach
- Prepare project estimates and schedules
- Assist/input to agency/consultant design
- Constructability reviews
- Cost engineering reviews
- Value analysis
- Coordinate with third-party stakeholders.

The preconstruction services fee was negotiated after award. The CMR's post-award construction fee was also negotiated after award. No specific training of the CMR's personnel was required and no formal partnering was conducted.

Quality Management: Table C2 shows the distribution of quality management responsibilities among parties to the contract. The agency believed that CMR produces better quality than DBB owing to the close collaboration between the designer and the builder on a CMR project.

Summary: The contractor interviewed on this project agreed with the city in its assessment of enhanced quality, but its reason was that the parties in this project kicked the project off by holding a "scope definition and clarification" meeting where they essentially negotiated the final technical scope of work before launching into the design and assigned each risk to the party that could best manage it. This resulted in the CMR taking on identifying the underground conditions at a very early stage in design, as well as producing a construction sequencing plan that was synchronized with the design schedule. The two allowed the CMR to start digging as soon as possible and therefore it could identify those conflicts that were previously unknown as early as possible.

TABLE C2
GLENDALE CMR PROJECT QUALITY MANAGEMENT RESPONSIBILITIES

Quality Assurance/Quality Control Tasks	Does Not Apply	Agency	Designer	CMR	Agency-Hired Consultant
Technical review of construction shop drawings			X		
Technical review of construction material submittals			X		
Checking of pay quantities			X		
Routine construction inspection			X		
Quality control testing			X	X	
Establishment of horizontal and vertical control on site			X		
Verification testing			X		
Acceptance testing			X		
Independent assurance testing/inspection			X		
Approval of progress payments for construction progress		X			
Approval of construction post-award QM/QA/QC plans		X			
Report of nonconforming work or punchlist		X			

Case 3—Florida DOT Miami Intermodal Center

Location: Miami, Florida
Value: $1.7 billion
Scope of Work: This huge project entails road, bridge, and interchange construction to upgrade access to Miami International Airport in Miami, Florida; rail component, including heavy rail transportation modes both at-grade and elevated; public concourses connecting all transport modes both at-grade and elevated; bus facilities; and airport landside improvements, including arrivals and departures roadways. It also involves constructing the new Miami Intermodal Center (MIC) and Miami International Airport APM Station (MIC-MIA Connector), parking, joint development space involving private sector partners on the MIC site, and a rental car facility.

Rationale: The Florida DOT (FDOT) has a respectable amount of CMR experience having completed more than 10 projects using the method. However, most are primarily vertical in nature. It makes the project delivery method selection decision before starting design. On this project, the major reason for selecting CMR was the technical nature of the project. The vertical component was substantial and the horizontal portion included light rail transit features, making it a non-typical FDOT project and leading the agency to view the CMR as an additional point of technical expertise. Additionally, complex coordination requirements and the desire to get early contractor involvement contributed to the decision to select CMR project delivery. Less important reasons for selecting CMR were cited as follows:

- Compress the project delivery period
- Establish project budget at an early stage of design development
- Encourage innovative solutions to conflicting requirements
- Encourage constructability, facilitate value engineering, and gain flexibility during the construction phase
- Redistribute risk.

Procurement: A consultant furnished all design services and was selected before CMR. It did not assist with the CMR selection process. The CMR is selected as early in the process as possible, immediately after the consultant. The CMR was selected from a request for letters of interest. FDOT then published a short list of three firms. The solicitation documents contained a description of the scope of work as well as preliminary plans and specifications. Competing CMRs were required to submit the following information:

- Past CMR project experience
- Past related project experience (non-CMR)
- Qualifications of the CMR's project manager.

The agency interviewed each candidate in person. The interview was based on a standing list of questions that are asked to all competitors on the short list. The winner was determined by the output from the selection panel's direct point scoring in unweighted categories published in the advertisement. Price was not considered in the selection. Additionally, there were no protests of the decision.

Project Administration: This project used a unit price GMP contract. The final GMP was established before 100% design completion and is completed as early as possible. The GMP contained transparent project contingencies for both the owner and CMR. The CMR gets to keep its unused contingency as an incentive savings. The consultant design contract was only modified to show that the design services are in conjunction with a CMR project. The CMR is allowed to self-perform up to 50% of work and must publicly accept bids to conduct subcontractor selection. The preconstruction services fee was negotiated after award. The CMR's post-award construction fee was also negotiated after award. No specific training of the CMR's personnel was required and no formal partnering was conducted.

Quality Management: Table C3 shows the distribution of quality management responsibilities among parties to the contract. The agency believed that CMR produces comparable quality to DBB.

Summary: FDOT is generally satisfied with the results of its CMR program and intends to continue to use the project

TABLE C3
MIAMI INTERMODAL CENTER CMR PROJECT QUALITY MANAGEMENT RESPONSIBILITIES

Quality Assurance/Quality Control Tasks	Does Not Apply	Agency	Designer	CMR	Agency-Hired Consultant
Technical review of construction shop drawings		X	X		
Technical review of construction material submittals					X
Checking of pay quantities					X
Routine construction inspection			X		
Quality control testing				X	
Establishment of horizontal and vertical control on site					X
Verification testing					X
Acceptance testing					X
Independent assurance testing/inspection					X
Approval of progress payments for construction progress					X
Approval of construction post-award QM/QA/QC plans					X
Report of nonconforming work or punchlist					X

delivery method for those projects where it makes sense. It is also expanding it into its more typical road and bridge projects on a case-by-case basis.

Case 6—Oregon DOT I-5 Willamette River Bridge

Location: Eugene, Oregon
Value: $150 million
Scope: Remove existing decommissioned Willamette River Bridge; construct new 1,800-foot-long bridge in place of the decommissioned Willamette River Bridge structure. Replacement of the decommissioned Canoe Canal bridge; reconstructing approximately 2,500 feet of roadway approaching and between the bridges; construct modifications of the Franklin Boulevard northbound off-ramp and southbound on-ramp to adjust to I-5 alignment modifications.

Rationale: This is the Oregon DOT's (ODOT) first CMR project. The decision to use CMR was made before 30% design completion. The overarching reason for selecting CMR was to gain experience with the project delivery method before using it on a much larger and more complex bridge over the Columbia River. Project-specific reasons for selecting CMR for the Willamette River Bridge were project budget and schedule control issues, as well as a desire to redistribute the risk from that normally found in a design-build project. Less important reasons for selecting CMR were cited as follows:

- Compress the project delivery period
- Establish project budget at an early stage of design development
- Gain better control over a constrained budget
- Get early construction contractor involvement
- Encourage constructability and facilitate value engineering
- Assign the responsibility for coordinating third-party issues to the contractor.

Procurement: A consultant furnished all design services and was selected before CMR. It did not assist with the CMR selection process. In the future they will appoint as a non-voting member of panel. The CMR is selected as early in the process as possible after the consultant. The CMR was selected from a Request for Proposal (RFP), which contained four to five unit prices for major pay items. The Oregon DOT planned to short list three firms, but received only two proposals. The solicitation documents contained a description of the scope of work, quality management roles and responsibilities, and design criteria checklists. Competing CMRs were required to submit the following information:

- Past CMR project experience
- Past related project experience (non-CMR)
- Qualifications of the CMR's project manager, construction manager, and project principal
- Construction quality management plan and public relations plan
- Preliminary project schedule
- Proposed preconstruction services fee, post-construction services fee (profit), and general conditions fee.

The agency interviewed each candidate in person. The interview was based on a pre-published list of questions that are asked to all competitors on the shortlist. Formal presentation of project-specific issues and details of preconstruction services took place. The winner was determined by the output from the selection panel's direct point scoring in weighted categories published in the advertisement. Price carried a 15% weight in the selection. There was a protest on this project for ODOT's alleged failure to pursue clarifications requested during proposal preparation that affected the final scoring. The protest was denied.

Project Administration: This project used a lump sum GMP contract. The final GMP was established before 100% design completion. The GMP contained a single transparent project contingency and the CMR was allowed to keep any remaining contingency as a shared savings incentive. The consultant design contract was modified to include CMR specific clauses on joint value engineering with the CMR, coordination of design and subcontractor bid packages, selection of means and methods in concert with the CMR, and joint coordination with third parties. The CMR is allowed to self-perform up to 30% of the work, but there are no restrictions on the CMR regarding subcontractor selection.

Preconstruction Services: The following preconstruction services were provided:

- Validate agency/consultant estimates, schedules, and design approach
- Prepare project estimates and schedules
- Assist/input to agency/consultant design
- Constructability reviews
- Cost engineering reviews
- Value analysis
- Coordinate with third-party stakeholders.

The preconstruction services fee was presented in the proposal. ODOT fixed the post-construction fee and general conditions at 13.5% of the GMP. There was no negotiation of these items after award. Context-sensitive design training for the CMR's personnel was required and formal partnering was conducted.

Quality Management: Table C4 shows the distribution of quality management responsibilities among parties to the contract. The agency had no means of forming an opinion about the comparative quality with DBB as the project was in design when the interview was conducted.

Summary: The contractor interviewed on this project had no objections to the agency fixing the profit and general conditions fee in the RFP. He stated that this took that element out of the

TABLE C4
WILLAMETTE RIVER BRIDGE CMR PROJECT QUALITY MANAGEMENT RESPONSIBILITIES

Quality Assurance/Quality Control Tasks	Does Not Apply	Agency	Designer	CMR	Agency-Hired Consultant
Technical review of construction shop drawings					X
Technical review of construction material submittals					X
Checking of pay quantities		X			
Routine construction inspection		X			
Quality control testing				X	
Establishment of horizontal and vertical control on site					X
Verification testing		X			
Acceptance testing		X			
Independent assurance testing/inspection		X			
Approval of progress payments for construction progress		X			
Approval of construction post-award QM/QA/QC plans		X			
Report of nonconforming work or punchlist		X			

competition and allowed his team to focus on demonstrating the value that it could add without worrying about being undercut on the margin amount. The contractor also felt that project quality would be better on CMR than DBB projects because the fundamental design is better and reflects the actual constructed product. One interesting aspect on this project was that the CMR found that it could get permits in about one-quarter the time it took the agency because the permitting agencies perceived that the design would not change from that displayed in the permit application if a construction contractor was the one pulling the permit. This is even more interesting when one considers that Eugene, Oregon, has some of the most stringent environmental constraints in the nation.

Case 5—Pinal County Public Works; Ironwood–Gantzell Multi-Phase Road Improvement

Location: Florence, Arizona
Value: $63.7 million
Scope of Work: Convert 2-lane highway to 4-lane, construct bridges and approach roads; at-grade intersections and ancillary safety improvements.

Rationale: Pinal County had some experience with CMR, having completed four previous projects. The decision to use CMR was made before 30% design completion. The major reason for selecting CMR was the need to compress the schedule along with the requirement to maintain extensive coordination with third-party stakeholders, such as utility companies, and the need for positive public interface throughout the project. Less important reasons for selecting CMR were cited as follows:

- Get early construction contractor involvement
- Encourage constructability and facilitate value engineering
- Sort out complex project requirements
- Gain flexibility during construction
- Assign the responsibility for coordinating third-party issues to the contractor
- Take advantage of innovative financing.

Procurement: A consultant furnished all design services and was selected before CMR. It assisted the agency with the CMR selection process by evaluating CMR qualifications, participating as a voting member of the panel, and developing the short list. The local Associated General Contractors (AGC) also furnished a voting member to the selection panel. The CMR was selected from an RFQ and a short list of all qualified proposers. It is possible in Pinal County to have more than three on the short list. The solicitation documents contained a description of the scope of work quality management roles, preliminary plans and specifications, quality management roles and responsibilities, and a conceptual schedule. Competing CMRs were required to submit the following information:

- Past CMR project experience with references
- Past related project experience (non-CMR) with references
- Qualifications of the CMR's project manager, preconstruction services manager, general superintendent, and public relations person
- Construction traffic control plan and public relations plan
- Preliminary project schedule
- Declaration of self-performed work and subcontracting plan
- Critical analysis of project budget.

The agency interviewed each candidate in person and consisted of a formal presentation, including qualifications, past projects, key personnel, details of preconstruction services, and CMR's analysis of potential project issues and how they can be managed. The winner was determined by the output from the selection panel's direct point scoring in weighted categories published in the advertisement. Price was not scored. Pinal County has never had a protest of a CMR selection decision.

Project Administration: This project used a lump sum progressive GMP contract. The final GMP was established before 100% design completion and was the sum of previous work package GMPs and the estimate for the final work package plus contingencies. The GMP contained transparent contingencies for both the owner and the CMR with no shared savings incentive. The consultant design contract was modified to include CMR specific clauses for design review and milestones to facilitate preconstruction services, a requirement to notify CMR of major design changes, joint value engineering with CMR, coordination of design and subcontractor bid packages, and joint coordination with third parties. The CMR is allowed to self-perform up to 45% of work; however, there are no restrictions on the CMR regarding subcontractor selection.

Preconstruction Services: The following preconstruction services were provided:

- Validate agency/consultant estimates, schedules, and design approach
- Assist in permitting actions
- Assist in right-of-way acquisition
- Prepare project estimates and schedules
- Assist/input to agency/consultant design
- Constructability and cost engineering reviews
- Value analysis
- Coordinate with third-party stakeholders
- Conduct material market survey for cost and availability during design
- Establish sequence of design work to coordinate with construction work packages
- Forecast material/labor pricing to make input to contingencies.

The preconstruction services fee and post-construction management fee were negotiated after award. No special training was required, but formal partnering was mandatory.

Quality Management: Table C5 shows the distribution of quality management responsibilities among parties to the contract. The agency held that CMR produces better quality than DBB because of better relationships among all project stakeholders.

Summary: The contractor for this project agreed with the owner that the project's quality is better if delivered using CMR because in his words: "Being able to make input to the design creates a sense of ownership in that design." This case study project had the most robust preconstruction services program, involving the contractor in material selection, permitting, right-of-way acquisition, and public relations. Both the agency and the contractor agreed that the progressive GMP system allowed the CMR to keep contingencies at a minimum and allowed the project to proceed in those areas where third-party issues were settled. This created the reduction of uncertainty and permitted the project's schedule to be compressed to its greatest extant without excessive time-related contingencies.

Case 6—Utah DOT I-80

Location: Salt Lake City, Utah
Value: $130 million
Scope of Work: Add one lane to each side of I-80; construct six new bridges; improve two interchanges, including adding lanes; retaining walls; residential sound/noise walls.

Rationale: The Utah DOT (UDOT) had 48 CMR projects either finished or underway at the time of the interview and is very comfortable with the status of its procurement system, as well as the provisions in their design and CMR contracts. The decision to use CMR was made before 30% design completion. The major reason for selecting CMR on this project was the need to bring in technical expertise and experience with Accelerated Bridge Construction, a process where a bridge is constructed offsite and driven into place atop a specialized bridge erection vehicle. Additionally, UDOT believed that the need to control budget and schedule on a technically complex project was best met by CMR project delivery. Less important reasons for selecting CMR were cited as follows:

- Get early construction contractor involvement and redistribute risk
- Accelerate the project delivery period and establish the budget at an early stage
- Encourage innovation, constructability, and facilitate value engineering

TABLE C5
IRONWOOD–GANTZELL CMR PROJECT QUALITY MANAGEMENT RESPONSIBILITIES

Quality Assurance/Quality Control Tasks	Does Not Apply	Agency	Designer	CMR	Agency-Hired Consultant
Technical review of construction shop drawings			X		
Technical review of construction material submittals			X		
Checking of pay quantities		X			
Routine construction inspection				X	
Quality control testing				X	
Establishment of horizontal and vertical control on site				X	
Verification testing		X		X	
Acceptance testing		X			
Independent assurance testing/inspection		X			
Approval of progress payments for construction progress		X			
Approval of construction post-award QM/QA/QC plans		X			
Report of nonconforming work or punchlist		X			

- Assign responsibility for third-party issues to the CMR
- Gain flexibility during construction
- Reduce agency oversight requirements during design and reduce life-cycle costs.

The rationale for using CMR on this project is stated as follows: "[we] chose CMGC because the owner is more involved in the design decision process. As owners we make better decisions when we understand the project and that occurs during design. Furthermore, our understanding is enhanced by the contractors experience of how to build it. Evolving the contractor in design is like having a continuous peer review. We catch our mistakes, gain a better understanding of our choices, and make better decisions" (Alder 2009).

Procurement: The project was designed by a combination of consultant and in-house designers with the in-house group initiating conceptual design. The designer is selected before CMR and assists DOT with CMR selection process as non-voting member of panel. The CMR was selected by a two-step RFQ/RFP process. A short list of the three most qualified firms was formed and then asked to submit a proposal containing four to five unit prices for major pay items. The process is described by one of its authors here:

> Using price in the selection process forces the contractor to think about what they will be building. When we add price they have to apply assumptions, boundaries, quantities, schedules, etc., to the project. Price forces the contractor to think through a project like they would have to think through a traditional Design, Bid, Build project. It also adds price completion to the selection process. Associated with this effort we ask them to document assumptions, risks, innovations, and risk mitigation strategies. We are not as concerned about the proposed price as we are about their process in getting there. We want to know if they will open their cost estimating books to us. Will they be good team players and follow an open book process in their cost estimating? Cost is an important part of the design decision process and we need a contractor that shows his cards.
>
> In the design process the engineer and the contractor share price information. We can then compare their prices for the bid items they responded to in the proposal. We also consider assumption used in the creation of those prices and make adjustment where it is justified. In the bid opening process we compare the contractor's price to a cost estimate performed by an Independent Cost Estimator (ICE). The ICE is not told contractor prices during the design. The ICE knows measurement and payment information and what is included in each bid item. The ICE is an experienced contractor estimator who bids the project like another contractor. We compare the contractor's price to the ICE for each bid item. We also compare the contractor's price to the bid items he proposed on in the selection process. If oil or other material costs have gone up then a price increase on HMA [hot mix asphalt] for example is permitted, else we expect the same price at bid opening as we were given at contractor selection.
>
> The process is not perfect and we are looking for ways to improve it. One technique we are developing is a Cost Model being developed by a local university professor. We have a model for HMA, PCCP [portland cement concrete pavement], storm drains, and sidewalks. We intend to expand this to 20% of the bid items that represent 80% of a projects cost. The primary purpose of this tool is to force a discussion about assumptions—like what is the material cost, the labor rates, the production rates, and other relevant choices that are used to estimate the cost. This gives the engineer a better understanding of what the construction challenges are. The engineer is then better able to create an estimate from historical data. The contractor is better able to share his cost and create a more accurate construction cost (Alder 2009).

The solicitation documents contained quality management roles and responsibilities and preliminary plans and specifications. Competing CMRs were required to submit the following information:

- Organizational structure/chart
- Past CMR project experience with references
- Past related project experience (non-CMR) with references
- Qualifications of the CMR's project manager, preconstruction services manager, general superintendent, and public relations coordinator
- Construction traffic control plan and public relations plan
- Preliminary project schedule
- Subcontracting plan
- Proposed post-construction services fee
- Rates for self-performed work
- Critical analysis of project budget.

The agency interviewed each candidate in person, which consisted of a formal presentation, including qualifications, past projects, key personnel, details of preconstruction services, and CMR's analysis of potential project issues and how they can be managed. The winner was determined by the output from the selection panel's direct point scoring in weighted categories published in the advertisement. Price weight ranges from 26% to 50%; this project was about 30%. UDOT has never had a protest of a CMR selection decision.

Project Administration: UDOT uses different contract types based on project type. They have used Unit Price GMP; Unit Price with no GMP; Preconstruction fee only with construction features hard bid by subs. This project used a progressive Unit Price GMP, which is assembled incrementally as the design of bid packages are completed and subcontractor bids are received. The final GMP was established after 100% design and there is a single transparent contingency and no shared savings. The contingency was broken down into three categories: material contingency, westbound portion plus Accelerated Bridge Construction, and eastbound portion. UDOT does not modify its typical consultant design contract for CMR. The CMR can self-perform up to 70% of the project and there are no restrictions on the CMR regarding subcontractor selection.

Preconstruction Services: The following preconstruction services were provided:

- Validate agency/consultant estimates, schedules, and design approach
- Prepare project estimates and schedules
- Assist/input to agency/consultant design

TABLE C6
I-80 CMR PROJECT QUALITY MANAGEMENT RESPONSIBILITIES

Quality Assurance/Quality Control Tasks	Does Not Apply	Agency	Designer	CMR	Agency-Hired Consultant
Technical review of construction shop drawings			X		X
Technical review of construction material submittals		X			X
Checking of pay quantities		X			X
Routine construction inspection		X			
Quality control testing				X	
Establishment of horizontal and vertical control on-site			X		
Verification testing		X			
Acceptance testing		X			
Independent assurance testing/inspection		X			
Approval of progress payments for construction progress		X			X
Approval of construction post-award QM/QA/QC plans		X			
Report of nonconforming work or punchlist		X			X

- Constructability and cost engineering reviews
- Coordinate with third-party stakeholders
- Public relations and public information planning.

The preconstruction services fee was negotiated after award. There is no contractual post-construction services fee. In a unit price, GMP is contained in the construction costs provided in the GMP. No special training was required, but formal partnering was mandatory.

Quality Management: Table C6 shows the distribution of quality management responsibilities among parties to the contract. The agency that held CMR produces better quality than DBB because CMR believes that the quality of its work reflects on its competitiveness for the next UDOT CMR project.

Summary: The contractor on this project agreed that CMR produces better quality than DBB because the contractor design input can assist in literally designing the quality into the project. It also believed that the progressive GMP allowed for keeping contingencies as low as possible. It also preferred breaking out the material contingencies from the time-related contingencies in that it created an open-books method for discussing contingency issues with the state. Finally, the contractor believed that requiring the competing contractors to detail their project approach during the interview was a particularly effective way to differentiate the winner. UDOT agreed that the winner's approach to the project was the overwhelming reason for its selection.

DEPARTMENT OF TRANSPORTATION OVERSIGHT OF CONSTRUCTION MANAGER-AT-RISK PROJECTS

The next case study is a CMR project where the DOT is overseeing the project and had much less input into the decision to use CMR project delivery. As result, as much information as possible was collected by interview or from the literature. It is included to furnish examples of nonstandard project delivery. This includes an additional section indicating the agency providing the funding for the project.

Case 7—Michigan DOT: Oversight—Passenger Ship Terminal Expansion

Agency Providing Funds: Detroit Wayne County Port Authority
Location: Detroit, Michigan
Value: $10 million
Scope of Work: Construct new wharf and expand service roads that service the new wharf.

Rationale: The Michigan DOT (MDOT) had no prior experience with CMR; this project is the first one. MDOT was not involved in the rationale behind the decision to use CMR project delivery. The decision by the Port Authority was made before 30% design completion. The major reasons for selecting CMR were the technical complexity of the project and the need to reduce agency staffing to oversee the project.

Procurement: A consultant furnished all design services and was selected before CMR. It assisted the funding agency with the CMR selection process as a voting member of panel, evaluating qualifications, checking references, and evaluating fees after award. The CMR was selected from an RFQ and no short list was formed. All proposals were considered. The DOT was not involved in the selection decision. The agency interviewed each candidate in person and consisted of a formal presentation, including qualifications, past projects, key personnel, details of preconstruction services, and CMR's analysis of potential project issues and how they can be managed. The winner was determined by the output from the selection panel's direct point scoring in weighted categories published in the advertisement. Price was not scored. There was no protest of a CMR selection decision.

Project Administration: This project used a lump sum GMP contract. The final GMP was established after 100% design completion and after subcontractor bids had been received. The GMP contained transparent contingencies for both the owner and the CMR, with a shared savings incentive of the unused contingencies. The consultant design contract was not modified. The CMR is allowed to self-perform up to 35%

TABLE C7
PASSENGER SHIP TERMINAL CMR PROJECT QUALITY MANAGEMENT RESPONSIBILITIES

Quality Assurance/Quality Control Tasks	Does Not Apply	Agency	Designer	CMR	Agency-Hired Consultant
Technical review of construction shop drawings			X	X	
Technical review of construction material submittals		X	X		
Checking of pay quantities	X				
Routine construction inspection			X		
Quality control testing			X	X	
Establishment of horizontal and vertical control on site			X	X	
Verification testing			X		
Acceptance testing			X		
Independent assurance testing/inspection			X		
Approval of progress payments for construction progress		X			
Approval of construction post-award QM/QA/QC plans			X		
Report of nonconforming work or punchlist			X		

of the work, but there are no restrictions on the CMR regarding subcontractor selection.

Preconstruction Services: The following preconstruction services were provided:

- Validate agency/consultant estimates and design approach
- Prepare project estimates and schedules
- Constructability reviews
- Value analysis
- Coordinate with third-party stakeholders.

The agency specified a fixed preconstruction services fee of $50,000. It also specified a post-construction management fee of 3.5%. No special training or partnering were required.

Quality Management: Table C7 shows the distribution of quality management responsibilities among parties to the contract. The agency had no opinion regarding the comparative quality of CMR as the project is not complete and this is the agency's first CMR job.

Summary: No contractor interview was forthcoming on this project. The agency is evaluating the outcome of this project before deciding if it will apply it to traditional MDOT projects.

NON-HIGHWAY SECTOR CASE STUDY PROJECTS

The final three case study projects are from outside the highway sector. There is an airport case study from Tennessee, a transit CMR project from Utah, and a university building from Texas. The first two projects were taken from previous research projects for ACRP (Touran et al. 2008) and TCRP (Touran et al. 2009). The third was taken from a research project completed at the University of Oklahoma on CMR use in the building sector (Gransberg and Carlisle 2008). As a result, no specific structured interviews were made for this synthesis. The information collected in the three cited research studies was extracted and input into the format used for the case studies collected by the consultants for this project. Therefore, there are some details of interest to this study that are missing, but overall the three case studies are complete enough to allow a comparison of highway CMR projects with the three other sectors.

Case 8—Utah Transit Authority: Weber County Commuter Rail Project

Location: Salt Lake City, Utah
Value: $241 million
Scope: The 44 miles of new transitway alignment begins in downtown Salt Lake City at the Inter-modal Hub and extends north along the Union Pacific Railroad right-of-way through Davis and Weber counties, passing on new elevated structures over the Ogden Yard continuing north of Union Station in Ogden to Pleasant View, Utah. Grade crossings and grade crossing protective devices for the commuter rail line are also being constructed or reconstructed as needed. The project also includes seven stations that include Park and Ride capabilities and an upgrade of an existing maintenance facility and storage site to maintain the commuter rail fleet.

Rationale: This project involved coordinating with multiple stakeholders as it passed through 10 different municipalities and shared or abutted on right-of-way owned by the Union Pacific Railroad. The Utah Transit Authority (UTA) had limited experience with CMR, having completed fewer than five previous projects. The decision to use CMR was made before 30% design completion. The major reason for selecting CMR was the project's technical complexity, along with the requirement to maintain extensive coordination with the third-party stakeholders, such as utility companies, impacted municipalities, and the railroad. Finally, there was a need to ensure continuous public interface, as well as a desire to compress the schedule to accrue transit and parking revenue as early as possible. Less important reasons for selecting CMR were cited as follows:

- Get early construction contractor involvement
- Establish the project budget for each phase as early as possible

- Encourage constructability and facilitate value engineering
- Gain flexibility during construction
- Assign the responsibility for coordinating third-party issues to the contractor
- Reduce agency staffing requirements.

Procurement: A consultant was selected to complete the design. The designers were selected before the CMR. The consultant assisted the agency with the CMR selection process as a non-voting member of the panel. The CMR was selected from an RFP and a short list of three qualified proposers. The solicitation documents contained a description of the scope of work and quality management roles and responsibilities. Competing CMRs were required to submit the following information:

- Past CMR project experience with references
- Qualifications of the CMR's project manager and quality manager
- Proposed preconstruction fee.

The agency interviewed each candidate in person and consisted of a formal presentation, including qualifications, past projects, key personnel, details of preconstruction services, and CMR's analysis of potential project issues and how they can be managed. The winner was determined by the output from the selection panel's direct point scoring in weighted categories published in the advertisement. Price was not scored and UTA has never had a protest of a CMR selection decision.

Project Administration: This project used a lump sum GMP contract. The final GMP was established as soon as practical before 100% design completion. The GMP contained separate transparent contingencies for the CMR and the owner and the CMR with no shared savings incentive. The consultant design contract was modified to include CMR specific clauses for CMR design review, joint value engineering, and joint coordination with third parties. The CMR is allowed to self-perform as much of the work as it pleases, and it had no restriction on its selection of subcontractors.

Preconstruction Services: The following preconstruction services were provided:

- Validate consultant design
- Prepare project estimates and schedules
- Assist/input to agency/consultant design
- Constructability and cost engineering reviews
- Value analysis
- Market surveys to assist in material selection design decisions
- Coordinate with third-party stakeholders
- Assist in right-of-way acquisition and permitting actions.

The preconstruction services fee was proposed before award and the post-construction management fee was negotiated after award. No special training was required. Formal partnering was mandated.

Quality Management: Table C8 shows the distribution of quality management responsibilities among parties to the contract. The agency held that CMR produces better quality than DBB because of the CMR's ability to work with third parties to reduce permitting delays and maintain the schedule.

Summary: The UTA was able to complete this project 9 months ahead of schedule and within budget. They believed that the use of CMR project delivery and especially the early contractor involvement in the design process was largely responsible for project success. The CMR initiated a value engineering study of a large fly-over bridge that crossed the Union Pacific railroad yard. The basis of the savings was a right-of-way swap between UP and UTA that allowed the fly-over to be reduced to two small bridges on three fills. UTA accrued the entire savings of nearly $7 million because it was paying for value engineering services in the preconstruction services contract. UTA also used an innovative clause in their CMR contract that created an incentive for the contractor to maintain good public relations. The clause effectively put half of CMR's post-construction services fee at risk by requiring a monthly meeting of a stakeholder panel that included the impacted municipalities, the state environmental quality agency, and

TABLE C8
WEBER COUNTY COMMUTER RAIL CMR PROJECT QUALITY MANAGEMENT RESPONSIBILITIES

Quality Assurance/Quality Control Tasks	Does Not Apply	Agency	Designer	CMR	Agency-Hired Consultant
Technical review of construction shop drawings			X		X
Technical review of construction material submittals			X		X
Checking of pay quantities		X			X
Routine construction inspection		X		X	X
Quality control testing				X	
Establishment of horizontal and vertical control on site				X	X
Verification testing				X	
Acceptance testing		X			X
Independent assurance testing/inspection					
Approval of progress payments for construction progress		X			
Approval of construction post-award QM/QA/QC plans		X			
Report of nonconforming work or punchlist		X			

representatives from the railroad and the FTA. The panel reviewed the issues that arose in the past month and made a recommendation to UTA as to how much of the at-risk fee should be awarded in the monthly progress payment. The clause worked because there was only one month that less than the full amount was applied, and the panel decided to restore it the next month after the CMR had taken aggressive and immediate corrective action to resolve the issue. Finally, it should be noted that UTA's desire to minimize the agency's oversight staff was realized in that the project was successfully completed with only two UTA employees assigned to manage it.

Case 9—Memphis–Shelby County Airport Authority: Whole Base Relocation Project

Location: Memphis, Tennessee
Value: $245 million
Scope: Relocate the 164th Airlift Wing base in its entirety to a new location at Memphis–Shelby County International Airport (MSCIA). New apron and taxiways, three specialized hangars with associated shops to support the C-5 program, and all related administrative base operations; design packages for 15 buildings (560,000 square feet); and associated utilities and infrastructure.

Rationale: This project involved multiple stakeholders: the MSCIA Authority, FedEx, Inc.; 164th Airlift Wing, Tennessee Air Guard; and Headquarters, Air National Guard, Washington, D.C. It also involved mixing private funding with different types of public funding. The MSCIA Authority had prior experience with CMR, having completed more than 10 previous projects. The decision to use CMR was made before advertising the design contract. The major reason for selecting CMR was the need to compress the schedule along with the requirement to maintain extensive coordination with the four stakeholders contributing funds to the project as well as third-party stakeholders, such as utility companies and the scheduled airlines. Finally, there was a need to be able to track which features in the scope of work were being designed and built from each pot of funds throughout the project. Less important reasons for selecting CMR were cited as follows:

- Get early construction contractor involvement
- Establish the project budget for each phase as early as possible
- Encourage price competition through competitive bidding by subcontractors
- Encourage constructability and facilitate value engineering
- Redistribute risk and sort out complex project requirements
- Assign the responsibility for coordinating third-party issues to the contractor
- Take advantage of available federal and private financing.

Procurement: A consultant was selected to act as CM-Agent and represents the MSCIA Authority throughout the course of the project. The project had five phases and the CM-Agent treated each as a separate project, procuring phase design consultants to complete the design and requiring full competition for each CMR contract. The designers were selected before the CMR. The CM-Agent assisted the agency with the CMR selection process by evaluating CMR qualifications, checking references, and participating in the interviews as a non-voting member of the panel. The CMR was selected from a two-step RFQ/RFP and a short list of three qualified proposers. The solicitation documents contained a description of the scope of work and preliminary plans and specifications. Competing CMRs were required to submit the following information:

- Organizational chart
- Past CMR project experience with references
- Past related project experience (non-CMR) with references
- Qualifications of the CMR's project manager, preconstruction services manager, general superintendent, and quality manager
- Construction traffic control plan and construction quality management plan
- Preliminary project schedule
- Declaration of self-performed work and subcontracting plan
- Critical analysis of project budget including target GMP
- Proposed preconstruction and post-construction fees.

The agency interviewed each candidate in person and each interview consisted of a formal presentation, including qualifications, past projects, key personnel, details of preconstruction services, and CMR's analysis of potential project issues and how they can be managed. The winner was determined by the output from the selection panel's direct point scoring in weighted categories published in the advertisement. Price was weighted at 25% of total points and the MSCIA Authority has never had a protest of a CMR selection decision.

Project Administration: This project used a lump sum GMP contract for each phase. The final GMP was established by the sum of phase GMPs and the estimate for the final phase contingencies. The GMP contained a single transparent contingency and the CMR with no shared savings incentive. The consultant design contract was modified to include CMR specific clauses for milestones to facilitate preconstruction services, budget review points, coordination of design and subcontractor bid packages, and joint coordination with third parties. Additionally, the MSCIA CMR design contract contained a provision that put up to 10% of design fee at risk based on the quality of the construction documents. This was measured by the number of additive change orders that had to be issued after 100% construction documents were released for construction. The CMR is allowed to self-perform as much of the work as it pleases, and it was required to accept competitive bids from the trade subcontractors. It was allowed to designate a subcontractor whose bid was not the lowest, but the CMR had to reduce its margin to be the difference between the low sub and the desired sub.

Preconstruction Services: The following preconstruction services were provided:

- Prepare project estimates and schedules
- Assist/input to agency/consultant design
- Constructability and cost engineering reviews
- Value analysis
- Coordinate with third-party stakeholders.

The preconstruction services fee and post-construction management fee were proposed before award. No special training or partnering was required.

Quality Management: Table C9 shows the distribution of quality management responsibilities among parties to the contract. The agency held that CMR produces better quality than DBB because it made the CMR more competitive for future work.

Summary: The MSCIA Authority was able to complete this project ahead of schedule and within budget. They believed that the use of both CMR and CM-Agency in this phased project was largely responsible for its success. The first phase had difficulty getting the design consultant to accept CMR input because it feared that this would compromise the contractual design liability. The second phase CMR design contract contained the provision that put up to 10% of design fee at risk based on the quality of the construction documents. This changed the consultant's attitude from viewing the CMR as technically unqualified interference to seeing the CMR reviews as a valuable contribution to the design quality control system. This contractual innovation along with furnishing the CMR with the ability to select a subcontractor whose bid was not the lowest by reducing its own fee created an environment where the CMR's value to the project was significant.

Case 10—Texas Tech University
Lanier Professional Development Center

Location: Lubbock, Texas
Value: $13.7 million
Scope: Construct a 34,560 gross square foot addition that includes a state-of-the-art 150 seat courtroom; a 300 seat auditorium–classroom, capable of holding an entire law school class as well as continuing education conferences; and office spaces for the Office of Academic Success Programs, Career Services and Alumni Development, and student organizations.

Rationale: Texas Tech University (TTU) had extensive experience with CMR, having completed more than 20 previous projects in the past decade. The decision to use CMR was made before 30% design completion. TTU's policy is to use CMR on all projects that are over $5.0 million and on technically complex projects under that limit. The major reason for selecting CMR was the project's technical complexity along with the requirement to maintain extensive coordination with the third-party stakeholders, such as the Law School Dean, the funding donor, and interested alumni. Finally, there was a need to ensure that construction did not interrupt the educational activities in the immediate area of the project. Less important reasons for selecting CMR were cited as follows:

- Compress the schedule
- Get early construction contractor involvement
- Establish the project budget for each phase as early as possible
- Encourage constructability and facilitate value engineering
- Redistribute risk for complex project requirements
- Gain flexibility during construction
- Assign the responsibility for coordinating third-party issues to the contractor
- Encourage sustainability
- Reduce agency review/inspection requirements.

Procurement: A consultant was selected to complete the design. The designers were selected before the CMR. The consultant

TABLE C9
WHOLE BASE RELOCATION CMR PROJECT QUALITY MANAGEMENT RESPONSIBILITIES

Quality Assurance/Quality Control Tasks	Does Not Apply	Agency	Designer	CMR	Agency-Hired Consultant
Technical review of construction shop drawings			X		X
Technical review of construction material submittals			X		X
Checking of pay quantities				X	
Routine construction inspection				X	
Quality control testing				X	
Establishment of horizontal and vertical control on site					X
Verification testing		X			
Acceptance testing					X
Independent assurance testing/inspection		X			
Approval of progress payments for construction progress		X			
Approval of construction post-award QM/QA/QC plans		X			
Report of nonconforming work or punchlist		X			

TABLE C10
LANIER PROFESSIONAL DEVELOPMENT CENTER CMR PROJECT QUALITY MANAGEMENT RESPONSIBILITIES

Quality Assurance/Quality Control Tasks	Does Not Apply	Agency	Designer	CMR	Agency-Hired Consultant
Technical review of construction shop drawings			X		
Technical review of construction material submittals			X		
Checking of pay quantities			X		
Routine construction inspection				X	
Quality control testing				X	
Establishment of horizontal and vertical control on site				X	
Verification testing			X		
Acceptance testing		X			
Independent assurance testing/inspection			X		
Approval of progress payments for construction progress		X			
Approval of construction post-award QM/QA/QC plans		X			
Report of nonconforming work or punchlist		X			

assisted the agency with the CMR selection process as a non-voting member of the panel. The CMR was selected from an RFP and a short list of three qualified proposers. The solicitation documents contained a description of the scope of work and quality management roles and responsibilities. Competing CMRs were required to submit the following information:

- Organization chart
- Past CMR project experience with references
- Qualifications of the CMR's project manager and quality manager
- Construction quality control and traffic control plan
- Preliminary project schedule
- Declaration of self-performed work
- Subcontracting and Disadvantaged Business Enterprise plan
- Proposed preconstruction, post-construction, and general conditions fee
- Critical analysis of the project budget.

The agency interviewed each candidate in person and each consisted of a formal presentation, including qualifications, past projects, key personnel, details of preconstruction services, and CMR's analysis of potential project issues and how they can be managed. The winner was determined by the output from the selection panel's adjectival rating in unweighted categories published in the advertisement. Price was scored and carried a weight of 25%. TTU has never had a protest of a CMR selection decision.

Project Administration: This project used a lump sum GMP contract. The final GMP was established as soon as practical before 100% design completion. The GMP contained separate transparent contingencies for the CMR and the owner and the CMR with no shared savings incentive. The consultant design contract was modified to include CMR specific clauses for CMR design review, design milestones for preconstruction services, budget review points, joint value engineering, coordination of design packages with subcontractor bid packages, and joint coordination with third parties. The CMR is allowed to self-perform as much of the work as it pleased, and it must accept bids from subcontractors and award to the lowest responsible bidder.

Preconstruction Services: The following preconstruction services were provided:

- Prepare project estimates and schedules
- Assist/input to agency/consultant design
- Constructability and cost engineering reviews
- Value analysis
- Market surveys to assist in material selection design decisions
- Coordinate with third-party stakeholders
- Assist in permitting actions and prepare sustainability certification paperwork.

The preconstruction services and post-construction management fees are proposed before award. No special training was required. Formal partnering was mandated.

Quality Management: Table C10 shows the distribution of quality management responsibilities among parties to the contract. The agency held that CMR produces better quality than DBB because of the CMR's ability to work with third parties to reduce permitting delays and maintain the schedule.

SUMMARY

The ten case study projects detailed in the previous section represent a cross section of the types of projects that state DOTs and other public transportation agencies might use CMR to deliver. The analysis of the output from the case study data collection will be detailed in the next chapters on the various aspects of CMR project delivery.

Abbreviations 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
HMCRP	Hazardous Materials Cooperative Research Program
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
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
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